The Engineering Staff of
TEXAS INSTRUMENTS INCORPORATED
Components Group

The Transistor and Diode Data Book

for Design Engineers

TEXAS INSTRUMENTS
INCORPORATED

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for

Design Engineers

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Third Printing

THE TRANSISTOR AND DIODE DATA BOOK

Since 1954, when Texas Instruments introduced the first silicon transistor to the marketplace, and later with the invention of the integrated circuit, TI has been pre-eminent in the semiconductor industry.

New semiconductor products are introduced almost daily; new applications for semiconductor products are being found or comtemplated at an ever-increasing rate, especially in the consumer and automotive fields. It is a difficult task for the equipment design engineer to stay abreast of all of the discrete and integrated-circuit products available to him in his efforts to choose the best device at the optimum cost effectiveness. It is the aim of Texas Instruments to provide the design engineer with the maximum amount of accurate product data organized in such a manner that the pertinent data may be located in the least amount of time.

Due to the amount of data involved, it would be inconvenient to present TI's complete line of standard discrete products in a single volume. TI's broad line of power products are described in *The Power Semiconductor Data Book for Design Engineers*, First Edition (CC-404); optoelectronic products are presented in *The Optoelectronics Data Book for Design Engineers*, First Edition (CC-405). For ease of reference, all current devices listed in those two volumes are contained in the Type Number Index (Section O) herein. This 1248-page volume is designed to complement those two volumes and essentially complete the current description of TI's line of discrete semiconductors by adding all low-power silicon transistors and diodes. (Generally, "low-power" denotes free-air power dissipation of one watt or less.)

This volume contains over 800 silicon transistor types (grown-junction, multijunction, unijunction, and field-effect transistors) and over 500 silicon diode types (switching, rectifying, voltage-regulating, voltage-variable-capacitance, and general purpose diodes as well as multielement diode arrays and matrices), over 150 of which are being announced for the first time.

Although this volume offers specification and interchangeability data only for low-power silicon transistors and diodes, complete technical information for all TI semiconductor products is available from your nearest TI field-sales office, local authorized TI distributor, or by writing direct to: Marketing and Information Services, Texas Instruments Incorporated, P.O. Box 5012, Dallas, Texas 75222.

We hope that you will find *The Transistor and Diode Data Book for Design Engineers* a useful addition to your technical library.

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*Not shown in this data book but still available from Texas Instruments.
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*Not shown in this data book but still available from Texas Instruments.
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POWER—Refer to The Power Semiconductor Data Book for Design Engineers, First Edition (CC-404).

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Glossary

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GLOSSARY

Introduction

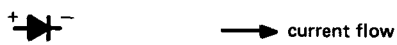
This glossary contains letter symbols, abbreviations, terms, and definitions commonly used with semiconductor devices. Most of the information was obtained from JEDEC Publication No. 77. That document has over-riding authority where any conflict may occur.

GENERAL

1

Terms and Definitions

Term	Definition
anode	The electrode from which the forward current flows within the device.
bipolar transistor	A transistor that utilizes charge carriers of both polarities.
breakdown	A phenomenon occuring in a reverse-biased semiconductor junction, the initiation of which is observed as a transition from a region of high small-signal resistance to a region of substantially lower small-signal resistance for an increasing magnitude of reverse current.
breakdown region	A region of the volt-ampere characteristic beyond the initiation of breakdown for an increasing magnitude of reverse current.
breakdown voltage	The voltage measured at a specified current in a breakdown region. (Ref MIL-S-19500D Par. 20.3)
blocking	A state of a semiconductor device or junction which essentially prevents the flow of current.
cathode	The electrode to which the forward current flows within the device. For diagram, see "anode".
electrode	An electrical and mechanical contact to a region of a semiconductor device.
forward bias	The bias which tends to produce current flow in the forward direction.
forward direction	The direction of current flow which results when the p-type semiconductor region is at a positive potential relative to the n-type region. (Ref IEEE 253)
open-circuit	A circuit in which halving the magnitude of the terminating impedance does not produce a change in the parameter being measured greater than the required accuracy of the measurement. (Ref MIL-S-19500D Par. 20.8)
rectifying junction	A junction in a semiconductor device which exhibits asymmetrical conductance.



Term	Definition
reverse bias	The bias which tends to produce current flow in the reverse direction.  current flow
reverse direction	The direction of current flow which results when the n-type semiconductor region is at a positive potential relative to the p-type region.
semiconductor device	A device whose essential characteristics are governed by the flow of charge carriers within a semiconductor.
semiconductor diode	A semiconductor device having two terminals and exhibiting a nonlinear voltage-current characteristic; in more restricted usage, a semiconductor device which has the asymmetrical voltage-current characteristic exemplified by a single p-n junction. (Ref IEEE 270)
semiconductor junction (commonly referred to as junction)	A region of transition between semiconductor regions of different electrical properties (e.g., n-n^+, p-n, p-p^+ semiconductors), or between a metal and a semiconductor.
short-circuit	A circuit in which doubling the magnitude of the terminating impedance does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement. (Ref MIL-S-19500D Par. 20.16)
small-signal	A signal which when doubled in magnitude does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement. (Ref MIL-S-19500D Par. 20.17)
static value	A non-varying value or quantity measured at a specified fixed point, or the slope of the line from the origin to the operating point on the appropriate characteristic curve. (Ref IEEE 255 Par. 2.2.1)
terminal	An externally available point of connection to one or more electrodes.
thermal resistance (steady-state)	The temperature difference between two specified points or regions divided by the power dissipation under conditions of thermal equilibrium. (Ref IEEE 223)
transient thermal impedance	The change of temperature difference between two specified points or regions at the end of a time interval divided by the step-function change in power dissipation at the beginning of the same time interval causing the change of temperature difference. (Ref IEEE 223)
transistor	An active semiconductor device capable of providing power amplification and having three or more terminals. (Ref IEC 147-0 Par. 0-2.8)

Letter Symbols, Terms, and Definitions

Symbol	Term	Definition
$\overline{F}$ or $\overline{NF}$*	average noise figure† or average noise factor†	The ratio of (1) the total output noise power within a designated output frequency band when the noise temperature of the input termination(s) is at the reference noise temperature, T_0, at all frequencies to (2) that part of (1) caused by the noise temperature of the designated signal-input termination within a designated signal-input frequency band.
F or NF*	spot noise figure† or spot noise factor†	The ratio of (1) the total output noise power per unit bandwidth (spectral density) at a designated output frequency when the noise temperature of the input termination(s) is at the reference noise temperature, T_0, at all frequencies to (2) that part of (1) caused by the noise temperature of the designated signal-input termination at a designated signal-input frequency.
I_F	forward current, dc	The dc current that flows through a semiconductor junction in the forward direction.
I_n	noise current, equivalent input	The noise current of an ideal current source (having a source impedance equal to infinity) in parallel with the input terminals of the device that, together with the equivalent input noise voltage, represents the noise of the device.
I_R	reverse current, dc	The dc current that flows through a semiconductor junction in the reverse direction.
R_θ (formerly θ)	thermal resistance	Refer to thermal resistance (steady-state), page 1-2.
$R_{\theta CA}$	thermal resistance, case-to-ambient	The thermal resistance (steady-state) from the device case to the ambient.
$R_{\theta JA}$ (formerly θ_{J-A})	thermal resistance, junction-to-ambient	The thermal resistance (steady-state) from the semiconductor junction (s) to the ambient.
$R_{\theta JC}$ (formerly θ_{J-C})	thermal resistance, junction-to-case	The thermal resistance (steady-state) from the semiconductor junction(s) to a stated location on the case.
s_f or s_{21}	forward transmission coefficient	The ratio of the voltage at the output port to the voltage incident on the input port with the output port terminated in a purely resistive reference impedance equal to the impedance of the source of the incident voltage.

*$\overline{NF}$ and NF abbreviations are often used for symbols $\overline{F}$ and F; however, the symbols $\overline{F}$ and F are preferred.
†These quantities may be expressed logarithmically in decibels (dB).

Symbol	Term	Definition
s_i or s_{11}	input reflection coefficient	The ratio of the voltage reflected from the input port to the voltage incident on the input port with the output port terminated in a purely resistive reference impedance equal to the impedance of the source of the incident voltage.
s_o or s_{22}	output reflection coefficient	The ratio of the voltage reflected from the output port to the voltage incident on the output port with the input port terminated in a purely resistive reference impedance equal to the impedance of the source of the incident voltage.
s_r or s_{12}	reverse transmission coefficient	The ratio of the voltage at the input port to the voltage incident on the output port with the input port terminated in a purely resistive reference impedance equal to the impedance of the source of the incident voltage.
T_A	free-air temperature or ambient temperature	The air temperature measured below a device, in an environment of substantially uniform temperature, cooled only by natural air convection and not materially affected by reflective and radiant surfaces. (Ref MIL-S-19500D Par. 20.20.1)
T_C	case temperature	The temperature measured at a specified location on the case of a device. (Ref MIL-S-19500D Par. 20.20.2)
T_J	virtual junction temperature	A temperature representing the temperature of the junction(s) calculated on the basis of a simplified model of the thermal and electrical behavior of the semiconductor device. NOTE: This term "virtual junction temperature" is taken from IEC standards. It is particularly applicable to multijunction semiconductors and is used in this publication to denote the temperature of the active semiconductor element when required in specifications and test methods. The term "virtual junction temperature" is used interchangeably with the term "junction temperature" in this publication.
T_{stg}	storage temperature	The temperature at which the device, without any power applied, is stored. (Ref MIL-S-19500D Par. 20.20.3)

Symbol	Term	Definition
T_n	noise temperature	The uniform physical absolute temperature (kelvin) at which a network (and all its sources, if a multiport) would have to be maintained if it (and its sources) were passive in order to make available (or deliver) the same random noise power per unit bandwidth (spectral density) at a given frequency as is actually available (or delivered) from the network.
T_0	reference noise temperature	A specified absolute temperature (kelvin) to be assumed as a noise temperature at the input ports of a network when calculating certain noise parameters, and for normalizing purposes. When the reference noise temperature is 290 K, it is considered to be the standard reference noise temperature.
t_d	delay time	The time interval from the point at which the leading edge of the input pulse has reached 10 percent of its maximum amplitude to the point at which the leading edge of the output pulse has reached 10 percent of its maximum amplitude. (Ref MIL-S-19500D Par. 20.11)
t_f	fall time	The time duration during which the trailing edge of a pulse is decreasing from 90 to 10 percent of its maximum amplitude. (Ref MIL-S-19500D Par. 20.12)
t_{off}	turn-off time	The sum of $t_s + t_f$.
t_{on}	turn-on time	The sum of $t_d + t_r$.
t_p	pulse time	The time duration from the point on the leading edge which is 90 percent of the maximum amplitude to the point on the trailing edge which is 90 percent of the maximum amplitude. (Ref MIL-S-19500D Par. 20.15)
t_r	rise time	The time duration during which the leading edge of a pulse is increasing from 10 to 90 percent of its maximum amplitude. (Ref MIL-S-19500 Par. 20.13)
t_s	storage time	The time interval from a point 90 percent of the maximum amplitude on the trailing edge of the input pulse to a point 90 percent of the maximum amplitude on the trailing edge of the output pulse. (Ref MIL-S-19500D Par. 20.14)

Symbol	Term	Definition
t_w	pulse average time	The time duration from the point on the leading edge which is 50 percent of the maximum amplitude to a point on the trailing edge which is 50 percent of the maximum amplitude. (Ref MIL-S-19500D Par. 20.10)

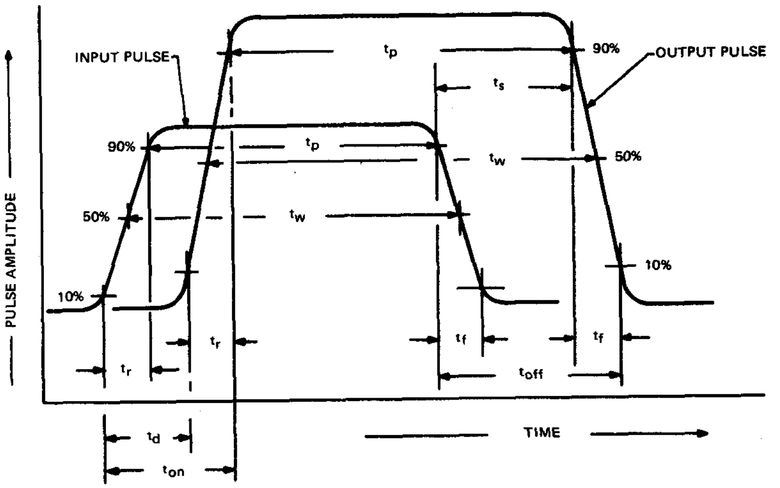


DIAGRAM ILLUSTRATING PULSE TIME SYMBOLOGY

V_F	forward voltage, dc	The dc voltage across a semiconductor junction associated with the flow of forward current.
V_n	noise voltage, equivalent input	The noise voltage of an ideal voltage source (having a source impedance equal to zero) in series with the input terminals of the device that, together with the equivalent input noise current, represents the noise of the device.
V_R	reverse voltage, dc	The dc voltage applied to a semiconductor junction which causes the current to flow in the reverse direction.

SIGNAL DIODES AND RECTIFIERS

Terms and Definitions

Term	Definition
semiconductor rectifier diode	A semiconductor diode having an asymmetrical voltage-current characteristic, used for rectification, and including its associated housing, mounting, and cooling attachments if integral with it.

Graphic symbol for a semiconductor rectifier diode and a *semiconductor signal diode* (Ref ANS Y32.2):

Term	Definition
semiconductor signal diode	A semiconductor diode having an asymmetrical voltage-current characteristic and used for signal detection.

For graphic symbol, see above.

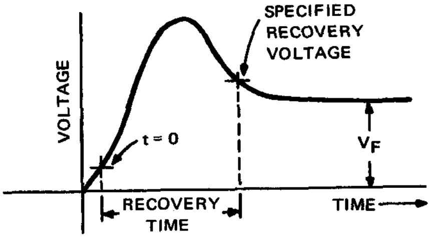
Letter Symbols, Terms, and Definitions

(For illustration of the following currents refer to diagrams on page 1-10)

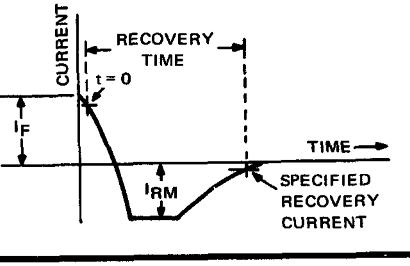
Symbol	Term	Definition
$I_{F(RMS)}$, I_f, I_F, $I_{F(AV)}$, i_F, I_{FM}	forward current (see table, page 1-11)	The respective value of current that flows through a semiconductor diode or rectifier diode in the forward direction.
I_{FRM}	forward current, repetitive peak	The peak value of the forward current including all repetitive transient currents.
I_{FSM}	forward current, surge peak	The maximum (peak) surge forward current having a specified waveform and a short specified time interval.
I_O	average rectified forward current	The value of the forward current averaged over a full cycle of half-sine-wave operation at 60 Hz with a conduction angle of 180°.
$I_{R(RMS)}$, I_r, I_R, $I_{R(AV)}$, i_R, I_{RM}	reverse current (see table, page 1-11)	The respective value of current that flows through a semiconductor diode or rectifier diode in the reverse direction.
$i_{R(REC)}$, $I_{RM(REC)}$	reverse recovery current (see table, page 1-11)	The transient component of reverse current associated with a change from forward conduction to reverse voltage.
I_{RRM}	reverse current, repetitive peak	The maximum (peak) repetitive instantaneous reverse current.
I_{RSM}	reverse current, surge peak	The maximum (peak) surge reverse current having a specified waveform and a short specified time interval.

GLOSSARY
SIGNAL DIODES AND RECTIFIERS

Symbol	Term	Definition
P_F, $P_{F(AV)}$, p_F, P_{FM}	forward power dissipation (see table, page 1-11)	The power dissipation resulting from the flow of the respective forward current.
P_R, $P_{R(AV)}$, p_R, P_{RM}	reverse power dissipation (see table, page 1-11)	The power dissipation resulting from the flow of the respective reverse current.
Q_S	stored charge	The total amount of charge recovered from a diode minus the capacitive component of that charge when the diode is switched from a specified conductive condition to a specified non-conductive condition with other circuit conditions (as described in EIA-JEDEC Suggested Standard No. 1) optimized to recover the largest possible amount of charge.
R_θ	thermal resistance	See pages 1-2 and 1-3.
T_J	junction temperature	See page 1-4.
t_{fr}	forward recovery time	The time required for the current or voltage to recover to a specified value after instantaneous switching from a stated reverse voltage condition to a stated forward current or voltage condition in a given circuit.



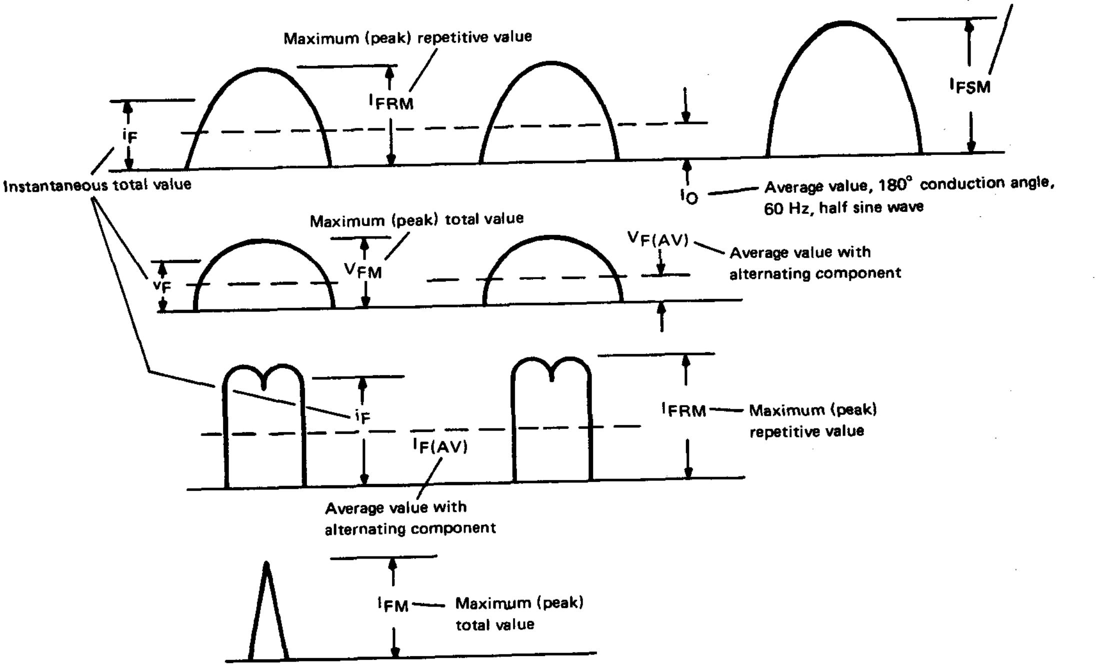
Symbol	Term	Definition
t_p	pulse time	See pages 1-5 and 1-6.
t_r	rise time	See pages 1-5 and 1-6.
t_{rr}	reverse recovery time	The time required for the current or voltage to recover to a specified value after instantaneous switching from a stated forward current condition to a stated reverse voltage or current condition in a given circuit.



Symbol	Term	Definition
t_w	pulse average time	See page 1-6.
$V_{(BR)}$, $v_{(BR)}$	breakdown voltage (dc, instantaneous total value)	The value of voltage at which breakdown occurs.
$V_{F(RMS)}$, V_f, V_F, $V_{F(AV)}$, v_F, V_{FM}	forward voltage (see table, page 1-11)	The voltage drop in a semiconductor diode resulting from the respective forward current.
$V_{R(RMS)}$, V_r, V_R, $V_{R(AV)}$, v_R, V_{RM}	reverse voltage (see table, page 1-11)	The voltage applied to a semiconductor diode which causes the respective current to flow in the reverse direction.
V_{RWM}	working peak reverse voltage	The maximum instantaneous value of the reverse voltage, excluding all transient voltages, which occurs across a semiconductor rectifier diode.
V_{RRM}	repetitive peak reverse voltage	The maximum instantaneous value of the reverse voltage, including all repetitive transient voltages but excluding all nonrepetitive transient voltages, which occurs across a semiconductor rectifier diode.
V_{RSM}	nonrepetitive peak reverse voltage	The maximum instantaneous value of the reverse voltage including all nonrepetitive transient voltages but excluding all repetitive transient voltages, which occurs across a semiconductor rectifier diode.

DIAGRAMS ILLUSTRATING SYMBOLS FOR DIODE CURRENTS AND VOLTAGES

I. FORWARD CURRENT AND VOLTAGE:



II. REVERSE CURRENT AND VOLTAGE:

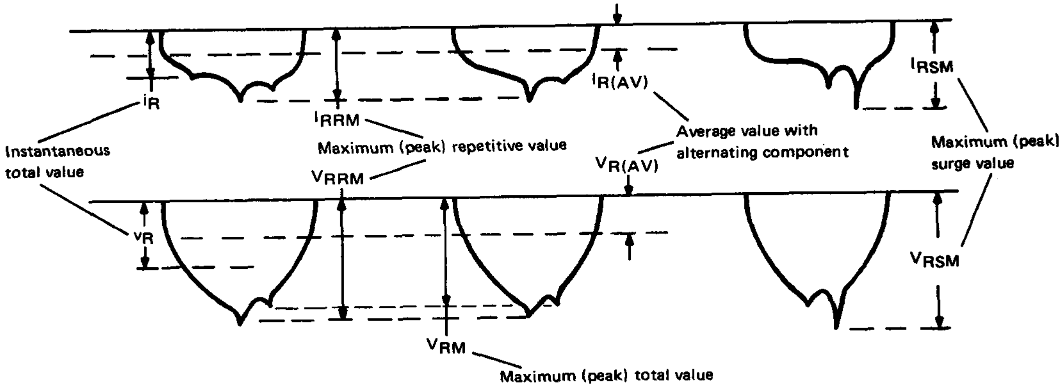


TABLE OF SYMBOLS FOR CURRENT, POWER, AND VOLTAGE

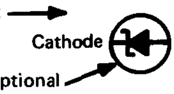
	Total RMS Value	RMS Value of Alternating Component	DC Value, No Alternating Component	DC Value, With Alternating Component	Instantaneous Total Value	Maximum (Peak) Total Value
Forward Current	$I_{F(RMS)}$	I_f	I_F	$I_{F(AV)}$	i_F	I_{FM}
Forward Current, Average, 180° Conduction Angle, 60-Hz, Half Sine Wave	–	–	–	I_O	–	–
Forward Current, Repetitive Peak	–	–	–	–	–	I_{FRM}
Forward Current, Surge Peak	–	–	–	–	–	I_{FSM}
Reverse Current	$I_{R(RMS)}$	I_r	I_R	$I_{R(AV)}$	i_R	I_{RM}
Reverse Recovery Current	–	–	–	–	$i_{R(REC)}$	$I_{RM(REC)}$
Forward Power Dissipation	–	–	P_F	$P_{F(AV)}$	p_F	P_{FM}
Reverse Power Dissipation	–	–	P_R	$P_{R(AV)}$	p_R	P_{RM}
Forward Voltage	$V_{F(RMS)}$	V_f	V_F	$V_{F(AV)}$	v_F	V_{FM}
Reverse Voltage	$V_{R(RMS)}$	V_r	V_R	$V_{R(AV)}$	v_R	V_{RM}
Reverse Voltage, Working Peak	–	–	–	–	–	V_{RWM}
Reverse Voltage, Repetitive Peak	–	–	–	–	–	V_{RRM}
Reverse Voltage, Nonrepetitive Peak	–	–	–	–	–	V_{RSM}
Breakdown Voltage	–	–	$V_{(BR)}$	–	$v_{(BR)}$	–

VOLTAGE-REGULATOR AND VOLTAGE-REFERENCE DIODES

Terms and Definitions

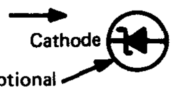
Term	Definition
anode	The electrode to which the reverse current flows within the device when it is biased to operate in its breakdown region.
cathode	The electrode from which the reverse current flows within the device when it is biased to operate in its breakdown region.
voltage-reference diode	A diode which is normally biased to operate in the breakdown region of its voltage-current characteristic and which develops across its terminals a reference voltage of specified accuracy, when biased to operate throughout a specified current and temperature range. (Ref IEC 147-0, Par. 0-2.3)

Graphic symbol for voltage-reference diode (Ref ANS Y32.2)



Term	Definition
voltage-regulator diode	A diode which is normally biased to operate in the breakdown region of its voltage-current characteristic and which develops across its terminals an essentially constant voltage throughout a specified current range. (Ref IEC 147-0, Par. 0-2.4)

Graphic symbol for voltage-regulator diode. (Ref ANS Y32.2)



Letter Symbols, Terms, and Definitions

(For illustration of the following currents and voltages refer to diagrams on page 1-13)

Symbol	Term	Definition
I_F	forward current, dc	The value of dc current that flows through the diode in the forward direction.
I_R	reverse current, dc	The value of dc current that flows through the diode in the reverse direction.
I_Z, I_{ZK}, I_{ZM}	regulator current, reference current (dc, dc near breakdown knee, dc maximum-rated current)	The value of dc reverse current that flows through the diode when it is biased to operate in its breakdown region and at a point on its voltage-current characteristic as follows: I_Z: a specified operating point between I_{ZK} and I_{ZM} I_{ZK}: a specified point near the breakdown knee I_{ZM}: a specified point based on the maximum-rated power.
T_J	junction temperature	See page 1-4.

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Symbol	Term	Definition
V_F	forward voltage, dc	The voltage drop in the diode, resulting from the dc forward current.
V_R	reverse voltage, dc	The voltage applied to the diode which causes the dc current to flow in the reverse direction.
V_Z, V_{ZM}	regulator voltage, reference voltage (dc, dc at maximum-rated current)	The value of dc voltage across the diode when it is biased to operate in its breakdown region and at a specified point in its voltage-current characteristic as follows: V_Z: at I_Z (see previous page) V_{ZM}: at I_{ZM} (see previous page)
z_z, z_{zk}, z_{zm}	regulator impedance, reference impedance, (small-signal, at I_Z, at I_{ZK}, at I_{ZM})	The small-signal impedance of the diode when it is biased to operate in its breakdown region and at a specified point in its voltage-current characteristic as follows: z_z: at I_Z (see previous page) z_{zk}: at I_{ZK} (see previous page) z_{zm}: at I_{ZM} (see previous page)

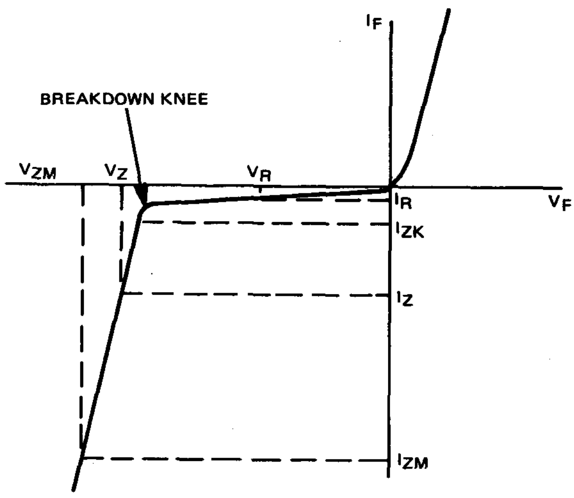


DIAGRAM ILLUSTRATING SYMBOLS FOR CURRENTS AND VOLTAGES

VOLTAGE-VARIABLE-CAPACITANCE DIODES

Terms and Definitions

Term	Definition
voltage-variable-capacitance diode (varactor diode)	A two-terminal semiconductor device in which use is made of the property that its capacitance varies with the applied voltage.
tuning diode	A voltage-variable-capacitance diode used for rf tuning. This includes functions such as automatic frequency control (AFC) and automatic fine tuning (AFT).

Letter Symbols, Terms, and Definitions

Symbol	Term	Definition
α_C	temperature coefficient of capacitance	The ratio of the change in capacitance to the change in temperature. The ratio is an average value for the total temperature change. (For symbol: Ref USAS Y10.5-1968 Par. 3.6)
C_c	case capacitance	The capacitance between the diode terminals of the case with the semiconductor chip not installed or with the semiconductor chip installed but not connected.
C_j	junction capacitance	The small-signal capacitance between the contacts of an uninstalled semiconductor chip.
C_t	total capacitance	The total small-signal capacitance between the diode terminals of a complete device. ($C_t \approx C_c + C_j$).
$\frac{C_{t1}}{C_{t2}}$	capacitance ratio	The ratio of total capacitance at one voltage to total capacitance at another voltage.
f_{co}	cut-off frequency	The frequency at which the figure of merit Q is equal to 1.
L_s	series inductance	The inductance between specified points on the diode terminals.
η	efficiency	The ratio of output power to input power.
Q	figure of merit	Two pi (2π) times the ratio of the energy stored per cycle to the energy dissipated per cycle.
r_s	series resistance, small-signal	The total small-signal resistance between the diode terminals.
T_J	junction temperature	See page 1-4.

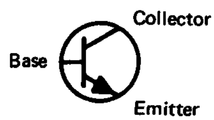
MULTIJUNCTION TRANSISTORS

Terms and Definitions

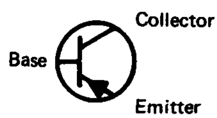
Term	Definition
base (B, b)*	A region which lies between an emitter and a collector of a transistor and into which minority carriers are injected. (Ref. 60 IRE 28.S1)
collector (C, c)*	A region through which a primary flow of charge carriers leaves the base. (Ref. 60 IRE 28.S1)
emitter (E, e)*	A region from which charge carriers that are minority carriers in the base are injected into the base. (Ref. 60 IRE 28.S1)
junction, collector	A semiconductor junction normally biased in the reverse direction, the current through which can be controlled by the introduction of minority carriers into the base. (Ref. 60 IRE 28.S1)
junction, emitter	A semiconductor junction normally biased in the forward direction to inject minority carriers into the base. (Ref. 60 IRE 28.S1)
saturation	A base-current and a collector-current condition resulting in a forward-biased collector junction.
transistor, multijunction	A transistor having a base and two or more junctions. Typical Graphic Symbols: (Ref. ANS Y32.2)

NOTE: In the graphic symbols, the envelope is optional if no element is connected to the envelope.

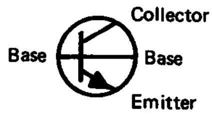
N-P-N TRIODE



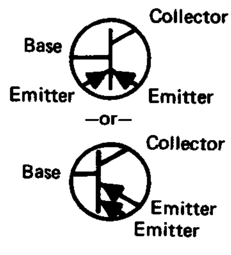
P-N-P TRIODE



N-P-N, DOUBLE-BASE

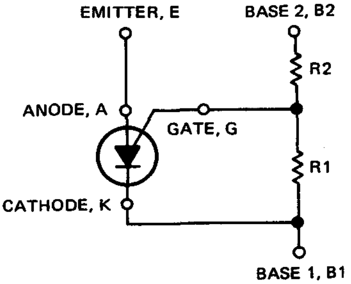


P-N-P DOUBLE-EMITTER



*References to base, collector and emitter symbolism (B, b, C, c, E, and e) refer to the device terminals connected to those regions.

Term	Definition
transistor, programmable unijunction	A P-N-P-N thyristor that, together with two external resistors, can generate a current-voltage characteristic similar to that of a unijunction transistor. The unijunction parameters η, r_{BB}, I_P, and I_V (see pages 1-27 and 1-28) can be varied by selection of the values of the two resistors.



Interbase Resistance $r_{BB} \approx R1+R2$

Intrinsic Standoff Ratio $\eta \approx \frac{R1}{R1+R2}$

PROGRAMMABLE UNIJUNCTION CIRCUIT

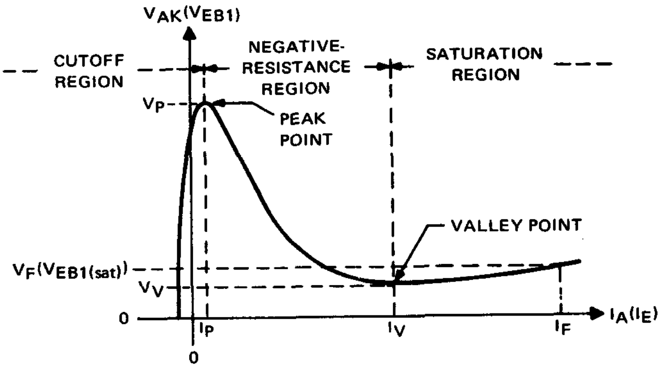


DIAGRAM ILLUSTRATING CURRENT-VOLTAGE CHARACTERISTIC OF THE PROGRAMMABLE UNIJUNCTION CIRCUIT

Letter Symbols, Terms, and Definitions

Symbol	Term	Definition
C_{cb}, C_{ce}, C_{eb}	interterminal capacitance (collector-to-base, collector-to-emitter, emitter-to-base)	The direct interterminal capacitance between the terminal indicated by the first subscript and the reference terminal indicated by the second subscript, with the respective junction (collector-base, collector-emitter, emitter-base) reverse-biased and with the remaining terminal (emitter, base, collector) open-circuited to dc, but ac-connected to the guard terminal of a three-terminal bridge. This capacitance includes the interelement capacitances plus capacitance to the shield where the shield is connected to one of the terminals under measurement.
C_{ibo}, C_{ieo}	open-circuit input capacitance (common-base, common-emitter)	The capacitance measured across the input terminals (emitter and base, base and emitter) with the collector open-circuited for ac. (Ref IEEE 255)
C_{ibs}, C_{ies}	short-circuit input capacitance (common-base, common-emitter)	The capacitance measured across the input terminals (emitter and base, base and emitter) with the collector short-circuited to the reference terminal for ac. (Ref IEEE 255)
C_{obo}, C_{oeo}	open-circuit output capacitance (common-base, common-emitter)	The capacitance measured across the output terminals (collector and base, collector and emitter) with the input open-circuited to ac. (Ref IEEE 255)
C_{obs}, C_{oes}	short-circuit output capacitance (common-base, common-emitter)	The capacitance measured across the output terminals (collector and base, collector and emitter) with the third terminal short-circuited to the reference terminal for ac. (Ref IEEE 255)
C_{rbs}, C_{res}	short-circuit reverse transfer capacitance (common-base, common-emitter)	The capacitance measured from the output terminal to the input terminal with the respective reference terminal (base or emitter) and the case, (unless connected internally to another terminal) connected to the guard terminal of a three-terminal bridge and with the device biased into the active region.
C_{tc}, C_{te}	depletion-layer capacitance (collector, emitter)	The part of the capacitance across the (collector-base, emitter-base) junction that is associated with its depletion layer. NOTE: This capacitance is a function of the total potential difference across the depletion layer. (Ref IEC 147-0 Par. II-4.8, 4.9)

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Symbol	Term	Definition
$\bar{F}$ or F	noise figure, average or spot	See page 1-3.
f_{hfb}, f_{hfe}	small-signal short-circuit forward current transfer ratio cutoff frequency (common-base, common-emitter)	The lowest frequency at which the modulus (magnitude) of the small-signal short-circuit forward current transfer ratio is 0.707 of its value at a specified low frequency (usually 1 kHz or less). (Ref IEEE 255)
f_{max}	maximum frequency of oscillation	The maximum frequency at which a transistor can be made to oscillate under specified conditions. NOTE: This approximates to the frequency at which the maximum available power gain has decreased to unity. (Ref IEC 147-0 Par. II-4.17)
f_T	transition frequency or frequency at which small-signal forward current transfer ratio (common-emitter) extrapolates to unity	The product of the modulus (magnitude) of the common-emitter small-signal short-circuit forward current transfer ratio, $\lvert h_{fe} \rvert$, and the frequency of measurement when this frequency is sufficiently high so that $\lvert h_{fe} \rvert$ is decreasing with a slope of approximately 6 dB per octave. (Ref IEEE 255)
f_1	frequency of unity current transfer ratio	The frequency at which the modulus (magnitude) of the common-emitter small-signal short-circuit forward current transfer ratio, $\lvert h_{fe} \rvert$, has decreased to unity. (Ref IEC 147-0 Par. 11-4.19)
G_{PB}, G_{PE}	large-signal insertion power gain (common-base, common-emitter)	The ratio, usually expressed in dB, of the signal power delivered to the load to the large-signal power delivered to the input.
G_{pb}, G_{pe}	small-signal insertion power gain (common-base, common-emitter)	The ratio, usually expressed in dB, of the signal power delivered to the load to the small-signal power delivered to the input.
G_{TB}, G_{TE}	large-signal transducer power gain (common-base, common-emitter)	The ratio, usually expressed in dB, of the signal power delivered to the load to the maximum large-signal power available from the source.
G_{tb}, G_{te}	small-signal transducer power gain (common-base, common-emitter)	The ratio, usually expressed in dB, of the signal power delivered to the load to the maximum small-signal power available from the source.
h_{FB}, h_{FE}	static forward current transfer ratio (common-base, common-emitter)	The ratio of the dc output current to the dc input current. (Ref MIL-S-19500D Par. 30.28)

Symbol	Term	Definition
h_{fb}, h_{fe}	small-signal short-circuit forward current transfer ratio (common-base, common-emitter)	The ratio of the ac output current to the small-signal ac input current with the output short-circuited to ac. (Ref MIL-S-19500D Par. 30.20)
h_{ib}, h_{ie}	small-signal short-circuit input impedance (common-base, common emitter)	The ratio of the small-signal ac input voltage to the ac input current with the output short-circuited to ac. (Ref MIL-S-19500D Par. 30.24)
$h_{ie(imag)}$ or $Im(h_{ie})$	imaginary part of the small-signal short-circuit input impedance, (common-emitter)	The ratio of the out-of-phase (imaginary) component of the small-signal ac base-emitter voltage to the ac base current with the collector terminal short-circuited to the emitter terminal for ac.
$h_{ie(real)}$ or $Re(h_{ie})$	real part of the small-signal short-circuit input impedance, (common-emitter)	The ratio of the in-phase (real) component of the small-signal ac base-emitter voltage to the ac base current with the collector terminal short-circuited to the emitter terminal for ac.
h_{ob}, h_{oe}	small-signal open-circuit output admittance (common-base, common-emitter)	The ratio of the ac output current to the small-signal ac output voltage applied to the output terminal, with the input open-circuited to ac. (Ref MIL-S-19500D Par. 30.15)
$h_{oe(imag)}$ or $Im(h_{oe})$	imaginary part of the small-signal open-circuit output admittance, (common-emitter)	The ratio of the ac collector current to the out-of-phase (imaginary) component of the small-signal collector-emitter voltage with the base terminal open-circuited to ac.
$h_{oe(real)}$ or $Re(h_{oe})$	real part of the small-signal open-circuit output admittance, (common-emitter)	The ratio of the ac collector current to the in-phase (real) component of the small-signal collector-emitter voltage with the base terminal open-circuited to ac.
h_{rb}, h_{re}	small-signal open-circuit reverse voltage transfer ratio (common-base, common-emitter)	The ratio of the ac input voltage to the small-signal ac output voltage with the input open-circuited to ac. (Ref MIL-S-19500D Par. 30.18)
I_B, I_C, I_E	current, dc (base-terminal, collector-terminal, emitter-terminal)	The value of the dc current into the terminal indicated by the subscript.
I_b, I_c, I_e	current, rms value of alternating component (base-terminal, collector-terminal, emitter-terminal)	The root-mean-square value of alternating current into the terminal indicated by the subscript.

Symbol	Term	Definition
i_B, i_C, i_E	current, instantaneous total value (base-terminal, collector-terminal, emitter-terminal)	The instantaneous total value of current into the terminal indicated by the subscript.

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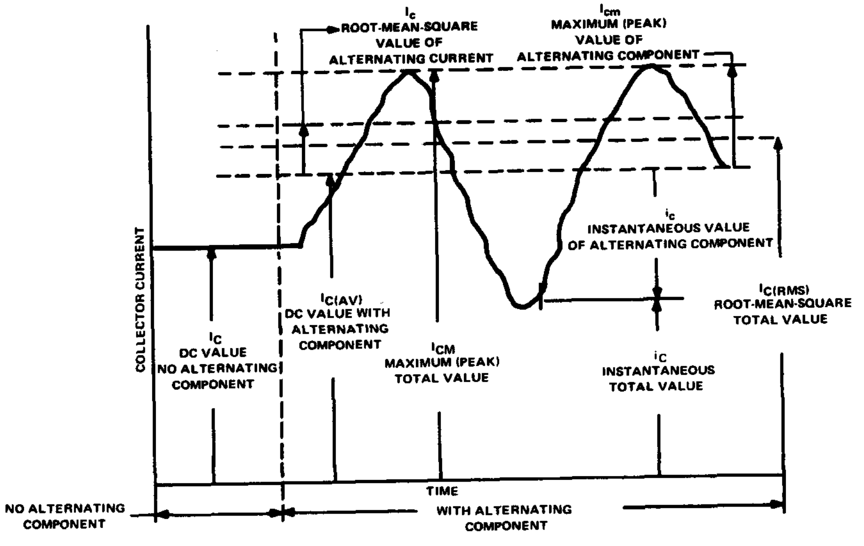

DIAGRAM ILLUSTRATING SYMBOLS AND TERMS FOR CURRENTS (Ref IEEE 255)

I_{BEV}	base cutoff current, dc	The dc current into the base terminal when it is biased in the reverse direction with respect to the emitter terminal and there is a specified voltage between the collector and emitter terminals.
I_{CBO}	collector cutoff current, dc, emitter open	The dc current into the collector terminal when it is biased in the reverse direction with respect to the base terminal and the emitter terminal is open-circuited. (Ref IEEE 255)

Symbol	Term	Definition
I_{CEO},	collector cutoff current, dc, with (base open,	The dc current into the collector terminal when it is biased in the reverse direction* with respect to the emitter terminal and the base terminal is (as indicated by the last subscript letter as follows):
I_{CER},	resistance between base and emitter,	O = open-circuited. R = returned to the emitter terminal through a specified resistance.
I_{CES},	base short-circuited to emitter,	S = short-circuited to the emitter terminal. V = returned to the emitter terminal through a specified voltage.
I_{CEV},	voltage between base and emitter,	X = returned to the emitter terminal through a specified circuit.
I_{CEX}	circuit between base and emitter)	(Ref IEEE 255) *For these parameters, the collector terminal is considered to be biased in the reverse direction when it is made positive for N-P-N transistors or negative for P-N-P transistors with respect to the emitter terminal.
$I_{E1E2(off)}$	emitter cutoff current	The current into the emitter-1 terminal of a double-emitter transistor when the emitter-1 terminal is biased with respect to the emitter-2 terminal and the transistor is in the off state (the collector-base diode is not forward-biased) with specified termination of the collector and base terminals.
I_{EBO}	emitter cutoff current, dc, collector open	The dc current into the emitter terminal when it is biased in the reverse direction with respect to the base terminal and the collector terminal is open-circuited. (Ref IEEE 255)
$I_{EC(ofs)}$	emitter-collector offset current	The external short-circuit current between the emitter and collector when the base-collector diode is reverse biased.
I_{ECS}	emitter cutoff current, dc, base short-circuited to collector	The dc current into the emitter terminal when it is biased in the reverse direction* with respect to the collector terminal and the base terminal is short-circuited to the collector terminal. (Ref IEEE 255) *For this parameter the emitter terminal is considered to be biased in the reverse direction when it is made positive for N-P-N transistors or negative for P-N-P transistors with respect to the collector terminal.
$Im(y_{ie})$		See preferred symbol $y_{ie(imag)}$

GLOSSARY
MULTIJUNCTION TRANSISTORS

Symbol	Term	Definition
$Im(y_{oe})$		See preferred symbol $y_{oe(imag)}$
I_n	noise current, equivalent input	See page 1-3.
$\overline{NF}$ or NF*	noise figure, average or spot	See page 1-3.
P_{IB}, P_{IE}	large-signal input power (common-base, common-emitter)	The product of the large-signal ac input current and voltage with the common reference terminal circuit configuration.
P_{ib}, P_{ie}	small-signal input power (common-base, common-emitter)	The product of the small-signal ac input current and voltage with the common reference terminal circuit configuration.
P_{OB}, P_{OE}	large-signal output power (common-base, common-emitter)	The product of the large-signal ac output current and voltage with the common reference terminal circuit configuration.
P_{ob}, P_{oe}	small-signal output power (common-base, common-emitter)	The product of the small-signal ac output current and voltage with the common reference terminal circuit configuration.
P_T	total nonreactive power input to all terminals	The sum of the products of the dc input currents and voltages, i.e., $V_{BE} \cdot I_B + V_{CE} \cdot I_C$ or $V_{BE} \cdot I_E + V_{CB} \cdot I_C$
$r_{b'}C_c$	collector-base time constant	The product of the intrinsic base resistance and collector capacitance under specified small-signal conditions.
$r_{CE(sat)}$	saturation resistance, collector-to-emitter	The resistance between the collector and emitter terminals for the saturation conditions specified. (Ref IEEE 255)
$Re(y_{ie})$		See preferred symbol $y_{ie(real)}$
$Re(y_{oe})$		See preferred symbol $y_{oe(real)}$
$r_{e1e2(on)}$	small-signal emitter-emitter on-state resistance	The small-signal resistance between the emitter terminals of a double-emitter transistor when the base-collector diode is forward-biased.
R_θ	thermal resistance	See pages 1-2 and 1-3.
s_{fb} or s_{21b}, s_{fe} or s_{21e}	forward transmission coefficient (common-base, common-emitter)	The respective forward or reverse transmission coefficient with the transistor in the indicated configuration. See pages 1-3 and 1-4.
s_{rb} or s_{12b}, s_{re} or s_{12e}	reverse transmission coefficient (common-base, common-emitter)	

*$\overline{NF}$ and NF abbreviations are often used for symbols $\overline{F}$ and F; however, the symbols $\overline{F}$ and F are preferred.

Symbol	Term	Definition
s_{ib} or s_{11b}, s_{ie} or s_{11e}	*input reflection coefficient* (common-base, common-emitter)	*The respective input or output reflection coefficient* with the transistor in the indicated configuration. See page 1-4.
s_{ob} or s_{22b}, s_{oe} or s_{22e}	output reflection coefficient (common-base, common-emitter)	
T_J	junction temperature	See page 1-4.
t_d	delay time	See pages 1-5 and 1-6.
t_f	fall time	See pages 1-5 and 1-6.
t_{off}	turn-off time	The sum of $t_s + t_f$. See pages 1-5 and 1-6.
t_{on}	turn-on time	The sum of $t_d + t_r$. See pages 1-5 and 1-6.
t_p	pulse time	See pages 1-5 and 1-6.
t_r	rise time	See pages 1-5 and 1-6.
t_s	storage time	See pages 1-5 and 1-6.
t_w	pulse average time	See page 1-6.
V_{BB}, V_{CC}, V_{EE}	supply voltage, dc (base, collector, emitter)	The dc supply voltage applied to a circuit connected to the reference terminal.
V_{BC}, V_{BE}, V_{CB}, V_{CE}, V_{EB}, V_{EC}	voltage, dc or average (base-to-collector, base-to-emitter, collector-to-base, collector-to-emitter, emitter-to-base, emitter-to-collector)	The dc voltage between the terminal indicated by the *first subscript and the reference terminal (stated in* terms of the polarity at the terminal indicated by the first subscript).
v_{bc}, v_{be}, v_{cb}, v_{ce}, v_{eb}, v_{ec}	voltage, instantaneous value of alternating component (base-to-collector, base-to-emitter, collector-to-base, collector-to-emitter, emitter-to-base, emitter-to-collector)	The instantaneous value of ac voltage between the terminal indicated by the first subscript and the reference terminal.
$V_{(BR)CBO}$ (formerly BV_{CBO})	breakdown voltage, collector-to-base, emitter open	The breakdown voltage between the collector terminal and the base terminal when the collector terminal is biased in the reverse direction with respect to the base terminal and the emitter terminal is open-circuited. (Ref IEEE 255)

GLOSSARY
MULTIJUNCTION TRANSISTORS

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Symbol	Term	Definition
$V_{(BR)CEO}$ (formerly BV_{CEO}) $V_{(BR)CER}$ (formerly BV_{CER}) $V_{(BR)CES}$ (fromerly BV_{CES}) $V_{(BR)CEV}$ (formerly BV_{CEV}) $V_{(BR)CEX}$ (formerly BV_{CEX})	breakdown voltage, collector-to-emitter with (base open, resistance between base and emitter, base short-circuited to emitter, voltage between base and emitter, circuit between base and emitter)	The breakdown voltage between the collector terminal and the emitter terminal when the collector terminal is biased in the reverse direction* with respect to the emitter terminal and the base terminal is (as indicated by the last subscript letter as follows): O = open-circuited. R = returned to the emitter terminal through a specified resistance. S = short-circuited to the emitter terminal. V = returned to the emitter terminal through a specified voltage. X = returned to the emitter terminal through a specified circuit. (Ref IEEE 255) *For these parameters, the collector terminal is considered to be biased in the reverse direction when it is made positive for N-P-N transistors or negative for P-N-P transistors with respect to the emitter terminal.
$V_{(BR)E1E2}$	emitter-emitter breakdown voltage	The breakdown voltage between the emitter terminals, of a double-emitter transistor, with specified termination between collector and base.
$V_{(BR)EBO}$ (formerly BV_{EBO})	breakdown voltage, emitter-to-base, collector open	The breakdown voltage between the emitter and base terminals when the emitter terminal is biased in the reverse direction with respect to the base terminal and the collector terminal is open-circuited. (Ref IEEE 255)
$V_{(BR)ECO}$ (formerly BV_{ECO})	breakdown voltage, emitter-to-collector, base open	The breakdown voltage between the emitter and collector terminals when the emitter terminal is biased in the reverse direction* with respect to the collector terminal and the base terminal is open-circuited. *For this parameter the emitter terminal is considered to be biased in the reverse direction when it is made positive for N-P-N transistors or negative for P-N-P transistors with respect to the collector terminal.
$V_{CB(fl)}$, $V_{CE(fl)}$, $V_{EB(fl)}$, $V_{EC(fl)}$	dc open-circuit voltage (floating potential) (collector-to-base, collector-to-emitter, emitter-to-base, emitter-to-collector)	The dc open-circuit voltage (floating potential) between the terminal indicated by the first subscript and the reference terminal when the remaining terminal is biased in the reverse direction with respect to the reference terminal. (Ref IEEE 255)

Symbol	Term	Definition
V_{CBO}	collector-to-base voltage, dc, emitter open	The dc voltage between the collector terminal and the base terminal when the emitter terminal is open-circuited.
$V_{CE(ofs)}$	collector-emitter offset voltage	The open-circuit voltage between the collector and emitter terminals when the base-emitter diode is forward-biased.
$V_{CE(sat)}$	saturation voltage, collector-to-emitter	The dc voltage between the collector and the emitter terminals for specified saturation conditions. (Ref IEEE 255)
V_{CEO},	collector-to-emitter voltage, dc, with (base open,	The dc voltage between the collector terminal and the emitter terminal when the base terminal is (as indicated by the last subscript letter as follows): O = open circuited. R = returned to the emitter terminal through a specified resistance. S = short-circuited to the emitter terminal. V = returned to the emitter terminal through a specified voltage. X = returned to the emitter terminal through a specified circuit.
V_{CER},	resistance between base and emitter,	
V_{CES},	base short-circuited to emitter,	
V_{CEV},	voltage between base and emitter,	
V_{CEX}	circuit between base and emitter)	
V_{EBO}	emitter-to-base voltage, dc, collector open	The dc voltage between the emitter terminal and the base terminal with the collector terminal open-circuited.
$V_{EC(ofs)}$	emitter-collector offset voltage	The open-circuit voltage between the emitter and collector when the base-collector diode is forward-biased.
$\|V_{E1E2(ofs)}\|$	magnitude of the emitter-emitter offset voltage	The absolute value of the open-circuit voltage between the two emitters of a double-emitter transistor when the base-collector diode is forward-biased.
$\|\Delta V_{E1E2(ofs)}\|_{\Delta I_B}$	magnitude of the change in offset voltage with base current	The absolute value of the algebraic difference between the emitter-emitter offset voltages of a double-emitter transistor at two specified base currents.
$\|\Delta V_{E1E2(ofs)}\|_{\Delta T_A}$	magnitude of the change in offset voltage with temperature	The absolute value of the algebraic difference between the emitter-emitter offset voltages of a double-emitter transistor at two specified ambient temperatures.
V_n	noise voltage, equivalent input	See page 1-6.

Symbol	Term	Definition
V_{RT}	reach-through (punch-through) voltage	That value of reverse collector-to-base voltage at which the space-charge region of the collector-base junction extends to the space-charge region of the emitter-base junction. (Ref IEEE 255)
y_{fb}, y_{fe}	small-signal short-circuit forward-transfer admittance (common-base, common-emitter)	The ratio of rms output current to rms input voltage with the output short-circuited to ac.
y_{ib}, y_{ie}	small-signal short-circuit input admittance (common-base, common-emitter)	The ratio of rms input current to rms input voltage with the output short-circuited to ac.
$y_{ie(imag)}$ or $Im(y_{ie})$	imaginary part of the small-signal short-circuit input admittance (common-emitter)	The ratio of rms input current to the rms out-of-phase (imaginary) component of the input voltage with the output short-circuited to ac.
$y_{ie(real)}$ or $Re(y_{ie})$	real part of the small-signal short-circuit input admittance (common-emitter)	The ratio of rms input current to the rms in-phase (real) component of the input voltage with the output short-circuited to ac.
y_{ob}, y_{oe}	small-signal short-circuit output admittance (common-base, common-emitter)	The ratio of rms output current to rms output voltage with the input short-circuited to ac.
$y_{oe(imag)}$ or $Im(y_{oe})$	imaginary part of the small-signal short-circuit output admittance (common-emitter)	The ratio of rms output current to the out-of-phase (imaginary) component of the rms output voltage with the input short-circuited to ac.
$y_{oe(real)}$ or $Re(y_{oe})$	real part of the small-signal short-circuit output admittance (common-emitter)	The ratio of rms output current to the in-phase (real) component of the rms output voltage with the input short-circuited to ac.
y_{rb}, y_{re}	small-signal short-circuit reverse transfer admittance (common-base, common-emitter)	The ratio of rms input current to rms output voltage with the input short-circuited to ac.

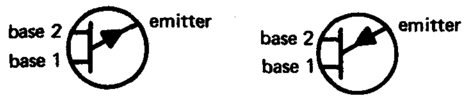
UNIJUNCTION TRANSISTORS

Terms and Definitions

Term	Definition
base (B)*	A region of a semiconductor device into which minority carriers are injected.
emitter (E)*	A region from which charge carriers that are minority carriers in the base are injected into the base. (Ref. 60 IRE 28.S1)
junction, emitter	A semiconductor junction normally biased in the forward direction to inject minority carriers into the base. (Ref 60 IRE 28.S1)
peak point	The point on the emitter current-voltage characteristic corresponding to the lowest current at which $dV_{EB1}/dI_E = 0$.
programmable unijunction transistor	See page 1-16.
valley point	The point on the emitter current-voltage characteristic corresponding to the second lowest current at which $dV_{EB1}/dI_E = 0$.
unijunction transistor	A three-terminal semiconductor device having one junction and a stable negative-resistance characteristic over a wide temperature range.

Graphic symbols for unijunction transistors (Ref. ANS Y32.2):

N-P (P-Type Base) P-N (N-Type Base)



NOTE: In the graphic symbols, the envelope is optional if no element is connected to the envelope.

Letter Symbols, Terms, and Definitions

Symbol	Term	Definition
η	intrinsic standoff ratio	The ratio $(V_P - V_F)/V_{B2B1}$, where V_F is the forward voltage drop of the emitter junction.
$I_{B2(mod)}$	interbase modulated current	The current into the base-2 terminal when the emitter current is greater than the valley-point current.
I_{EB2O}	emitter reverse current	The current into the emitter terminal when it is biased in the reverse direction with respect to the base-2 terminal and the base-1 terminal is open-circuited.
I_P	peak-point current	The emitter current at the peak point.

*Reference to base and emitter symbolism (B, E) refers to the device terminals connected to those regions.

Symbol	Term	Definition
I_V	valley-point current	The emitter current at the valley point.
r_{BB}	interbase resistance	The resistance between the two bases with the emitter current equal to zero.
T_J	junction temperature	See page 1-4.
t_p	pulse time	See pages 1-5 and 1-6.
t_w	pulse average time	See page 1-6.
V_{B2B1}	interbase voltage	The dc voltage between base 2 and base 1.
$V_{EB1(sat)}$	emitter saturation voltage	The forward voltage between the emitter and base 1 at an emitter current greater than the valley-point current.
V_{OB1}	base-1 peak voltage	The peak voltage measured across the resistor in series with base 1 when the device is operated as a relaxation oscillator in a specified circuit.
V_P	peak-point voltage	The voltage between the emitter and base 1 at the peak point.
V_V	valley-point voltage	The voltage between the emitter and base 1 at the valley point.

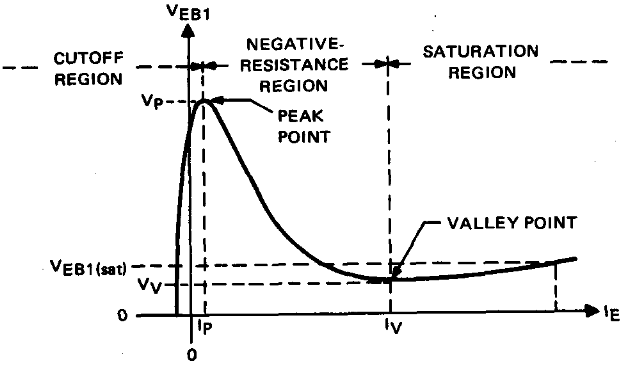


DIAGRAM ILLUSTRATING CURRENT-VOLTAGE CHARACTERISTIC

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FIELD-EFFECT TRANSISTORS

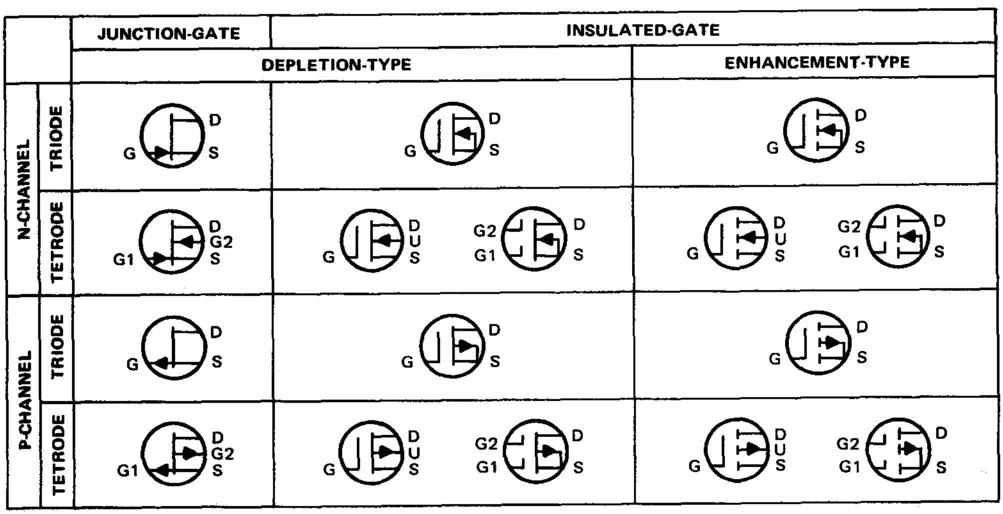
Terms and Definitions

Term	Definition
channel	A region of semiconductor material in which current flow is influenced by a transverse electrical field. A channel may physically be an inversion layer, a diffused layer, or bulk material. The type of channel is determined by the type of majority carriers during conduction; i.e., p-channel or n-channel.
depletion-mode operation	The operation of a field-effect transistor such that changing the gate-source voltage from zero to a finite value decreases the magnitude of the drain current.
depletion-type field-effect transistor	A field-effect transistor having appreciable channel conductivity for zero gate-source voltage; the channel conductivity may be increased or decreased according to the polarity of the applied gate-source voltage.
drain (D, d)	A region into which majority carriers flow from the channel.
dual-gate field-effect transistor	Alternate term for tetrode field-effect transistor.
enhancement-mode operation	The operation of a field-effect transistor such that changing the gate-source voltage from zero to a finite value increases the magnitude of the drain current.
enhancement-type field-effect transistor	A field-effect transistor having substantially zero channel conductivity for zero gate-source voltage; the channel conductivity may be increased by the application of a gate-source voltage of appropriate polarity.
field-effect transistor	A transistor in which the conduction is due entirely to the flow of majority carriers through a conduction channel controlled by an electric field arising from a voltage applied between the gate and source terminals.
gate (G, g)	The electrode associated with the region in which the electric field due to the control voltage is effective.
insulated-gate field-effect transistor	A field-effect transistor having one or more gate electrodes which are electrically insulated from the channel.
junction (junction-gate) field-effect transistor	A field-effect transistor that uses one or more gate regions that form p-n junction(s) with the channel.
metal-oxide-semiconductor (MOS) field-effect transistor	An insulated-gate field-effect transistor in which the insulating layer between each gate electrode and the channel is oxide material.

GLOSSARY
FIELD-EFFECT TRANSISTORS

Term	Definition
n-channel field-effect transistor	A field-effect transistor that has an n-type conduction channel.
p-channel field-effect transistor	A field-effect transistor that has a p-type conduction channel.
source (S, s)	A region from which majority carriers flow into the channel.
substrate (U, u) (of a junction field-effect transistor or an insulated-gate field-effect transistor)	A semiconductor material that contains a channel, a source, and a drain and which may be connected to a terminal.
substrate (of a thin-film field-effect transistor)	An insulating material that supports the thin semiconductor layer, the insulating layer, and the source, gate, and drain electrodes.
tetrode field-effect transistor	A field-effect transistor having two independent gates, a source, and a drain. An active substrate terminated externally and independently of other elements is considered a gate for the purpose of this definition.
triode field-effect transistor	A field-effect transistor having a gate, a source, and a drain.

GRAPHIC SYMBOLS FOR FIELD-EFFECT TRANSISTORS



In the above drawings of the insulated-gate devices, the substrate (bulk) is shown terminated either internally or externally. The symbol at the right illustrates an unterminated (passive) substrate.

PASSIVE SUBSTRATE

Letter Symbols, Terms, and Definitions

Symbol	Term	Definition
b_{fs}, b_{is}, b_{os}, b_{rs}	common-source small-signal (forward transfer, input, output, reverse transfer) susceptance	The imaginary part of the corresponding admittance. See y_{fs}, y_{is}, y_{os}, and y_{rs}. Symbols in the forms b_{xx} and $y_{xx(imag)}$ are equivalent.
C_{ds}	drain-source capacitance	The capacitance between the drain and source terminals with the gate terminal connected to the guard terminal of a three-terminal bridge.
C_{du}	drain-substrate capacitance	The capacitance between the drain and substrate terminals with the gate and source terminals connected to the guard terminal of a three-terminal bridge.
C_{iss}	short-circuit input capacitance, common-source	The capacitance between the input terminals (gate and source) with the drain short-circuited to the source for alternating current. (Ref. IEEE 255)
C_{oss}	short-circuit output capacitance, common-source	The capacitance between the output terminals (drain and source) with the gate short-circuited to the source for alternating current. (Ref. IEEE 255)
C_{rss}	short-circuit reverse transfer capacitance, common-source	The capacitance between the drain and gate terminals with the source connected to the guard terminal of a three-terminal bridge.
$\overline{F}$ or F	noise figure, average or spot	See page 1-3.
g_{fs}, g_{is}, g_{os}, g_{rs}	common-source small-signal (forward transfer, input, output, reverse transfer) conductance	The real part of the corresponding admittance. See y_{fs}, y_{is}, y_{os}, and y_{rs}. Symbols in the forms g_{xx} and $y_{xx(real)}$ are equivalent.
G_{pg}, G_{ps}	small-signal insertion power gain, (common-gate, common-source)	The ratio, usually expressed in dB, of the signal power delivered to the load to the signal power delivered to the input.
G_{tg}, G_{ts}	small-signal transducer power gain (common-gate, common-source)	The ratio, usually expressed in dB, of the signal power delivered to the load to the maximum signal power available from the source.
I_D	drain current, dc	The direct current into the drain terminal.
$I_{D(off)}$	drain cutoff current	The direct current into the drain terminal of a depletion-type transistor with a specified reverse gate-source voltage applied to bias the device to the off state.

GLOSSARY
FIELD-EFFECT TRANSISTORS

Symbol	Term	Definition
$I_{D(on)}$	on-state drain current	The direct current into the drain terminal with a specified forward gate-source voltage applied to bias the device to the on state.
I_{DSS}	zero-gate-voltage drain current	The direct current into the drain terminal when the gate-source voltage is zero. This is an on-state current in a depletion-type device, an off-state current in an enhancement-type device.
I_G	gate current, dc	The direct current into the gate terminal.
I_{GF}	forward gate current	The direct current into the gate terminal with a forward gate-source voltage applied. See V_{GSF}.
I_{GR}	reverse gate current	The direct current into the gate terminal with a reverse gate-source voltage applied. See V_{GSR}.
I_{GSS}	reverse gate current, drain short-circuited to source	The direct current into the gate terminal of a junction-gate field-effect transistor when the gate terminal is reverse-biased with respect to the source terminal and the drain terminal is short-circuited to the source terminal.
I_{GSSF}	forward gate current, drain short-circuited to source	The direct current into the gate terminal of an insulated-gate field-effect transistor with a forward gate-source voltage applied and the drain terminal short-circuited to the source terminal. See V_{GSF}.
I_{GSSR}	reverse gate current, drain short-circuited to source	The direct current into the gate terminal of an insulated-gate field-effect transistor with a reverse gate-source voltage applied and the drain terminal short-circuited to the source terminal. See V_{GSR}.
I_n	noise current, equivalent input	See page 1-3.
$Im(y_{fs})$, $Im(y_{is})$, $Im(y_{os})$, $Im(y_{rs})$		See preferred symbols: b_{fs} or $y_{fs(imag)}$, b_{is} or $y_{is(imag)}$, b_{os} or $y_{os(imag)}$, b_{rs} or $y_{rs(imag)}$
I_S	source current, dc	The direct current into the source terminal.
$I_{S(off)}$	source cutoff current	The direct current into the source terminal of a depletion-type transistor with a specified gate-drain voltage applied to bias the device to the off state.
I_{SDS}	zero-gate-voltage source current	The direct current into the source terminal when the gate-drain voltage is zero. This is an on-state current in a depletion-type device, an off-state current in an enhancement-type device.

Symbol	Term	Definition
$\overline{NF}$ or NF*	noise figure, average or spot	See page 1-3.
$r_{ds(on)}$	small-signal drain-source on-state resistance	The small-signal resistance between the drain and source terminals with a specified gate-source voltage applied to bias the device to the on state. For a depletion-type device, this gate-source voltage may be zero.
$r_{DS(on)}$	static drain-source on-state resistance	The dc resistance between the drain and source terminals with a specified gate-source voltage applied to bias the device to the on state. For a depletion-type device, this gate-source voltage may be zero.
$Re(y_{fs})$, $Re(y_{is})$, $Re(y_{os})$, $Re(y_{rs})$		See preferred symbols: g_{fs} or $y_{fs(real)}$, g_{is} or $y_{is(real)}$, g_{os} or $y_{os(real)}$, g_{rs} or $y_{rs(real)}$
R_{θ}	thermal resistance	See pages 1-2 and 1-3.
s_{fg} or s_{21g}, s_{fs} or s_{21s}	forward transmission coefficient (common-gate, common-source)	The respective forward or reverse transmission coefficient with the transistor in the indicated configuration. See pages 1-3 and 1-4.
s_{rg} or s_{12g}, s_{rs} or s_{12s}	reverse transmission coefficient (common-gate, common-source)	
s_{ig} or s_{11g}, s_{is} or s_{11s}	input reflection coefficient (common-gate, common-source)	The respective input or output reflection coefficient with the transistor in the indicated configuration. See page 1-4.
s_{og} or s_{22g}, s_{os} or s_{22s}	output reflection coefficient (common-gate, common-source)	
T_J	junction temperature	See page 1-4.
$t_{d(off)}$	turn-off delay time	The time interval from a point 90 percent of the maximum amplitude on the trailing edge of the input pulse to a point 90 percent of the maximum amplitude on the trailing edge of the output pulse. This corresponds to storage time for a multijunction transistor. See pages 1-5 and 1-6. NOTE: This definition assumes a device initially in the off state with an input pulse applied of proper polarity to switch the device to the on state.

*$\overline{NF}$ and NF abbreviations are often used for sumbols $\overline{F}$ and F; however, the symbols $\overline{F}$ and F are preferred.

GLOSSARY
FIELD-EFFECT TRANSISTORS

Symbol	Term	Definition
$t_{d(on)}$	turn-on delay time	The time interval from a point 10 percent of the maximum amplitude on the leading edge of the input pulse to a point 10 percent of the maximum amplitude on the leading edge of the output pulse. This corresponds to delay time for a multijunction transistor. See pages 1-5 and 1-6. NOTE: This definition assumes a device initially in the off state with an input pulse applied of proper polarity to switch the device to the on state.
t_f	fall time	See pages 1-5 and 1-6.
t_{off}	turn-off time	The sum of $t_{d(off)} + t_f$. See pages 1-5 and 1-6.
t_{on}	turn-on time	The sum of $t_{d(on)} + t_r$. See pages 1-5 and 1-6.
t_p	pulse time	See pages 1-5 and 1-6.
t_r	rise time	See pages 1-5 and 1-6.
t_w	pulse average time	See page 1-6.
$V_{(BR)GSS}$	gate-source breakdown voltage	The breakdown voltage between the gate and source terminals with the drain terminal short-circuited to the source terminal. NOTE: The symbol $V_{(BR)GSS}$ is primarily used with junction-gate field-effect transistors. The symbols $V_{(BR)GSSR}$ or $V_{(BR)GSSF}$ should be used with insulated-gate transistors having shunting diodes or similar voltage-limiting devices.
$V_{(BR)GSSF}$	forward gate-source breakdown voltage	The breakdown voltage between the gate and source terminals with a forward gate-source voltage applied and the drain terminal short-circuited to the source terminal. See V_{GSF}.
$V_{(BR)GSSR}$	reverse gate-source breakdown voltage	The breakdown voltage between the gate and source terminals with a reverse gate-source voltage applied and the drain terminal short-circuited to the source terminal. See V_{GSR}.
V_{DD}, V_{GG}, V_{SS}	supply voltage, dc (drain, gate, source)	The dc supply voltage applied to a circuit connected to the reference terminal.
V_{DG}	drain-gate voltage	The dc voltage between the drain and gate terminals.
V_{DS}	drain-source voltage	The dc voltage between the drain and source terminals.

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Symbol	Term	Definition
$V_{DS(on)}$	drain-source on-state voltage	The dc voltage between the drain and source terminals with a specified forward gate-source voltage applied to bias the device to the on state.
V_{DU}	drain-substrate voltage	The dc voltage between the drain and substrate terminals.
V_{GS}	gate-source voltage	The dc voltage between the gate and source terminals.
V_{GSF}	forward gate-source voltage	The dc voltage between the gate and source terminals of such polarity that an increase in its magnitude causes the channel resistance to decrease.
V_{GSR}	reverse gate-source voltage	The dc voltage between the gate and source terminals of such polarity that an increase in its magnitude causes the channel resistance to increase.
$V_{GS(off)}$	gate-source cutoff voltage	The reverse gate-source voltage at which the magnitude of the drain current of a depletion-type field-effect transistor has been reduced to a specified low value.
$V_{GS(th)}$	gate-source threshold voltage	The forward gate-source voltage at which the magnitude of the drain current of an enhancement-type field-effect transistor has been increased to a specified low value.
V_{GU}	gate-substrate voltage	The dc voltage between the gate and substrate terminals.
V_n	noise voltage, equivalent input	See page 1-6.
V_{SU}	source-substrate voltage	The dc voltage between the source and substrate terminals.
y_{fs}	common-source small-signal short-circuit forward transfer admittance	The ratio of rms drain current to rms gate-source voltage with the drain terminal ac short-circuited to the source terminal.
y_{is}	common-source small-signal short-circuit input admittance	The ratio of rms gate current to rms gate-source voltage with the drain terminal ac short-circuited to the source terminal.
y_{os}	common-source small-signal short-circuit output admittance	The ratio of rms drain current to rms drain-source voltage with the gate terminal ac short-circuited to the source terminal.

Symbol	Term	Definition
y_{rs}	common-source small-signal short-circuit reverse transfer admittance	The ratio of rms gate current to rms drain-source voltage with the gate terminal ac short-circuited to the source terminal.
$y_{fs(imag)}$, $y_{is(imag)}$, $y_{os(imag)}$, $y_{rs(imag)}$	common-source small-signal (forward transfer, input, output, reverse transfer) susceptance	The imaginary part of the corresponding admittance. See y_{fs}, y_{is}, y_{os}, and y_{rs}. Symbols in the forms $y_{xx(imag)}$ and b_{xx} are equivalent.
$y_{fs(real)}$, $y_{is(real)}$, $y_{os(real)}$, $y_{rs(real)}$	common-source small-signal (forward transfer, input, output, reverse transfer) conductance	The real part of the corresponding admittance. See y_{fs}, y_{is}, y_{os}, and y_{rs}. Symbols in the forms $y_{xx(real)}$ and g_{xx} are equivalent.

SEMICONDUCTOR STANDARDS DOCUMENTS

Following are sources of standards material relating to low-power transistors and diodes:

EIA and JEDEC Standards
Electronic Industries Association
2001 Eye St. N.W.
Washington, D.C. 20006
Telephone: 202-659-2200

Registered Outlines and Gauges for Semiconductor Devices—JEDEC Publication No. 12

Preferred Lead Configurations for Field-Effect Transistors—JEDEC Publication No. 69A

JEDEC Recommendations for Letter Symbols, Abbreviations, Terms, and Definitions for Semiconductor Device Data Sheets and Specifications—JEDEC Publication No. 77

Recommended Practice for Measurement of Transistor Lead Temperature—JEDEC Publication No. 84

Quality Program Requirements for Solid-State Device Manufacturers—JEDEC Publication No. 85

Standard Test Methods for Electronic Component Parts—EIA Standard RS-186-C

Test Methods for the Collector-Base Time Constant and the Resistive Part of the Common-Emitter Input Impedance—EIA Standard RS-284

Forward Transient Measurement on Semiconductor Diodes—EIA Standard RS-286

Measurement of Small-Signal HF, VHF, and UHF Power Gain of Transistors—EIA Standard RS-306

Voltage Regulator Diode Noise Voltage Measurement—EIA Standard RS-307

Measurement of Transistor Noise Figure at MF through VHF—EIA Standard RS-311A

Measurement of Reverse Recovery Time for Semiconductor Diodes—EIA Standard RS-318

Characterization of a Reverse Recovery Test Fixture—EIA Standard RS-318-1

Thermal Equilibrium Conditions for Measurement of Diode Static Parameters—EIA Standard RS-320

Numbering of Electrodes in Multiple Electrode Semiconductor Devices and Designation of Units in Multiple Unit Semiconductor Devices—EIA Standard RS-321A

The Measurement of $|C_{re}|$—EIA Standard RS-340

The Measurement of Transistor Noise Figure at Frequencies up to 20 kHz by Sinusoidal Signal-Generator Method—EIA Standard RS-353

Measurement of Transistor Equivalent Noise Voltage and Equivalent Noise Current at Frequencies up to 20 kHz—EIA Standard RS-354

Designation System for Discrete Semiconductor Devices—EIA Standard RS-370

The Measurement of Small-Signal VHF-UHF Transistor Short-Circuit Forward Current Transfer Ratio—EIA Standard RS-371

The Measurement of Small-Signal VHF-UHF Transistor Admittance Parameters—EIA Standard RS-372

Method of Diode "Q" Measurement—EIA Standard RS-381

Measurement of Small Values of Transistor Capacitance—EIA Standard RS-398

Method of Direct Measurement of Diode Stored Charge—JEDEC Suggested Standard No. 1

The Measurement of Small-Signal Transistor Scattering Parameters—JEDEC Tentative Standard No. 10

International Electrotechnical Commission (IEC) Standards
American National Standards Institute, Inc.
1430 Broadway
New York, N.Y. 10018
Telephone: 212-868-1220

1

Publication 147: Essential Ratings and Characteristics of Semiconductor Devices and General Principles of Measuring Methods.

Part 0 – General and Terminology
Part 1 – Essential Ratings and Characteristics
Part 2 – General Principles of Measuring Methods
Part 3 – Reference Methods of Measurement

Publication 148: Letter Symbols for Semiconductor Devices and Integrated Microcircuits

Publication 191: Mechanical Standardization of Semiconductor Devices

Military Standards
Commanding Officer
U.S. Naval Publications and Forms Center
5801 Tabor Avenue
Philadelphia, Pa. 19120

MIL-S-19500: Semiconductor Devices, General Specification for

MIL-STD-105: Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-202: Test Methods for Electronic and Electrical Component Parts

MIL-STD-750: Test Methods for Semiconductor Devices

MIL-STD-883: Test Methods and Procedures for Microelectronics

Transistor Selection Guides

TRANSISTOR SELECTION GUIDES

These guides are arrayed into families according to transistor structure and applications. These families are:

FAMILY GUIDE

		Page
N-P-N	Low-Level Amplifiers	2-1
P-N-P	Low-Level Amplifiers	2-2
N-P-N	High-Voltage Amplifiers	2-3
P-N-P	High-Voltage Amplifiers	2-3
N-P-N	High-Frequency Amplifiers	2-4
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JFET	N-Channel Low-Frequency, Low-Noise Amplifiers	2-14
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JFET	N-Channel General Purpose Amplifiers	2-15
JFET	P-Channel General Purpose Amplifiers	2-15
JFET	High-Frequency Amplifiers	2-16
IGFET	High-Frequency Amplifiers	2-16
JFET	N-Channel Switches and Choppers	2-17
JFET	P-Channel Switches and Choppers	2-17
IGFET	N-Channel Switches and Choppers	2-18
IGFET	P-Channel Switches and Choppers	2-18
JFET	Duals	2-18
IGFET	Duals	2-18
Unijunction, Conventional		2-19
Unijunction, Programmable		2-19

The tabular entries within these families are not made on the usual manner of increasing type number, which would have little inherent utility, but rather are ranked by the most-significant electrical characteristic of that family. Where there is more than one transistor type having the identical primary characteristic, the types within that group are further ranked by a secondary characteristic, and so on.

This form of organization works most efficiently when the user's selection criteria coincides with the organizational lay-out, but should not present undue difficulties if it does not.

It should be noted that the entries are nonexclusive; that is a transistor type may appear in more than one family if its specifications so dictate.

Grown-junction transistors and certain other types not recommended for new design do not appear in these guides.

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N-P-N LOW-LEVEL AMPLIFIERS

h_{FE} @ I_C	h_{FE} MIN-MAX	$V_{(BR)CEO}$ MIN	NOISE FIGURE F @ f $\overline{F}$ (NOISE BW) MAX	DEVICE TYPE	PACKAGE*	CHIP
10 μA	30-	30 V		2N4138	TO-46	N18
10 μA	30-	30 V		2N2432	TO-18	N18
10 μA	30-	45 V		2N2432A	TO-18	N18
10 μA	40-120	45 V	$\overline{4\text{ dB}}$ (15.7 kHz)	2N929	TO-18	N11
10 μA	40-120	60 V	4 dB @ 1 kHz	2N2483	TO-18	N11
10 μA	100-300	45 V	$\overline{3\text{ dB}}$ (15.7 kHz)	2N930	TO-18	N11
10 μA	100-500	60 V	3 dB @ 1 kHz	2N2484	TO-18	N11
10 μA	120-360	45 V		2N2586	TO-18	N11
10 μA	250-500	60 V	15 dB @ 10 Hz	2N3117	TO-18	N11
10 μA	400-800	60 V	15 dB @ 10 Hz	2N4104	TO-18	N11
100 μA	100-300	50 V	$\overline{3\text{ dB}}$ (15.7 kHz)	2N5209	TO-92	N21
100 μA	100-300	50 V	$\overline{3\text{ dB}}$ (15.7 kHz)	A5T5209	AAA	N21
100 μA	100-400	30 V	$\overline{5\text{ dB}}$ (15.7 kHz)	A8T3707	TO-92	N21
100 μA	100-400	30 V	$\overline{5\text{ dB}}$ (15.7 kHz)	2N3707	TO-92	N21
100 μA	100-400	30 V	$\overline{5\text{ dB}}$ (15.7 kHz)	A5T3707	AAA	N21
100 μA	200-600	50 V	$\overline{2\text{ dB}}$ (15.7 kHz)	2N5210	TO-92	N21
100 μA	200-600	50 V	$\overline{2\text{ dB}}$ (15.7 kHz)	A5T5210	AAA	N21
100 μA	250-700	40 V	2 dB @ 1 kHz	TIS94	TO-92	N21
100 μA	250-700	40 V	2 dB @ 1 kHz	TIS97	AAA	N21
1 mA	45-165	30 V		A8T3709	TO-92	N21
1 mA	45-165	30 V		2N3709	TO-92	N21
1 mA	45-165	30 V		A5T3709	AAA	N21
1 mA	45-660	30 V		A8T3708	TO-92	N21
1 mA	45-660	30 V		2N3708	TO-92	N21
1 mA	45-660	30 V		A5T3708	AAA	N21
1 mA	90-330	30 V		A8T3710	TO-92	N21
1 mA	90-330	30 V		2N3710	TO-92	N21
1 mA	90-330	30 V		A5T3710	AAA	N21
1 mA	100-300	60 V		TIS95	TO-92	N21
1 mA	100-300	60 V		TIS98	AAA	N21
1 mA	150-600	25 V		A5T3565	AAA	N21
1 mA	180-660	30 V		A8T3711	TO-92	N21
1 mA	180-660	30 V		2N3711	TO-92	N21
1 mA	180-660	30 V		A5T3711	AAA	N21
2 mA	35-500	15 V		2N5219	TO-92	N21
2 mA	35-500	15 V		A5T5219	AAA	N21
2 mA	50-800	20 V		2N5223	TO-92	N21
2 mA	50-800	20 V		A5T5223	AAA	N21
2 mA	150-300	25 V		A5T3392	AAA	N21
2 mA	150-300	25 V		A7T3392	TO-92	N21
2 mA	150-300	25 V		A8T3392	TO-92	N21
2 mA	250-500	25 V		A5T3391	AAA	N21
2 mA	250-500	25 V	$\overline{5\text{ dB}}$ (15.7 kHz)	A5T3391A	AAA	N21
2 mA	250-500	25 V		A7T3391	TO-92	N21
2 mA	250-500	25 V	$\overline{5\text{ dB}}$ (15.7 kHz)	A7T3391A	TO-92	N21
2 mA	250-500	25 V		A8T3391	TO-92	N21
2 mA	250-500	25 V	$\overline{5\text{ dB}}$ (15.7 kHz)	A8T3391A	TO-92	N21
100 mA	55-300	65 V		TIS96	TO-92	N21
100 mA	55-300	65 V		TIS99	AAA	N21

*See page 2-20.

P-N-P LOW-LEVEL AMPLIFIERS

@ I_C	h_{FE} MIN-MAX	$V_{(BR)CEO}$ MIN	NOISE FIGURE F @ f $\overline{F}$ (NOISE BW) MAX	DEVICE TYPE	PACKAGE*	CHIP
10 μA	40-120	45 V	$\overline{\text{4 dB}}$ (15.7 kHz)	A5T2604	AAA	P19
10 μA	40-120	45 V	$\overline{\text{4 dB}}$ (15.7 kHz)	2N2604	TO-46	P19
10 μA	100-300	45 V	$\overline{\text{3 dB}}$ (15.7 kHz)	A5T2605	AAA	P19
10 μA	100-300	45 V	$\overline{\text{3 dB}}$ (15.7 kHz)	2N2605	TO-46	P19
10 μA	100-300	60 V	3 dB @ 1 kHz	2N3962	TO-18	P18
10 μA	100-300	80 V	3 dB @ 1 kHz	2N3963	TO-18	P18
10 μA	100-400	30 V	$\overline{\text{5 dB}}$ (15.7 kHz)	2N4058	TO-92	P18
10 μA	100-400	30 V	$\overline{\text{5 dB}}$ (15.7 kHz)	A5T4058	AAA	P18
10 μA	250-500	45 V	2 dB @ 1 kHz	2N3964	TO-18	P18
10 μA	250-500	60 V	2 dB @ 1 kHz	2N3965	TO-18	P18
100 μA	50-	40 V		A5T4248	AAA	P18
100 μA	100-300	60 V	3 dB @ 1 kHz	A5T4249	AAA	P18
100 μA	100-400	30 V	$\overline{\text{5 dB}}$ (15.7 kHz)	A8T4058	TO-92	P18
100 μA	150-500	50 V	3 dB @ 1 kHz	2N5086	TO-92	P18
100 μA	150-500	50 V	3 dB @ 1 kHz	A5T5086	AAA	P18
100 μA	250-700	40 V	2 dB @ 1 kHz	A5T4250	AAA	P18
100 μA	250-800	50 V	2 dB @ 1 kHz	2N5087	TO-92	P18
100 μA	250-800	50 V	2 dB @ 1 kHz	A5T5087	AAA	P18
500 μA	150-450	60 V	3 dB @ 1 kHz	2N3798	TO-18	P19
500 μA	300-900	60 V	1.5 dB @ 1 kHz	2N3799	TO-18	P19
1 mA	25-	32 V		TIS38	TO-92	P24
1 mA	25-	32 V		TIS138	AAA	P24
1 mA	30-	35 V		2N2946	TO-46	P14
1 mA	40-	20 V		2N2945	TO-46	P14
1 mA	45-	32 V	2.5 dB typ @ 1 MHz	TIS37	TO-92	P24
1 mA	45-	32 V	2.5 dB typ @ 1 MHz	TIS137	AAA	P24
1 mA	45-165	30 V		A8T4060	TO-92	P18
1 mA	45-165	30 V		2N4060	TO-92	P18
1 mA	45-165	30 V		A5T4060	AAA	P18
1 mA	45-660	30 V		A8T4059	TO-92	P18
1 mA	45-660	30 V		2N4059	TO-92	P18
1 mA	45-660	30 V		A5T4059	AAA	P18
1 mA	50-	35 V		2N2946A	TO-46	P14
1 mA	70-	20 V		2N2945A	TO-46	P14
1 mA	80-	10 V		2N2944	TO-46	P14
1 mA	90-330	30 V		A8T4061	TO-92	P18
1 mA	90-330	30 V		2N4061	TO-92	P18
1 mA	90-330	30 V		A5T4061	AAA	P18
1 mA	100-	10 V		2N2944A	TO-46	P14
1 mA	180-660	30 V		A8T4062	TO-92	P18
1 mA	180-660	30 V		2N4062	TO-92	P18
1 mA	180-660	30 V		A5T4062	AAA	P18
2 mA	50-700	30 V		A5T5227	AAA	P18
2 mA	50-700	30 V		2N5227	TO-92	P18
12 mA	30-400	24 V		A8T404	TO-92	P14
12 mA	30-400	35 V		A8T404A	TO-92	P14
12 mA	30-400	24 V		A5T404	AAA	P14
12 mA	30-400	35 V		A5T404A	AAA	P14

*See package drawings on page 2-20.

N-P-N HIGH-VOLTAGE AMPLIFIERS

$V_{(BR)CEO}$ MIN	h_{FE} @ I_C	h_{FE} MIN-MAX	DEVICE TYPE	PACKAGE*	CHIP
140 V	1 mA	60-	2N5550	TO-92	N27
140 V	1 mA	60-	A5T5550	AAA	N27
150 V	30 mA	30-120	2N3114	TO-39	N15
150 V	25 mA	30-	TIS101	AAA	N27
160 V	1 mA	80-	2N5551	TO-92	N27
160 V	1 mA	80-	A5T5551	AAA	N27
180 V	25 mA	30-	TIS100	AAA	N27
250 V	30 mA	30-150	A5T5059	AAA	N15
250 V	30 mA	30-150	2N5059	TO-39	N15
300 V	30 mA	35-150	A5T5058	AAA	N15
300 V	30 mA	35-150	2N5058	TO-39	N15

P-N-P HIGH-VOLTAGE AMPLIFIERS

$V_{(BR)CEO}$ MIN	h_{FE} @ I_C	h_{FE} MIN-MAX	DEVICE TYPE	PACKAGE*	CHIP
80 V	1 mA	40-	2N3494	TO-5	P17
80 V	1 mA	40-	A5T3496	AAA	P17
80 V	1 mA	40-	2N3496	TO-18	P17
120 V	1 mA	40-	2N3495	TO-5	P17
120 V	1 mA	40-	A5T3497	AAA	P17
120 V	1 mA	40-	2N3497	TO-18	P17
120 V	10 mA	40-180	A5T5400	AAA	P22
120 V	10 mA	40-180	2N5400	TO-92	P22
140 V	50 mA	50-150	2N3634	TO-39	P22
140 V	50 mA	100-300	2N3635	TO-39	P22
150 V	10 mA	60-240	A5T5401	AAA	P22
150 V	10 mA	60-240	2N5401	TO-92	P22
175 V	50 mA	50-150	2N3636	TO-39	P22
175 V	50 mA	100-300	2N3637	TO-39	P22

*See package drawings on page 2-20.

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N-P-N HIGH-FREQUENCY AMPLIFIERS

f_T MIN	$V_{(BR)CEO}$ MIN	CAPACITANCE PARAMETER	CAPACITANCE MAX	DEVICE TYPE	PACKAGE*	CHIP
500 MHz	12 V	Ccb	1.3 pF	TIS64A	AAA	N22
300 MHz	45 V	Ccb	1 pF	TIS105	AAA	N20
350 MHz	30 V	Cres	0.4 pF	TIS84	AAA	N17
350 MHz	30 V	Cres	0.4 pF	TIS108	AAA	N17
500 MHz	12 V	Ccb	1.3 pF	TIS63A	AAA	N22
450 MHz	30 V	Cce	0.3 pF	TIS125	AAA	N26
450 MHz	15 V	Ccb	1.3 pF	2N5222	TO-92	N24
450 MHz	15 V	Ccb	1.3 pF	A6T5222	AAA	N24
500 MHz	12 V	C_{cb}	1.3 pF	TIS62A	AAA	N22
500 MHz	30 V	Cres	0.45 pF	TIS86	AAA	N16
500 MHz	45 V	Cres	0.45 pF	TIS87	AAA	N16
500 MHz	15 V	Cobo	1.7 pF	2N917	TO-72	N22
600 MHz	15 V	Cobo	1.7 pF	2N918	TO-72	N22
600 MHz	18 V	Ccb	0.45 pF	2N4252	TO-72	N16
600 MHz	18 V	Ccb	0.45 pF	2N4253	TO-72	N16
600 MHz	18 V	Ccb	0.65 pF	2N4996	AAA	N16
600 MHz	18 V	Ccb	0.65 pF	2N4997	AAA	N16
600 MHz	40 V	Ccb	0.36 pF	TIS126	AAA	N29
800 MHz	25 V	C_{cb}	0.8 pF	TIS129	AAA	N30
1000 MHz	13 V	Ccb	0.85 pF	A5T3572	AAA	N28
1000 MHz	13 V	Ccb	0.85 pF	2N3572	TO-72	N28
1200 MHz	15 V	Ccb	0.85 pF	A5T3571	AAA	N28
1200 MHz	15 V	Ccb	0.85 pF	2N3571	TO-72	N28
1500 MHz	15 V	Ccb	0.75 pF	2N3570	TO-72	N28

P-N-P HIGH-FREQUENCY AMPLIFIERS

f_T MIN	$V_{(BR)CEO}$ MIN	CAPACITANCE PARAMETER	CAPACITANCE MAX	DEVICE TYPE	PACKAGE*	CHIP
50 MHz	32 V	Ccb	1.7 pF	TIS38	TO-92	P24
50 MHz	32 V	Ccb	1.7 pF	TIS138	AAA	P24
80 MHz	32 V	Ccb	1.7 pF	TIS37	TO-92	P24
80 MHz	32 V	Ccb	1.7 pF	TIS137	AAA	P24
650 MHz	45 V	C_{ce}	0.3 pF	TIS128	AAA	P25
1600 MHz	15 V	Ccb	2.5 pF	2N4260	TO-72	P27
1600 MHz	15 V	Ccb	2.5 pF	A5T4260	AAA	P27
2000 MHz	15 V	Ccb	2.5 pF	2N4261	TO-72	P27
2000 MHz	15 V	Ccb	2.5 pF	A5T4261	AAA	P27

*See package drawings on page 2-20.

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N-P-N GENERAL PURPOSE

$V_{(BR)CEO}$ MIN	h_{FE} @ I_C	h_{FE} MIN-MAX	f_T MIN	DEVICE TYPE	PACKAGE*	CHIP
15 V	50 mA	30-600	100 MHz	2N5220	TO-92	N24
15 V	50 mA	30-600	100 MHz	A5T5220	AAA	N24
20 V	50 mA	30-600	100 MHz	A8T3706	TO-92	N24
20 V	50 mA	30-600	100 MHz	2N3706	TO-92	N24
20 V	50 mA	30-600	100 MHz	2N5451	AAA	N24
25 V	1 mA	150-600	40 MHz	A5T3565	AAA	N21
25 V	2 mA	120-360	300 MHz	A5T4124	AAA	N14
25 V	2 mA	120-360	300 MHz	2N4124	TO-92	N14
25 V	2 mA	150-300		A5T3392	AAA	N21
25 V	2 mA	150-300		A7T3392	TO-92	N21
25 V	2 mA	150-300		A8T3392	TO-92	N21
25 V	2 mA	250-500		A5T3391	AAA	N21
25 V	2 mA	250-500		A5T3391A	AAA	N21
25 V	2 mA	250-500		A7T3391	TO-92	N21
25 V	2 mA	250-500		A7T3391A	TO-92	N21
25 V	2 mA	250-500		A8T3391	TO-92	N21
25 V	2 mA	250-500		A8T3391A	TO-92	N21
25 V	10 mA	100-500		A5T5172	AAA	N21
25 V	10 mA	100-500		A7T5172	TO-92	N21
25 V	10 mA	100-500		A8T5172	TO-92	N21
25 V	50 mA	30-600	50 MHz	2N5225	TO-92	N24
25 V	50 mA	30-600	50 MHz	A5T5225	AAA	N24
30 V	2 mA	50-150	250 MHz	A5T4123	AAA	N14
30 V	2 mA	50-150	250 MHz	2N4123	TO-92	N14
30 V	10 mA	1000-	200 MHz	2N5526	TO-92	N21
30 V	10 mA	5000-	200 MHz	2N5525	TO-92	N21
30 V	50 mA	50-150	100 MHz	A8T3705	TO-92	N24
30 V	50 mA	50-150	100 MHz	2N3705	TO-92	N24
30 V	50 mA	50-150	100 MHz	2N5450	AAA	N24
30 V	50 mA	100-300	100 MHz	A8T3704	TO-92	N24
30 V	50 mA	100-300	100 MHz	2N3704	TO-92	N24
30 V	50 mA	100-300	100 MHz	2N5449	AAA	N24
30 V	150 mA	20-60	250 MHz	2N2217	TO-5	N24
30 V	150 mA	20-60	250 MHz	2N2220	TO-18	N24
30 V	150 mA	40-120	250 MHz	2N2218	TO-5	N24
30 V	150 mA	40-120	250 MHz	2N2221	TO-18	N24
30 V	150 mA	100-400	250 MHz	TIS109	AAA	N24
30 V†	150 mA	100-300	70 MHz	2N956	TO-18	N24
30 V	150 mA	100-300	50 MHz	2N1420	TO-5	N24
30 V	150 mA	100-300	50 MHz	2N1507	TO-5	N24
30 V	150 mA	100-300	250 MHz	2N2219	TO-5	N24
30 V	150 mA	100-300	250 MHz	Q2T2222	TO-116	N24
30 V	150 mA	100-300	250 MHz	A5T2222	AAA	N24
30 V	150 mA	100-300	250 MHz	2N2222	TO-18	N24
40 V	100 μA	250-700	200 MHz	TIS94	TO-92	N21
40 V	100 μA	250-700	200 MHz	TIS97	AAA	N21
40 V	10 mA	50-150	250 MHz	A5T3903	AAA	N14
40 V	10 mA	50-150	250 MHz	2N3903	TO-92	N14
40 V	10 mA	100-300	300 MHz	A5T3904	AAA	N14

*See package drawings on page 2-20. †$V_{(BR)CEO}$ approximated from $V_{(BR)CER}$.

N-P-N GENERAL PURPOSE (Continued)

$V_{(BR)CEO}$ MIN	h_{FE} @ I_C	h_{FE} MIN-MAX	f_T MIN	DEVICE TYPE	PACKAGE*	CHIP
40 V	10 mA	100-300	300 MHz	2N3904	TO-92	N14
40 V	50 mA	100-300		TIS90	TO-92	N24
40 V	50 mA	100-300		TIS92	AAA	N24
40 V	100 mA	7000-70,000		2N997	TO-18	N23
40 V	150 mA	20-60	40 MHz	2N696	TO-5	N24
40 V‡	150 mA	20-60	40 MHz	2N717	TO-18	N24
40 V	150 mA	20-60	40 MHz	2N730	TO-18	N24
40 V	150 mA	20-60	50 MHz	2N2194	TO-39	N23
40 V	150 mA	20-60	50 MHz	2N2194A	TO-39	N23
40 V‡	150 mA	40-120	50 MHz	2N697	TO-5	N24
40 V‡	150 mA	40-120	50 MHz	2N718	TO-18	N24
40 V†	150 mA	40-120	60 MHz	2N718A	TO-18	N24
40 V	150 mA	40-120	50 MHz	2N731	TO-18	N24
40 V†	150 mA	40-120	60 MHz	2N1613	TO-5	N24
40 V	150 mA	40-120	250 MHz	2N2218A	TO-5	N24
40 V	150 mA	40-120	250 MHz	2N2221A	TO-18	N24
40 V	150 mA	50-150	200 MHz	TIS110	AAA	N24
40 V	150 mA	50-250	100 MHz	2N3053	TO-39	N13
40 V	150 mA	100-300	250 MHz	TIS111	AAA	N24
40 V†	150 mA	100-300	70 MHz	2N1711	TO-5	N24
40 V	150 mA	100-300	50 MHz	A5T2192	AAA	N23
40 V	150 mA	100-300	50 MHz	2N2192	TO-39	N23
40 V	150 mA	100-300	50 MHz	2N2192A	TO-39	N23
40 V	150 mA	100-300	300 MHz	2N2219A	TO-5	N24
40 V	150 mA	100-300	300 MHz	2N2222A	TO-18	N24
45 V	150 mA	50-200	100 MHz	2N2270	TO-39	N23
50 V	10 mA	60-400	60 MHz	2N4409	TO-92	N23
50 V	10 mA	60-400	60 MHz	A5T4409	AAA	N23
50 V	150 mA	40-120	50 MHz	A5T2193	AAA	N23
50 V	150 mA	40-120	50 MHz	2N2193	TO-39	N23
50 V	150 mA	40-120	50 MHz	2N2193A	TO-39	N23
60 V	1 mA	100-300	200 MHz	TIS95	TO-92	N21
60 V	1 mA	100-300	200 MHz	TIS98	AAA	N21
60 V	5 mA	60-200	60 MHz	2N1566	TO-39	N23
60 V	10 mA	15-	40 MHz	2N1975	TO-39	N23
60 V	10 mA	15-	40 MHz	2N912	TO-18	N23
60 V	10 mA	35-	50 MHz	2N911	TO-18	N23
60 V	10 mA	35-	50 MHz	2N1974	TO-39	N23
60 V	10 mA	75-	60 MHz	2N910	TO-18	N23
60 V	10 mA	75-	60 MHz	2N1973	TO-39	N23
60 V	10 mA	1600-8000		2N998	TO-72	N23
60 V	100 mA	7000-70,000		2N999	TO-72	N23
60 V	150 mA	20-60	40 MHz	2N698	TO-39	N23
60 V†	150 mA	20-60	40 MHz	2N719	TO-18	N23
60 V	150 mA	20-60	40 MHz	2N719A	TO-18	N23
60 V†	150 mA	40-120	50 MHz	2N699	TO-39	N23
60 V†	150 mA	40-120	50 MHz	2N720	TO-18	N23
60 V	150 mA	40-120	50 MHz	2N870	TO-18	N23

*See package drawings on page 2-20. †$V_{(BR)CEO}$ approximated from $V_{(BR)CER}$. ‡$V_{(BR)CER}$

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N-P-N GENERAL PURPOSE (Continued)

$V_{(BR)CEO}$ MIN	h_{FE} @ I_C	h_{FE} MIN-MAX	f_T MIN	DEVICE TYPE	PACKAGE*	CHIP
60 V	150 mA	40-120	50 MHz	2N1889	TO-39	N23
60 V	150 mA	100-300	60 MHz	2N871	TO-18	N23
60 V	150 mA	100-300	60 MHz	2N1890	TO-39	N23
65 V	150 mA	40-120	60 MHz	2N2102	TO-39	N23
65 V	150 mA	40-120	60 MHz	2N2102A	TO-39	N23
65 V	100 mA	55-300	200 MHz	TIS96	TO-92	N21
65 V	100 mA	55-300	200 MHz	TIS99	AAA	N21
80 V	10 mA	60-400	60 MHz	2N4410	TO-92	N23
80 V	10 mA	60-400	60 MHz	A5T4410	AAA	N23
80 V	150 mA	40-120	50 MHz	2N720A	TO-18	N23
80 V	150 mA	40-120	50 MHz	2N1893	TO-39	N23
80 V	150 mA	40-120	50 MHz	A5T2243	AAA	N23
80 V	150 mA	40-120	50 MHz	2N2243	TO-39	N23
80 V	150 mA	40-120	50 MHz	2N2243A	TO-39	N23
80 V	150 mA	50-150	50 MHz	2N3036	TO-39	N23

P-N-P GENERAL PURPOSE

$V_{(BR)CEO}$ MIN	h_{FE} @ I_C	h_{FE} MIN-MAX	f_T MIN	DEVICE TYPE	PACKAGE*	CHIP
15 V	50 mA	30-600	100 MHz	A5T5221	AAA	P20
15 V	50 mA	30-600	100 MHz	2N5221	TO-92	P20
25 V	2 mA	120-360	250 MHz	2N4126	TO-92	P15
25 V	2 mA	120-360	250 MHz	A5T4126	AAA	P15
25 V	50 mA	30-	100 MHz	A5T3638	AAA	P20
25 V	50 mA	30-600	50 MHz	2N5226	TO-92	P20
25 V	50 mA	30-600	50 MHz	A5T5226	AAA	P20
25 V	50 mA	60-300	100 MHz	2N3702	TO-92	P20
25 V	50 mA	60-300	100 MHz	A8T3702	TO-92	P20
25 V	50 mA	60-300	100 MHz	2N5447	AAA	P20
25 V	50 mA	100-	150 MHz	A5T3638A	AAA	P20
30 V	2 mA	50-150	200 MHz	A5T4125	AAA	P15
30 V	2 mA	50-150	200 MHz	2N4125	TO-92	P15
30 V	50 mA	30-150	100 MHz	2N3703	TO-92	P20
30 V	50 mA	30-150	100 MHz	A8T3703	TO-92	P20
30 V	50 mA	30-150	100 MHz	2N5448	AAA	P20
35 V	150 mA	20-45	50 MHz	2N721	TO-18	P20
35 V	150 mA	20-45	50 MHz	2N1131	TO-39	P20
35 V	150 mA	30-90	60 MHz	2N722	TO-18	P20
35 V	150 mA	30-90	60 MHz	2N1132	TO-39	P20
35 V	150 mA	75-200	60 MHz	2N2303	TO-5	P20
40 V	10 mA	50-150	250 MHz	2N3250	TO-18	P23
40 V	10 mA	50-150	200 MHz	A5T3905	AAA	P15
40 V	10 mA	50-150	200 MHz	2N3905	TO-92	P15
40 V	10 mA	100-300	300 MHz	2N3251	TO-18	P23
40 V	10 mA	100-300	250 MHz	A5T3906	AAA	P15
40 V	10 mA	100-300	250 MHz	2N3906	TO-92	P15
40 V	50 mA	100-300		TIS91	TO-92	P20
40 V	50 mA	100-300		TIS93	AAA	P20

*See package drawings on page 2-20.

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P-N-P GENERAL PURPOSE (Continued)

$V_{(BR)CEO}$ MIN	h_{FE} @ I_C	h_{FE} MIN-MAX	f_T MIN	DEVICE TYPE	PACKAGE*	CHIP
40 V	150 mA	40-120	200 MHz	2N2904	TO-5	P20
40 V	150 mA	40-120	200 MHz	2N2906	TO-18	P20
40 V	150 mA	40-120	200 MHz	2N3485	TO-46	P20
40 V	150 mA	50-150	150 MHz	A5T4402	AAA	P20
40 V	150 mA	50-150	150 MHz	2N4402	TO-92	P20
40 V	150 mA	100-300	200 MHz	TIS112	AAA	P20
40 V	150 mA	100-300	200 MHz	Q2T2905	TO-116	P20
40 V	150 mA	100-300	200 MHz	2N2905	TO-5	P20
40 V	150 mA	100-300	200 MHz	A5T2907	AAA	P20
40 V	150 mA	100-300	200 MHz	2N2907	TO-18	P20
40 V	150 mA	100-300	200 MHz	2N3486	TO-46	P20
40 V	150 mA	100-300	200 MHz	A5T4403	AAA	P20
40 V	150 mA	100-300	200 MHz	2N4403	TO-92	P20
45 V	150 mA	100-300	200 MHz	2N3502	TO-5	P20
45 V	150 mA	100-300	200 MHz	A5T3504	AAA	P20
45 V	150 mA	100-300	200 MHz	2N3504	TO-18	P20
45 V	150 mA	100-300	200 MHz	A5T3644	AAA	P20
60 V	10 mA	50-150	250 MHz	2N3250A	TO-18	P23
60 V	10 mA	100-300	300 MHz	2N3251A	TO-18	P23
60 V	100 mA	40-120	100 MHz	A8T4026	TO-92	P16
60 V	100 mA	40-120	100 MHz	A5T4026	AAA	P16
60 V	100 mA	40-120	100 MHz	2N4026	TO-18	P16
60 V	100 mA	40-120	100 MHz	2N4030	TO-39	P16
60 V	100 mA	100-300	150 MHz	A8T4028	TO-92	P16
60 V	100 mA	100-300	150 MHz	A5T4028	AAA	P16
60 V	100 mA	100-300	150 MHz	2N4028	TO-18	P16
60 V	100 mA	100-300	150 MHz	2N4032	TO-39	P16
60 V	150 mA	40-120	200 MHz	2N2904A	TO-5	P20
60 V	150 mA	40-120	200 MHz	2N2906A	TO-18	P20
60 V	150 mA	40-120	200 MHz	2N3485A	TO-46	P20
60 V	150 mA	100-300	200 MHz	2N2905A	TO-5	P20
60 V	150 mA	100-300	200 MHz	2N2907A	TO-18	P20
60 V	150 mA	100-300	200 MHz	2N3486A	TO-46	P20
60 V	150 mA	100-300	200 MHz	2N3503	TO-5	P20
60 V	150 mA	100-300	200 MHz	A5T3505	AAA	P20
60 V	150 mA	100-300	200 MHz	2N3505	TO-18	P20
60 V	150 mA	100-300	200 MHz	A5T3645	AAA	P20
80 V	100 mA	40-120	100 MHz	A8T4027	TO-92	P16
80 V	100 mA	40-120	100 MHz	A5T4027	AAA	P16
80 V	100 mA	40-120	100 MHz	2N4027	TO-18	P16
80 V	100 mA	40-120	100 MHz	2N4031	TO-39	P16
80 V	100 mA	100-300	150 MHz	A8T4029	TO-92	P16
80 V	100 mA	100-300	150 MHz	A5T4029	AAA	P16
80 V	100 mA	100-300	150 MHz	2N4029	TO-18	P16
80 V	100 mA	100-300	150 MHz	2N4033	TO-39	P16

*See package drawings on page 2-20.

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N-P-N SWITCHES

SWITCHING TIMES @ I_C	t_{on} MAX	t_{off} MAX	$V_{(BR)CEO}$ MIN	$V_{CE(sat)}$ @ I_C	DEVICE TYPE	PACKAGE*	CHIP
10 mA	70 ns	225 ns	40 V	0.2 V @ 10 mA	A5T3903	AAA	N14
10 mA	70 ns	225 ns	40 V	0.2 V @ 10 mA	2N3903	TO-92	N14
10 mA	70 ns	250 ns	40 V	0.2 V @ 10 mA	A5T3904	AAA	N14
10 mA	70 ns	250 ns	40 V	0.2 V @ 10 mA	2N3904	TO-92	N14
10 mA	22 typ ns	32 typ ns	30 V	0.3 V @ 50 mA	2N4123	TO-92	N14
10 mA	22 typ ns	32 typ ns	30 V	0.3 V @ 50 mA	A5T4123	AAA	N14
10 mA	22 typ ns	32 typ ns	25 V	0.3 V @ 50 mA	2N4124	TO-92	N14
10 mA	22 typ ns	32 typ ns	25 V	0.3 V @ 50 mA	A5T4124	AAA	N14
150 mA	20 typ ns	113 typ ns	40 V	0.4 V @ 150 mA	TIS110	AAA	N24
150 mA	20 typ ns	113 typ ns	40 V	0.4 V @ 150 mA	TIS111	AAA	N24
150 mA	35 ns	285 ns	40 V	0.3 V @ 150 mA	2N2218A	TO-5	N24
150 mA	35 ns	285 ns	40 V	0.3 V @ 150 mA	2N2219A	TO-5	N24
150 mA	35 ns	285 ns	40 V	0.3 V @ 150 mA	2N2221A	TO-18	N24
150 mA	35 ns	285 ns	40 V	0.3 V @ 150 mA	2N2222A	TO-18	N24
150 mA	40 ns	40 ns	30 V	0.45 V @ 150 mA	2N2537	TO-5	N19
150 mA	40 ns	40 ns	30 V	0.45 V @ 150 mA	2N2538	TO-5	N19
150 mA	40 ns	40 ns	30 V	0.45 V @ 150 mA	2N2539	TO-18	N19
150 mA	40 ns	40 ns	30 V	0.45 V @ 150 mA	2N2540	TO-18	N19
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	TIS109	AAA	N24
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	2N2217	TO-5	N24
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	2N2218	TO-5	N24
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	2N2219	TO-5	N24
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	2N2220	TO-18	N24
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	2N2221	TO-18	N24
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	Q2T2222	TO-116	N24
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	A5T2222	AAA	N24
150 mA	20 typ ns	113 typ ns	30 V	0.4 V @ 150 mA	2N2222	TO-18	N24
500 mA	35 ns	60 ns	30 V	0.65 V @ 500 mA	TIS133	AAA	N13
500 mA	35 ns	60 ns	30 V	0.72 V @ 500 mA	TIS134	AAA	N13
500 mA	35 ns	60 ns	50 V	0.65 V @ 500 mA	TIS135	AAA	N13
500 mA	35 ns	60 ns	40 V	0.72 V @ 500 mA	TIS136	AAA	N13
500 mA	35 ns	60 ns	30 V	0.42 V @ 500 mA	2N3724	TO-39	N13
500 mA	35 ns	65 ns	40 V	0.52 V @ 500 mA	Q2T3725	TO-116	N13
500 mA	35 ns	60 ns	50 V	0.52 V @ 500 mA	2N3725	TO-39	N13
500 mA	35 ns	60 ns	30 V	0.42 V @ 500 mA	2N4013	TO-18	N13
500 mA	35 ns	60 ns	50 V	0.52 V @ 500 mA	2N4014	TO-18	N13
500 mA	40 ns	60 ns	30 V	1 V @ 500 mA	2N3015	TO-5	N19
500 mA	45 ns	70 ns	30 V	0.5 V @ 500 mA	2N3252	TO-39	N13
500 mA	50 ns	70 ns	40 V	0.6 V @ 500 mA	2N3253	TO-39	N13
500 mA	50 ns	70 ns	50 V	0.6 V @ 500 mA	2N3444	TO-39	N13
1 A	30 ns	50 ns	30 V	0.75 V @ 1 A	2N3724A	TO-39	N13
1 A	30 ns	50 ns	50 V	0.9 V @ 1 A	2N3725A	TO-39	N13
1 A	48 ns	60 ns	30 V	0.9 V @ 1 A	2N3734	TO-39	N13
1 A	48 ns	60 ns	50 V	0.9 V @ 1 A	2N3735	TO-39	N13
1 A	50 ns	105 ns	30 V	1 V @ 1 A	2N3554	TO-39	N13

*See package drawings on page 2-20.

P-N-P SWITCHES

SWITCHING TIMES @I_C	t_{on} MAX	t_{off} MAX	$V_{(BR)CEO}$ MIN	$V_{CE(sat)}$ @ I_C	DEVICE TYPE	PACKAGE*	CHIP
10 mA	30 ns	50 ns	15 V	0.15 V @ 10 mA	2N3576	TO-18	P11
10 mA	70 ns	225 ns	40 V	0.25 V @ 10 mA	2N3250	TO-18	P23
10 mA	70 ns	225 ns	60 V	0.25 V @ 10 mA	2N3250A	TO-18	P23
10 mA	70 ns	250 ns	40 V	0.25 V @ 10 mA	2N3251	TO-18	P23
10 mA	70 ns	250 ns	60 V	0.25 V @ 10 mA	2N3251A	TO-18	P23
10 mA	70 ns	260 ns	40 V	0.25 V @ 10 mA	A5T3905	AAA	P15
10 mA	70 ns	260 ns	40 V	0.25 V @ 10 mA	2N3905	TO-92	P15
10 mA	70 ns	300 ns	40 V	0.25 V @ 10 mA	A5T3906	AAA	P15
10 mA	70 ns	300 ns	40 V	0.25 V @ 10 mA	2N3906	TO-92	P15
10 mA	26 typ ns	82 typ ns	30 V	0.4 V @ 50 mA	A5T4125	AAA	P15
10 mA	26 typ ns	82 typ ns	30 V	0.4 V @ 50 mA	2N4125	TO-92	P15
10 mA	26 typ ns	82 typ ns	25 V	0.4 V @ 50 mA	A5T4126	AAA	P15
10 mA	26 typ ns	82 typ ns	25 V	0.4 V @ 50 mA	2N4126	TO-92	P15
30 mA	25 ns	65 ns	20 V	0.18 V @ 30 mA	2N3829	TO-52	P11
30 mA	60 ns	75 ns	12 V	0.2 V @ 30 mA	2N3012	TO-18	P11
30 mA	60 ns	90 ns	12 V	0.2 V @ 30 mA	2N2894	TO-18	P11
150 mA	35 ns	255 ns	40 V	0.4 V @ 150 mA	A5T4402	AAA	P20
150 mA	35 ns	255 ns	40 V	0.4 V @ 150 mA	2N4402	TO-92	P20
150 mA	35 ns	255 ns	40 V	0.4 V @ 150 mA	A5T4403	AAA	P20
150 mA	35 ns	255 ns	40 V	0.4 V @ 150 mA	2N4403	TO-92	P20
150 mA	45 ns	140 ns	40 V	0.4 V @ 150 mA	TIS112	AAA	P20
150 mA	45 ns	100 ns	40 V	0.4 V @ 150 mA	2N2904	TO-5	P20
150 mA	45 ns	100 ns	60 V	0.4 V @ 150 mA	2N2904A	TO-5	P20
150 mA	45 ns	100 ns	40 V	0.4 V @ 150 mA	Q2T2905	TO-116	P20
150 mA	45 ns	100 ns	40 V	0.4 V @ 150 mA	2N2905	TO-5	P20
150 mA	45 ns	100 ns	60 V	0.4 V @ 150 mA	2N2905A	TO-5	P20
150 mA	45 ns	100 ns	40 V	0.4 V @ 150 mA	2N2906	TO-18	P20
150 mA	45 ns	100 ns	60 V	0.4 V @ 150 mA	2N2906A	TO-18	P20
150 mA	45 ns	100 ns	40 V	0.4 V @ 150 mA	A5T2907	AAA	P20
150 mA	45 ns	100 ns	40 V	0.4 V @ 150 mA	2N2907	TO-18	P20
150 mA	45 ns	100 ns	60 V	0.4 V @ 150 mA	2N2907A	TO-18	P20
150 mA	50 ns	110 ns	40 V	0.4 V @ 150 mA	2N3485	TO-46	P20
150 mA	50 ns	110 ns	60 V	0.4 V @ 150 mA	2N3485A	TO-46	P20
150 mA	50 ns	110 ns	40 V	0.4 V @ 150 mA	2N3486	TO-46	P20
150 mA	50 ns	110 ns	60 V	0.4 V @ 150 mA	2N3486A	TO-46	P20
150 mA	19 typ ns	80 typ ns	35 V	1.5 V @ 150 mA	2N721	TO-18	P20
150 mA	19 typ ns	80 typ ns	35 V	1.5 V @ 150 mA	2N722	TO-18	P20
300 mA	40 ns	100 ns	45 V	1 V @ 300 mA	2N3502	TO-5	P20
300 mA	40 ns	100 ns	60 V	1 V @ 300 mA	2N3503	TO-5	P20
300 mA	40 ns	100 ns	45 V	1 V @ 300 mA	A5T3504	AAA	P20
300 mA	40 ns	100 ns	60 V	1 V @ 300 mA	A5T3505	AAA	P20
300 mA	40 ns	100 ns	45 V	1 V @ 300 mA	2N3504	TO-18	P20
300 mA	40 ns	100 ns	60 V	1 V @ 300 mA	2N3505	TO-18	P20
300 mA	40 ns	100 ns	45 V	1 V @ 300 mA	A5T3644	AAA	P20
300 mA	40 ns	100 ns	60 V	1 V @ 300 mA	A5T3645	AAA	P20
300 mA	75 ns	170 ns	25 V	1 V @ 300 mA	A5T3638	AAA	P20
300 mA	75 ns	170 ns	25 V	1 V @ 300 mA	A5T3638A	AAA	P20
500 mA	40 ns	90 ns	40 V	0.5 V @ 500 mA	2N3467	TO-39	P12

*See package drawings on page 2-20.

P-N-P SWITCHES (Continued)

SWITCHING TIMES @ I_C	t_{on} MAX	t_{off} MAX	$V_{(BR)CEO}$ MIN	$V_{CE(sat)}$ @ I_C	DEVICE TYPE	PACKAGE*	CHIP
500 mA	40 ns	90 ns	50 V	0.6 V @ 500 mA	2N3468	TO-39	P12
500 mA	55 ns	165 ns	50 V	0.6 V @ 500 mA	2N3245	TO-39	P12
500 mA	50 ns	185 ns	40 V	0.5 V @ 500 mA	Q2T3244	TO-116	P12
500 mA	50 ns	185 ns	40 V	0.5 V @ 500 mA	2N3244	TO-39	P12
500 mA	100 ns	400 ns	60 V	0.5 V @ 500 mA	A5T4026	AAA	P16
500 mA	100 ns	400 ns	60 V	0.5 V @ 500 mA	2N4026	TO-18	P16
500 mA	100 ns	400 ns	60 V	0.5 V @ 500 mA	A5T4028	AAA	P16
500 mA	100 ns	400 ns	60 V	0.5 V @ 500 mA	2N4028	TO-18	P16
500 mA	100 ns	400 ns	60 V	0.5 V @ 500 mA	2N4030	TO-39	P16
500 mA	100 ns	400 ns	60 V	0.5 V @ 500 mA	2N4032	TO-39	P16
500 mA	100 ns	400 ns	80 V	0.5 V @ 500 mA	A5T4027	AAA	P16
500 mA	100 ns	400 ns	80 V	0.5 V @ 500 mA	2N4027	TO-18	P16
500 mA	100 ns	400 ns	80 V	0.5 V @ 500 mA	A5T4029	AAA	P16
500 mA	100 ns	400 ns	80 V	0.5 V @ 500 mA	2N4029	TO-18	P16
500 mA	100 ns	400 ns	80 V	0.5 V @ 500 mA	2N4031	TO-39	P16
500 mA	100 ns	400 ns	80 V	0.5 V @ 500 mA	2N4033	TO-39	P16

N-P-N CHOPPERS

OFFSET VOLTAGE $V_{EC(ofs)}$ $V_{E1E2(ofs)}$§ @ I_B MAX	ON-STATE RESISTANCE $r_{ec(on)}$ r_{e1e2}§	$h_{FE(inv)}$ MIN	$V_{(BR)EBO}$ MIN	DEVICE TYPE	POLARITY	PACKAGE*	CHIP
§50 μV @ 1 mA	§40 Ω		18 V	3N74	NPN	TO-72	N12
§100 μV @ 1 mA	§40 Ω		18 V	3N75	NPN	TO-72	N12
§50 μV @ 1 mA	§50 Ω		12 V	3N77	NPN	TO-72	N12
§200 μV @ 1 mA	§50 Ω		18 V	3N76	NPN	TO-72	N12
§100 μV @ 1 mA	§50 Ω		12 V	3N78	NPN	TO-72	N12
§200 μV @ 1 mA	§60 Ω		12 V	3N79	NPN	TO-72	N12
0.7 mV @ 1 mA	15 Ω	3	18 V	2N2432A	NPN	TO-18	N18
1 mV @ 1 mA	20 Ω	2	15 V	2N2432	NPN	TO-18	N18
1 mV @ 1 mA	20 Ω	2	15 V	2N4138	NPN	TO-46	N18

P-N-P CHOPPERS

OFFSET VOLTAGE $V_{EC(ofs)}$ $V_{E1E2(ofs)}$§ @ I_B MAX	ON-STATE RESISTANCE $r_{ec(on)}$ r_{e1e2}§	$h_{FE(inv)}$ MIN	$V_{(BR)EBO}$ MIN	DEVICE TYPE	POLARITY	PACKAGE*	CHIP
§30 μV @ 1 mA	§50 Ω		50 V	3N108	PNP	TO-72	P13
§30 μV @ 1 mA	§50 Ω		30 V	3N110	PNP	TO-72	P13
§150 μV @ 1 mA	§50 Ω		50 V	3N109	PNP	TO-72	P13
§150 μV @ 1 mA	§50 Ω		30 V	3N111	PNP	TO-72	P13
0.6 mV @ 1 mA	4 Ω	50	15 V	2N2944A	PNP	TO-46	P14
0.6 mV @ 1 mA	20 Ω	6	15 V	2N2944	PNP	TO-46	P14
1 mV @ 1 mA	6 Ω	30	25 V	2N2945A	PNP	TO-46	P14
1 mV @ 1 mA	35 Ω	4	25 V	2N2945	PNP	TO-46	P14
2 mV @ 1 mA	8 Ω	20	40 V	2N2946A	PNP	TO-46	P14
2 mV @ 1 mA	45 Ω	3	40 V	2N2946	PNP	TO-46	P14

*See package drawings on page 2-20.

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N-P-N MATCHED DUALS

h_{FE} @ I_C	h_{FE} MIN-MAX	h_{FE1}/h_{FE2} MIN	ΔV_{BE} MAX	$\Delta V_{BE}/\Delta T$ MAX	DEVICE TYPE	POLARITY	PACKAGE*	CHIP
10 μA	50-300	0.9	5 mV	10 μV/°C	2N2639	NPN	TO-78	N11
10 μA	50-300	0.8	10 mV	20 μV/°C	2N2640	NPN	TO-78	N11
10 μA	60-240	0.9	1.5 mV	5 μV/°C	2N2915A	NPN	TO-78	N11
10 μA	60-240	0.9	1.5 mV	5 μV/°C	2N2919A	NPN	TO-78	N11
10 μA	60-240	0.9	3 mV	10 μV/°C	2N2919	NPN	TO-78	N11
10 μA	60-240	0.9	3 mV	10 μV/°C	2N2974	NPN	TO-71	N11
10 μA	60-240	0.9	3 mV	10 μV/°C	2N2915	NPN	TO-78	N11
10 μA	60-240	0.9	3 mV	10 μV/°C	2N2978	NPN	TO-71	N11
10 μA	60-240	0.8	5 mV	20 μV/°C	2N2917	NPN	TO-78	N11
10 μA	60-240	0.8	5 mV	20 μV/°C	2N2976	NPN	TO-71	N11
10 μA	100-300	0.9	5 mV	10 μV/°C	2N2642	NPN	TO-78	N11
10 μA	100-300	0.8	10 mV	20 μV/°C	2N2643	NPN	TO-78	N11
10 μA	150-600	0.9	1.5 mV	5 μV/°C	2N2920A	NPN	TO-78	N11
10 μA	150-600	0.9	1.5 mV	5 μV/°C	2N2916A	NPN	TO-78	N11
10 μA	150-600	0.9	3 mV	10 μV/°C	2N2916	NPN	TO-78	N11
10 μA	150-600	0.9	3 mV	5 μV/°C	2N3680	NPN	TO-78	N11
10 μA	150-600	0.9	3 mV	10 μV/°C	2N2920	NPN	TO-78	N11
10 μA	150-600	0.9	3 mV	10 μV/°C	2N2975	NPN	TO-71	N11
10 μA	150-600	0.9	3 mV	10 μV/°C	2N2979	NPN	TO-71	N11
10 μA	150-600	0.8	5 mV	20 μV/°C	2N2918	NPN	TO-78	N11
10 μA	150-600	0.8	5 mV	20 μV/°C	2N2977	NPN	TO-71	N11
100 μA	25-150	0.9	5 mV	25 μV/°C	2N2223A	NPN	TO-78	N23
100 μA	25-150	0.8	15 mV	25 μV/°C	2N2223	NPN	TO-78	N23
100 μA	30-90	0.9	5 mV	10 μV/°C	2N2060	NPN	TO-78	N23
1 mA	150-600	0.9	3 mV	10 μV/°C	2N2453	NPN	TO-78	N11

P-N-P MATCHED DUALS

h_{FE} @ I_C	h_{FE} MIN-MAX	h_{FE1}/h_{FE2} MIN	ΔV_{BE} MAX	$\Delta V_{BE}/\Delta T$ MAX	DEVICE TYPE	POLARITY	PACKAGE*	CHIP
10 μA	40-300	0.9	5 mV	10 μV/°C	2N3347	PNP	TO-78	P19
10 μA	40-300	0.8	10 mV	20 μV/°C	2N3348	PNP	TO-78	P19
10 μA	40-300	0.6	20 mV	40 μV/°C	2N3349	PNP	TO-78	P19
10 μA	100-300	0.9	5 mV	10 μV/°C	2N3350	PNP	TO-78	P19
10 μA	100-300	0.8	10 mV	20 μV/°C	2N3351	PNP	TO-78	P19
10 μA	100-300	0.6	20 mV	40 μV/°C	2N3352	PNP	TO-78	P19
100 μA	20-120	0.9	5 mV	10 μV/°C	2N2802	PNP	TO-78	P19
100 μA	20-120	0.8	10 mV	20 μV/°C	2N2803	PNP	TO-78	P19
100 μA	40-120	0.9	5 mV	10 μV/°C	2N2805	PNP	TO-78	P19
100 μA	40-120	0.8	10 mV	20 μV/°C	2N2806	PNP	TO-78	P19
100 μA	150-450	0.9	3 mV	10 μV/°C	2N3810	PNP	TO-78	P19
100 μA	150-450	0.8	5 mV	20 μV/°C	2N3808	PNP	TO-78	P19
100 μA	300-900	0.9	3 mV	10 μV/°V	2N3811	PNP	TO-78	P19
100 μA	300-900	0.8	5 mV	20 μV/°V	2N3809	PNP	TO-78	P19

*See package drawings on page 2-20.

N-P-N UNMATCHED DUALS

h_{FE} @ I_C	h_{FE} MIN-MAX	$V_{(BR)CEO}$ MIN	NOISE FIGURE F @ f $\overline{F}$ (Noise BW) MAX	DEVICE TYPE	POLARITY	PACKAGE*	CHIP
10 µA	50-300	45 V	$\overline{4\ dB}$ (15.7 kHz)	2N2641	NPN	TO-78	N11
10 µA	60-240	45 V	4 dB @ 1 kHz	2N2913	NPN	TO-78	N11
10 µA	60-240	45 V	4 dB @ 1 kHz	2N2972	NPN	TO-71	N11
10 µA	100-300	45 V	$\overline{4\ dB}$ (15.7 kHz)	2N2644	NPN	TO-78	N11
10 µA	150-600	45 V	3 dB @ 1 kHz	2N2914	NPN	TO-78	N11
10 µA	150-600	45 V	3 dB @ 1 kHz	2N2973	NPN	TO-71	N11
3 mA	20-	15 V	6 dB @ 60 MHz	D2T918	NPN	TO-78	N22
50 mA	100-300	40 V		TIS90M	NPN	TO-92	N24
50 mA	100-300	40 V		TIS92M	NPN	AAA	N24
150 mA	40-120	30 V		D2T2218	NPN	TO-78	N24
150 mA	40-120	40 V		D2T2218A	NPN	TO-78	N24
150 mA	40-120	40 V	8 dB @ 1 kHz	2N4855	N/P	TO-78	N24, P20
150 mA	100-300	30 V		D2T2219	NPN	TO-78	N24
150 mA	100-300	40 V		D2T2219A	NPN	TO-78	N24
150 mA	100-300	40 V	8 dB @ 1 kHz	2N4854	N/P	TO-78	N24, P20

P-N-P UNMATCHED DUALS

h_{FE} @ I_C	h_{FE} MIN-MAX	$V_{(BR)CEO}$ MIN	NOISE FIGURE F @ f $\overline{F}$ (Noise BW) MAX	DEVICE TYPE	POLARITY	PACKAGE*	CHIP
100 µA	20-120	20 V	$\overline{4\ dB}$ (15.7 kHz)	2N2804	PNP	TO-78	P19
100 µA	40-120	20 V	$\overline{4\ dB}$ (15.7 kHz)	2N2807	PNP	TO-78	P19
1 mA	150-450	60 V	3 dB @ 1 kHz	2N3806	PNP	TO-78	P19
1 mA	300-900	60 V	1.5 dB @ 1 kHz	2N3807	PNP	TO-78	P19
50 mA	100-300	40 V		TIS91M	PNP	TO-92	P20
50 mA	100-300	40 V		TIS93M	PNP	AAA	P20
150 mA	40-120	40 V		D2T2904	PNP	TO-78	P20
150 mA	40-120	40 V	8 dB @ 1 kHz	2N4855	N/P	TO-78	N24, P20
150 mA	40-120	60 V		D2T2904A	PNP	TO-78	P20
150 mA	100-300	40 V		D2T2905	PNP	TO-78	P20
150 mA	100-300	40 V	8 dB @ 1 kHz	2N4854	N/P	TO-78	N24, P20
150 mA	100-300	60 V		D2T2905A	PNP	TO-78	P20

N-P-N AND P-N-P QUADS

POLARITY	$V_{(BR)CEO}$ MIN	h_{FE} @ I_C	h_{FE} MIN-MAX	DEVICE TYPE	PACKAGE*	CHIP
N-P-N	30 V	150 mA	100-300	Q2T2222	TO-116 (DUAL-IN-LINE PLASTIC)	N24
N-P-N	40 V	100 mA	60-200	Q2T3725	TO-116 (DUAL-IN-LINE PLASTIC)	N13
P-N-P	40 V	150 mA	100-300	Q2T2905	TO-116 (DUAL-IN-LINE PLASTIC)	P20
P-N-P	40 V	500 mA	50-150	Q2T3244	TO-116 (DUAL-IN-LINE PLASTIC)	P12

*See package drawings on page 2-20.

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JFET N-CHANNEL LOW-FREQUENCY, LOW-NOISE AMPLIFIERS

NOISE FIGURE F @ f MAX	I_{DSS} MIN-MAX	$V_{(BR)GSS}$ MIN	DEVICE TYPE	CHANNEL POLARITY	PACKAGE*	CHIP
1.5 dB @ 10 Hz	5 mA-20 mA	20 V	2N6451	N	TO-72	JN55
1.5 dB @ 10 Hz	15 mA-50 mA	20 V	2N6453	N	TO-72	JN55
2.5 dB @ 100 Hz	0.8 mA-1.6 mA	40 V	2N5359	N	TO-72	JN51
2.5 dB @ 10 Hz	5 mA-20 mA	25 V	2N6452	N	TO-72	JN55
2.5 dB @ 100 Hz	9 mA-18 mA	40 V	2N5364	N	TO-72	JN51
2.5 dB @ 10 Hz	15 mA-50 mA	25 V	2N6454	N	TO-72	JN55
5 dB @ 10 Hz	0.5 mA-2.5 mA	50 V	A5T3821	N	AAA	JN51
5 dB @ 10 Hz	0.5 mA-2.5 mA	50 V	2N3821	N	TO-72	JN51
5 dB @ 10 Hz	2 mA-10 mA	50 V	2N3822	N	TO-72	JN51
5 dB @ 10 Hz	2 mA-10 mA	50 V	A5T3822	N	AAA	JN51
4 dB @ 20 Hz	0.2 mA-1 mA	50 V	2N3460	N	TO-18	JN51
4 dB @ 20 Hz	0.8 mA-4 mA	50 V	2N3459	N	TO-18	JN51
6 dB @ 20 Hz	3 mA-15 mA	50 V	2N3458	N	TO-18	JN51
2.5 dB @ 100 Hz	0.5 mA-1 mA	40 V	2N5358	N	TO-72	JN51
2.5 dB @ 100 Hz	1.5 mA-3 mA	40 V	2N5360	N	TO-72	JN51
2.5 dB @ 100 Hz	2.5 mA-5 mA	40 V	2N5361	N	TO-72	JN51
2.5 dB @ 100 Hz	4 mA-8 mA	40 V	2N5362	N	TO-72	JN51
2.5 dB @ 100 Hz	7 mA-14 mA	40 V	2N5363	N	TO-72	JN51
2 dB @ 1000 Hz	2.5 mA-5 mA	30 V	2N5953	N	AAA	JN51
2 dB @ 1000 Hz	4 mA-8 mA	30 V	2N5952	N	AAA	JN51
2 dB @ 1000 Hz	7 mA-13 mA	30 V	2N5951	N	AAA	JN51
2 dB @ 1000 Hz	10 mA-15 mA	30 V	2N5950	N	AAA	JN51
2 dB @ 1000 Hz	12 mA-18 mA	30 V	2N5949	N	AAA	JN51

JFET P-CHANNEL LOW-FREQUENCY, LOW-NOISE AMPLIFIERS

NOISE FIGURE F @ f MAX	I_{DSS} MIN-MAX	$V_{(BR)GSS}$ [$V_{(BR)DGO}$] MIN	DEVICE TYPE	CHANNEL POLARITY	PACKAGE*	CHIP
5 dB @ 10 Hz	1 mA-6 mA	[20 V]	2N2500	P	TO-5	JP71
5 dB @ 10 Hz	1 mA-6 mA	20 V	2N3332	P	TO-72	JP71
2.5 dB @ 100 Hz	1 mA-5 mA	40 V	2N5460	P	TO-92	JP71
2.5 dB @ 100 Hz	1 mA-5 mA	40 V	A5T5460	P	AAA	JP71
2.5 dB @ 100 Hz	2 mA-9 mA	40 V	2N5461	P	TO-92	JP71
2.5 dB @ 100 Hz	2 mA-9 mA	40 V	A5T5461	P	AAA	JP71
2.5 dB @ 100 Hz	4 mA-16 mA	40 V	2N5462	P	TO-92	JP71
2.5 dB @ 100 Hz	4 mA-16 mA	40 V	A5T5462	P	AAA	JP71
3 dB @ 1000 Hz	0.9 mA-4.5 mA	30 V	2N2608	P	TO-18	JP71
3 dB @ 1000 Hz	1 mA-3 mA	[20 V]	2N2497	P	TO-5	JP71
3 dB @ 1000 Hz	1 mA-3 mA	20 V	2N3329	P	TO-72	JP71
3 dB @ 1000 Hz	2 mA-6 mA	[20 V]	2N2498	P	TO-5	JP71
3 dB @ 1000 Hz	2 mA-6 mA	20 V	2N3330	P	TO-72	JP71
3 dB @ 1000 Hz	2 mA-10 mA	30 V	2N2609	P	TO-18	JP71
4 dB @ 1000 Hz	5 mA-15 mA	[20 V]	2N2499	P	TO-5	JP71
4 dB @ 1000 Hz	5 mA-15 mA	20 V	2N3331	P	TO-72	JP71

*See package drawings on page 2-20.

JFET N-CHANNEL GENERAL PURPOSE AMPLIFIERS

I_{DSS} MIN-MAX	$\lvert y_{fs}\rvert$ @ f MIN-MAX	$V_{(BR)GSS}$ MIN	DEVICE TYPE	CHANNEL POLARITY	PACKAGE*	CHIP
0.5 mA-1 mA	1-3 mmho @ 1 kHz	40 V	2N5358	N	TO-72	JN51
0.5 mA-3 mA	1-4 mmho @ 1 kHz	30 V	2N4220	N	TO-72	JN51
0.5 mA-3 mA	1-4 mmho @ 1 kHz	30 V	2N4220A	N	TO-72	JN51
0.8 mA-1.6 mA	1.2-3.6 mmho @ 1 kHz	40 V	2N5359	N	TO-72	JN51
1.5 mA-3 mA	1.4-4.2 mmho @ 1 kHz	40 V	2N5360	N	TO-72	JN51
2 mA-6 mA	2-5 mmho @ 1 kHz	30 V	2N4221	N	TO-72	JN51
2 mA-6 mA	2-5 mmho @ 1 kHz	30 V	2N4221A	N	TO-72	JN51
2 mA-10 mA	0.5-3 mmho @ 1 kHz	200 V	A5T6450	N	AAA	JN54
2 mA-10 mA	0.5-3 mmho @ 1 kHz	200 V	2N6450	N	TO-39	JN54
2 mA-10 mA	0.5-3 mmho @ 1 kHz	300 V	A5T6449	N	AAA	JN54
2 mA-10 mA	0.5-3 mmho @ 1 kHz	300 V	2N6449	N	TO-39	JN54
2 mA-10 mA	3-6.5 mmho @ 1 kHz	50 V	2N3822	N	TO-72	JN51
2 mA-10 mA	3-6.5 mmho @ 1 kHz	50 V	A5T3822	N	AAA	JN51
2 mA-20 mA	2-6.5 mmho @ 1 kHz	25 V	2N3819	N	TO-92	JN51
2.5 mA-5 mA	1.5-4.5 mmho @ 1 kHz	40 V	2N5361	N	TO-72	JN51
2.5 mA-5 mA	2-6.5 mmho @ 1 kHz	30 V	2N5953	N	AAA	JN51
2.5 mA-8 mA	4 typ mmho @ 1 kHz	25 V	TIS58	N	TO-92	JN51
4 mA-8 mA	2-5.5 mmho @ 1 kHz	40 V	2N5362	N	TO-72	JN51
4 mA-8 mA	2-6.5 mmho @ 1 kHz	30 V	2N5952	N	AAA	JN51
5 mA-15 mA	2.5-6 mmho @ 1 kHz	30 V	2N4222	N	TO-72	JN51
5 mA-15 mA	2.5-6 mmho @ 1 kHz	30 V	2N4222A	N	TO-72	JN51
6 mA-25 mA	4.8 typ mmho @ 1 kHz	25 V	TIS59	N	TO-92	JN51
7 mA-13 mA	3.5-6.5 mmho @ 1 kHz	30 V	2N5951	N	AAA	JN51
7 mA-14 mA	2.5-6 mmho @ 1 kHz	40 V	2N5363	N	TO-72	JN51
9 mA-18 mA	2.7-6.5 mmho @ 1 kHz	40 V	2N5364	N	TO-72	JN51
10 mA-15 mA	3.5-7.5 mmho @ 1 kHz	30 V	2N5950	N	AAA	JN51
12 mA-18 mA	3.5-7.5 mmho @ 1 kHz	30 V	2N5949	N	AAA	JN51
12 mA-24 mA		50 V	2N3824	N	TO-72	JN51
12 mA-24 mA		50 V	A5T3824	N	AAA	JN51

JFET P-CHANNEL GENERAL PURPOSE AMPLIFIERS

I_{DSS} MIN-MAX	$\lvert y_{fs}\rvert$ @ f MIN-MAX	$V_{(BR)GSS}$ MIN	DEVICE TYPE	CHANNEL POLARITY	PACKAGE*	CHIP
0.3 mA-15 mA	0.8-5 mmho @ 1 kHz	20 V	2N3820	P	TO-92	JP71
0.3 mA-15 mA	1-5 mmho @ 1 kHz	20 V	2N3909	P	TO-72	JP71
1 mA-5 mA	1-4 mmho @ 1 kHz	40 V	2N5460	P	TO-92	JP71
1 mA-5 mA	1-4 mmho @ 1 kHz	40 V	A5T5460	P	AAA	JP71
1 mA-15 mA	2.2-5 mmho @ 1 kHz	20 V	2N2386A	P	TO-5	JP71
1 mA-15 mA	2.2-5 mmho @ 1 kHz	20 V	2N3909A	P	TO-72	JP71
2 mA-9 mA	1.5-5 mmho @ 1 kHz	40 V	2N5461	P	TO-92	JP71
2 mA-9 mA	1.5-5 mmho @ 1 kHz	40 V	A5T5461	P	AAA	JP71
4 mA-16 mA	2-6 mmho @ 1 kHz	40 V	2N5462	P	TO-92	JP71
4 mA-16 mA	2-6 mmho @ 1 kHz	40 V	A5T5462	P	AAA	JP71

*See package drawings on page 2-20.

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JFET HIGH-FREQUENCY AMPLIFIERS (N-CHANNEL)

C_{rss} MAX	$\|y_{fs}\|$ @ f MIN	NOISE FIGURE F @ f MAX	GAIN G_{ps} @ f MIN	DEVICE TYPE	PACKAGE*	CHIP
0.8 pF	4 mmho @ 400 MHz	4 dB @ 400 MHz	10 dB @ 400 MHz	2N4416	TO-72	JN53
0.8 pF	4 mmho @ 400 MHz	4 dB @ 400 MHz	10 dB @ 400 MHz	2N4416A	TO-72	JN53
1 pF	2.5 mmho @ 400 MHz			2N5246	AAA	JN53
1 pF	4 mmho @ 400 MHz	4 dB @ 400 MHz	10 dB @ 400 MHz	2N5245	AAA	JN53
1 pF	4 mmho @ 400 MHz			2N5247	AAA	JN53
1.2 pF	5.5 mmho @ 450 MHz	3.5 dB @ 450 MHz	15 dB @ 450 MHz	2N5397	TO-72	
1.3 pF	5 mmho @ 450 MHz			2N5398	TO-72	
2 pF	0.8 mmho @ 100 MHz	2.5 dB @ 100 Hz		2N5358	TO-72	JN51
2 pF	0.9 mmho @ 100 MHz	2.5 dB @ 100 Hz		2N5359	TO-72	JN51
2 pF	1.4 mmho @ 100 MHz	2.5 dB @ 100 Hz		2N5360	TO-72	JN51
2 pF	1.7 mmho @ 100 MHz	2.5 dB @ 100 Hz		2N5361	TO-72	JN51
2 pF	1.7 mmho A 200 MHz			2N4224	TO-72	JN51
2 pF	1.9 mmho @ 100 MHz	2.5 dB @ 100 Hz		2N5362	TO-72	JN51
2 pF	2.1 mmho @ 100 MHz	2.5 dB @ 100 Hz		2N5363	TO-72	JN51
2 pF	2.2 mmho @ 100 MHz	2.5 dB @ 100 Hz		2N5364	TO-72	JN51
2 pF	2.7 mmho @ 200 MHz	5 dB @ 200 MHz	10 dB @ 200 MHz	2N4223	TO-72	JN51
2 pF	3 mmho @ 200 MHz			2N5248	TO-92	JN51
2 pF	3.2 mmho @ 200 MHz	2.5 dB @ 100 MHz		2N3823	TO-72	JN51
2 pF	3.2 mmho @ 200 MHz	2.5 dB @ 100 MHz		A5T3823	AAA	JN51

IGFET HIGH-FREQUENCY AMPLIFIERS (N-CHANNEL, DEPLETION-TYPE)

C_{rss} MAX	$\|y_{fs}\|$ @ f MIN-MAX	NOISE FIGURE F @ f MAX	GAIN G_{ps} @ f MIN	DEVICE TYPE	PACKAGE*	CHIP
0.03 pF	7-17 mmho @ 1 kHz	4 dB @ 45 MHz	25 dB @ 45 MHz	3N206	TO-72	MN81
0.03 pF	7-15 mmho @ 1 kHz	6 dB @ 45 MHz	20 dB @ 45 MHz	3N203	TO-72	MN81
0.03 pF	8-20 mmho @ 1 kHz	4.5 dB @ 200 MHz	15 dB @ 200 MHz	3N201	TO-72	MN81
0.03 pF	8-20 mmho @ 1 kHz		15 dB @ 200 MHz	3N202	TO-72	MN81
0.03 pF	10-22 mmho @ 1 kHz	5 dB @ 450 MHz	14 dB @ 450 MHz	3N204	TO-72	MN81
0.03 pF	10-22 mmho @ 1 kHz		17 dB @ 200 MHz	3N205	TO-72	MN81
0.05 pF	15-35 mmho @ 1 kHz	4 dB @ 45 MHz	27 dB @ 45 MHz	3N213	TO-72	MN85
0.05 pF	17-40 mmho @ 1 kHz	3.5 dB @ 200 MHz	24 dB @ 200 MHz	3N211	TO-72	MN85
0.05 pF	17-40 mmho @ 1 kHz		21 dB @ 200 MHz	3N212	TO-72	MN85
0.35 pF	5-12 mmho @ 1 kHz	5 dB @ 200 MHz	13.5 dB @ 200 MHz	3N128	TO-72	MN82

*See package drawings on page 2-20.

TEXAS INSTRUMENTS
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JFET N-CHANNEL SWITCHES AND CHOPPERS

$r_{ds(on)}$ MAX	$V_{GS(off)}$ MIN-MAX	$V_{(BR)GSS}$ MIN	I_{DSS} MIN-MAX	DEVICE TYPE	PACKAGE*	CHIP
25 Ω	4-10 V	30 V	50- mA	TIS73	AAA	JN52
25 Ω	4-10 V	30 V	50- mA	2N4859	TO-18	JN52
25 Ω	4-10 V	30 V	50- mA	2N4859A	TO-18	JN52
25 Ω	4-10 V	40 V	50- mA	2N4856	TO-18	JN52
25 Ω	4-10 V	40 V	50- mA	2N4856A	TO-18	JN52
30 Ω	4-10 V	40 V	50-150 mA	2N3970	TO-18	JN52
30 Ω	4-10 V	40 V	50-150 mA	2N4391	TO-18	JN52
30 Ω	5-10 V	40 V	30- mA	2N4091	TO-18	JN52
40 Ω	2-6 V	30 V	20-100 mA	TIS74	AAA	JN52
40 Ω	2-6 V	30 V	20-100 mA	2N4860	TO-18	JN52
40 Ω	2-6 V	30 V	20-100 mA	2N4860A	TO-18	JN52
40 Ω	2-6 V	40 V	20-100 mA	2N4857A	TO-18	JN52
40 Ω	2-6 V	40 V	20-100 mA	2N4857	TO-18	JN52
50 Ω	2-7 V	40 V	15- mA	2N4092	TO-18	JN52
60 Ω	0.8-4 V	30 V	8-80 mA	TIS75	AAA	JN52
60 Ω	0.8-4 V	30 V	8-80 mA	2N4861	TO-18	JN52
60 Ω	0.8-4 V	30 V	8-80 mA	2N4861A	TO-18	JN52
60 Ω	0.8-4 V	40 V	8-80 mA	2N4858	TO-18	JN52
60 Ω	0.8-4 V	40 V	8-80 mA	2N4858A	TO-18	JN52
60 Ω	2-5 V	40 V	25-75 mA	2N3971	TO-18	JN52
60 Ω	2-5 V	40 V	25-75 mA	2N4392	TO-18	JN52
80 Ω	1-5 V	40 V	8- mA	2N4093	TO-18	JN52
100 Ω	0.5-3 V	40 V	5-30 mA	2N3972	TO-18	JN52
100 Ω	0.5-3 V	40 V	5-30 mA	2N4393	TO-18	JN52
100 Ω	2-6 V	40 V	10-60 mA	2N5549	TO-18	JN52
200 Ω	3-7 V	30 V	12-18 mA	2N5949	AAA	JN51
210 Ω	2.5-6 V	30 V	10-15 mA	2N5950	AAA	JN51
220 Ω	4-6 V	30 V	2- mA	2N3966	TO-72	JN51
250 Ω		50 V	12-24 mA	2N3824	TO-72	JN51
250 Ω		50 V	12-24 mA	A5T3824	AAA	JN51

JFET P-CHANNEL SWITCHES AND CHOPPERS

$r_{ds(on)}$ MAX	$V_{GS(off)}$ MIN-MAX	$V_{(BR)GSS}$ MIN	I_{DSS} MIN-MAX	DEVICE TYPE	PACKAGE*	CHIP
300 Ω	1-5.5 V	25 V	2- mA	2N3994	TO-72	JP72
300 Ω	1-5.5 V	25 V	2- mA	2N3994A	TO-72	JP72
400 Ω	1.8-9 V	40 V	4-16 mA	2N5462	TO-92	JP71
400 Ω	1.8-9 V	40 V	4-16 mA	A5T5462	AAA	JP71
800 Ω	1-7.5 V	40 V	2-9 mA	2N5461	TO-92	JP71
800 Ω	1-7.5 V	40 V	2-9 mA	A5T5461	AAA	JP71

*See package drawings on page 2-20.

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IGFET N-CHANNEL SWITCHES AND CHOPPERS

$r_{ds(on)}$ MAX	$V_{GS(th)}$ MIN-MAX	$V_{(BR)DSS}$ MIN	$I_{D(on)}$ MIN-MAX	DEVICE TYPE	ENH/DEPL	PACKAGE*	CHIP
20 Ω		20 V	50- mA	3N214	D	TO-72	MN84
35 Ω		20 V	50- mA	3N215	D	TO-72	MN84
50 Ω		20 V	50- mA	3N216	D	TO-72	MN84
70 Ω		20 V	50- mA	3N217	D	TO-72	MN84
200 Ω	0.5-1.5 V	25 V	10- mA	3N169	E	TO-72	MN83
200 Ω	1-2 V	25 V	10- mA	3N170	E	TO-72	MN83
200 Ω	1.5-3 V	25 V	10- mA	3N171	E	TO-72	MN83
300 Ω		20 V	5- mA	3N153	D	TO-72	MN82

IGFET P-CHANNEL SWITCHES AND CHOPPERS

$r_{ds(on)}$ MAX	$V_{GS(th)}$ MIN-MAX	$V_{(BR)DSS}$ MIN	$I_{D(on)}$ MIN-MAX	DEVICE TYPE	ENH/DEPL	PACKAGE*	CHIP
60 typ Ω	1.5-5 V	25 V	40-120 mA	3N160	E	TO-72	MP92
60 typ Ω	1.5-5 V	25 V	40-120 mA	3N161	E	TO-72	MP92
250 Ω	2-5 V	40 V	5-30 mA	3N163	E	TO-72	MP91
300 Ω	2-5 V	30 V	3-30 mA	3N164	E	TO-72	MP91
300 Ω	1.5-3.2 V	50 V	5- mA	3N155A	E	TO-72	MP91
300 Ω	3-5 V	50 V	5- mA	3N156A	E	TO-72	MP91
600 Ω	1.5-3.2 V	50 V	5- mA	3N155	E	TO-72	MP91
600 Ω	3-5 V	50 V	5- mA	3N156	E	TO-72	MP91
1000 Ω	2-6 V	30 V	3-12 mA	3N174	E	TO-72	MP93

JFET DUALS (N-CHANNEL)

I_{DSS} MIN-MAX	$\frac{I_{DSS1}}{I_{DSS2}}$ MIN	$\frac{\lvert y_{fs}\rvert_1}{\lvert y_{fs}\rvert_2}$ MIN	ΔV_{GS} MAX	DEVICE TYPE	PACKAGE*	CHIP
0.5-8 mA	0.95	0.97	5 mV	2N5545	TO-71	JN51
0.5-8 mA	0.95	0.95	5 mV	2N5045	TO-71	JN51
0.5-8 mA	0.95	0.95	5 mV	TIS25	TO-78	JN51
0.5-8 mA	0.9	0.95	10 mV	2N5546	TO-71	JN51
0.5-8 mA	0.9	0.9	10 mV	TIS69	2 TO-92	JN51
0.5-8 mA	0.9	0.9	10 mV	2N5046	TO-71	JN51
0.5-8 mA	0.9	0.9	15 mV	2N5547	TO-71	JN51
0.5-8 mA	0.9	0.9	10 mV	TIS26	TO-78	JN51
0.5-8 mA	0.8	0.8	15 mV	2N5047	TO-71	JN51
0.5-8 mA	0.8	0.8	15 mV	TIS27	TO-78	JN51
0.5-8 mA	0.8	0.8	15 mV	TIS70	2 TO-92	JN51

IGFET DUALS (P-CHANNEL, ENHANCEMENT-TYPE)

$r_{ds(on)}$ MAX	$V_{GS(th)}$ MIN/MAX	$I_{D(on)}$ MIN	DEVICE TYPE	PACKAGE*	CHIP
400 Ω	−3/−6 V	−1.5 mA	3N207	TO-76	MP94
400 Ω	−3/−6 V	−1.5 mA	3N208	TO-76	MP94

*See package drawings on page 2-20.

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UNIJUNCTION, CONVENTIONAL

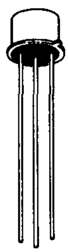
η MIN-MAX	I_P MAX	I_V MIN	r_{BB} MIN-MAX	DEVICE TYPE	PACKAGE*	CHIP
0.47-0.62	6 µA	8 mA	4.7-9.1 kΩ	2N1671B	U	BAR
0.47-0.62	25 µA	8 mA	4.7-9.1 kΩ	2N1671	U	BAR
0.47-0.62	25 µA	8 mA	4.7-9.1 kΩ	2N1671A	U	BAR
0.47-0.80	25 µA	8 mA	4-12 kΩ	2N2160	U	BAR
0.51-0.62	6 µA	8 mA	4.7-6.8 kΩ	2N489B	U	BAR
0.51-0.62	6 µA	8 mA	6.2-9.1 kΩ	2N490B	U	BAR
0.51-0.62	12 µA	8 mA	4.7-6.8 kΩ	2N489	U	BAR
0.51-0.62	12 µA	8 mA	4.7-6.8 kΩ	2N489A	U	BAR
0.51-0.62	12 µA	8 mA	6.2-9.1 kΩ	2N490	U	BAR
0.51-0.62	12 µA	8 mA	6.2-9.1 kΩ	2N490A	U	BAR
0.51-0.69	2 µA	4 mA	4-9.1 kΩ	2N4892	AAA	U42
0.51-0.69	2 µA	4 mA	4-9.1 kΩ	2N4947	OOO	U42
0.55-0.82	2 µA	2 mA	4-12 kΩ	2N4893	AAA	U42
0.55-0.82	2 µA	2 mA	4-12 kΩ	2N4948	OOO	U42
0.55-0.82	5 µA	2 mA	4-9.1 kΩ	TIS43	TO-92	U42
0.55-0.82	5 µA	2 mA	4-9.1 kΩ	2N4891	AAA	U42
0.56-0.68	6 µA	8 mA	4.7-6.8 kΩ	2N491B	U	BAR
0.56-0.68	6 µA	8 mA	6.2-9.1 kΩ	2N492B	U	BAR
0.56-0.68	12 µA	8 mA	4.7-6.8 kΩ	2N491	U	BAR
0.56-0.68	12 µA	8 mA	4.7-6.8 kΩ	2N491A	U	BAR
0.56-0.68	12 µA	8 mA	6.2-9.1 kΩ	2N492	U	BAR
0.56-0.68	12 µA	8 mA	6.2-9.1 kΩ	2N492A	U	BAR
0.56-0.75	5 µA	4 mA	4.7-9.1 kΩ	2N2646	OOO	U42
0.56-0.75	2 µA	2 mA	4.7-9.1 kΩ	2N4851	OOO	U42
0.62-0.75	6 µA	8 mA	4.7-6.8 kΩ	2N493B	U	BAR
0.62-0.75	12 µA	8 mA	4.7-6.8 kΩ	2N493	U	BAR
0.62-0.75	12 µA	8 mA	4.7-6.8 kΩ	2N493A	U	BAR
0.68-0.82	2 µA	8 mA	4.7-9.1 kΩ	2N2647	OOO	U42
0.68-0.82	2 µA	1 mA	4-8 kΩ	2N3980	OOO	U42
0.70-0.85	2 µA	4 mA	4.7-9.1 kΩ	2N4852	OOO	U42
0.70-0.85	0.4 µA	6 mA	4.7-9.1 kΩ	2N4853	OOO	U42
0.74-0.86	1 µA	2 mA	4-12 kΩ	2N4894	AAA	U42
0.74-0.86	1 µA	2 mA	4-12 kΩ	2N4949	OOO	U42

UNIJUNCTION, PROGRAMMABLE

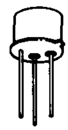
I_P @ R_G MAX	I_V @ R_G MIN	DEVICE TYPE	PACKAGE*	CHIP
1 µA @ 10 kΩ	25 µA @ 10 kΩ	A7T6028	TO-92	U41
1 µA @ 10 kΩ	50 µA @ 10 kΩ	2N6118	TO-18	U41
1 µA @ 10 kΩ	50 µA @ 10 kΩ	A5T6118	AAA	U41
2 µA @ 10 kΩ	50 µA @ 10 kΩ	2N6117	TO-18	U41
2 µA @ 10 kΩ	50 µA @ 10 kΩ	A5T6117	AAA	U41
5 µA @ 10 kΩ	70 µA @ 10 kΩ	A7T6027	TO-92	U41
5 µA @ 10 kΩ	70 µA @ 10 kΩ	2N6116	TO-18	U41
5 µA @ 10 kΩ	70 µA @ 10 kΩ	A5T6116	AAA	U41

*See package drawings on page 2-20.

PACKAGE DRAWINGS


TO-5


TO-18


TO-39

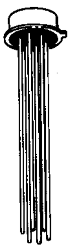

TO-46


TO-52

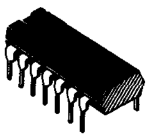

TO-71

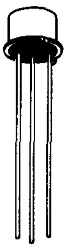

TO-72


TO-76


SHORT CAN VERSION OF TO-78


TO-92


TO-116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Transistor Interchangeability

TRANSISTOR INTERCHANGEABILITY

These lists of low-power (generally one watt or less of power dissipation in free-air) transistors are designed to assist the design engineer in determining the recommended TI replacement when only the device type number is known. Also included is a summary of the significant ratings and electrical characteristics of the referenced types.

These lists are extensive (approximately 4600 entries) but not definitive. An attempt was made to include all current and recently obsolete domestic types, both JEDEC registered and nonregistered. Undoubtedly there are some inadvertent omissions. Purposely omitted are the European PROELECTRON types, Japanese 2S types, and "hobbyist" types.

Careful engineering judgement has been used to provide the recommended TI replacement based on the specifications alone; final application might dictate another choice. Equally careful judgement should be used in selecting a replacement except where the recommended replacement type number coincides with the referenced type.

In most cases, the recommended replacement has the same general package as the referenced type; that is, plastic for plastic and metal for metal. For plastic-encapsulated devices, the "recommended" replacement has the same or similar terminal assignments as the referenced type although this terminal assignment may not be truly preferred. The user may consider this.

ORGANIZATION

These interchangeability lists are divided into six broad classes as follows:

Master List of Registered Types 3-1

Master List of Nonregistered Types 3-63

Registered Field-Effect Transistors 3-92

Nonregistered Field-Effect Transistors 3-104

Registered Unijunction Transistors 3-115

Nonregistered Unijunction Transistors 3-117

The Field-Effect Transistor and Unijunction Transistor lists are subsets of the appropriate Master List, either registered or nonregistered.

Every effort has been made to ensure the accuracy of each entry. However, TI makes no warranty as to the information furnished and the user assumes all risk in the use thereof.

KEY TO MANUFACTURER CODES

CR – Crystallonics Division, Teledyne Incorporated
F – Fairchild Semiconductor Corporation
GE – General Electric Company
GI – General Instrument Corporation
IN – Intersil, Incorporated
M – Motorola Semiconductor Products
NA – National Semiconductor Corporation
RC – RCA Corporation
SI – Siliconix, Incorporated
TI – Texas Instruments Incorporated

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS			ELECTRICAL CHARACTERISTICS					
				P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N117	NPN	GP	2N117	150	30							
2N118	NPN	GP	2N118	150	30							
2N118A	NPN	GP	2N118A	150	45							
2N119	NPN	GP	2N119	150	30							
2N120	NPN	GP	2N120	150	45		76-333					
2N160	NPN	GP	2N2217	150	40		9-19					
2N160A	NPN	GP	2N2217	150	40		9-19					
2N161	NPN	GP	2N2217	150	40		19-39					
2N161A	NPN	GP	2N2217	150	40		19-39					
2N162	NPN	GP	2N2218	150	40		19-199					
2N162A	NPN	GP	2N2218	150	40		19-199					
2N163	NPN	GP	2N2218	150	40		39-199					
2N163A	NPN	GP	2N2218	150	40		39-199					
2N243	NPN	GP	2N243	750	60							
2N244	NPN	GP	2N244	750	60							
2N258	PNP	GP	2N2906	250	30	30					15	
2N259	PNP	GP	2N2906	250	30	30					32	
2N260	PNP	GP	2N2906	200	10							
2N260A	PNP	GP	2N2906	200	30							
2N261	PNP	GP	2N2906	200	75							
2N262	PNP	GP	2N2906	200	10							
2N262A	PNP	GP	2N2906	200	30							
2N263	NPN	GP	2N2218	150	45	30	45-150	10	1.5	10	39	
2N264	NPN	GP	2N2217	150	45	30	20-55	10	1.5	10	9	
2N327	PNP	GP	2N2904	350	50							
2N327A	PNP	GP	2N2904	385	50	40	9-22	3	.3	5		
2N327B	PNP	GP	2N2904	385	50	40	9-22	3	.3	5	18	
2N328	PNP	GP	2N2904	350	35							
2N328A	PNP	GP	2N2904	385	50	35	18-44	3	.5	10		
2N328B	PNP	GP	2N2904	385	50	35	18-44	3	.5	10	36	
2N329	PNP	GP	2N2904	350	30							
2N329A	PNP	GP	2N2904	385	50	30	36-88	3	.6	15		
2N329B	PNP	GP	2N2904	385	50	30	36-88	3	.6	15	9	
2N330	PNP	GP	2N2906	350	45							
2N330A	PNP	GP	2N2906	385	50	30						
2N332	NPN	GP	2N332	150	45							
2N332A	NPN	GP	2N332A	500	45				1	5		
2N333	NPN	GP	2N333	150	45							
2N333A	NPN	GP	2N333A	500	45	45			1	5		
2N334	NPN	GP	2N334	150	45							

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N334A	NPN	GP	2N334A	500	45	45				1	5		
2N334B	NPN	GP	2N334A	500	60	60				1	5	18	
2N335	NPN	GP	2N335	150	45								
2N335A	NPN	GP	2N335A	500	45	45				1	5		
2N335B	NPN	GP	2N335A	500	60	60				1	5	37	
2N336	NPN	GP	2N336	150	45								
2N336A	NPN	GP	2N336A	500	45	45				1	5		
2N337	NPN	GP	2N337	125	45	30	20-55		10				
2N337A	NPN	GP	2N337	500	45	30	20-55		10			19	
2N338	NPN	GP	2N338	125	45	30	45-150		10				
2N338A	NPN	GP	2N338A	500	45	30	45-150		10			39	
2N339	NPN	GP	2N339	1W	55	55							
2N339A	NPN	GP	2N339	1W	60	60						25	10
2N340	NPN	GP	2N340	1W	85	85							
2N340A	NPN	GP	2N340	1W	85	85						25	10
2N341	NPN	GP	2N341	1W	125	85							
2N341A	NPN	GP	2N341A	1W	125	125						25	10
2N342	NPN	GP	2N342	1W	60	60							
2N342A	NPN	GP	2N342A	1W	85	85							
2N342B	NPN	GP	2N342B	750	85	85							9
2N343	NPN	GP	2N343	1W	60	60							
2N343A	NPN	GP	2N343	1W	60	60							
2N343B	NPN	GP	2N343	750	65	65						28	
2N354	PNP	GP	2N2906	150	25							9	
2N355	PNP	GP	2N2906	150	10					.15	5	9	
2N470	NPN	GP	2N2217	200	15	15				1.5	5	10	8
2N471	NPN	GP	2N2217	200	30	30				1	5	10	8
2N471A	NPN	GP	2N2217	200	30	30				1	5	10	8
2N472	NPN	GP	2N2217	200	45	45				1.5	5	10	8
2N472A	NPN	GP	2N2217	200	45	45				1	5	10	8
2N473	NPN	GP	2N2217	200	15	15				1.5	5	20	8
2N474	NPN	GP	2N2217	200	30	30				1.5	5	20	8
2N474A	NPN	GP	2N2217	200	30	30				1	5	20	8
2N475	NPN	GP	2N2217	200	45	45				1.5	5	20	8
2N475A	NPN	GP	2N2217	200	45	45				1	5	20	8
2N476	NPN	GP	2N2217	200	15	15				1.5	5	30	12
2N477	NPN	GP	2N2217	200	30	30				1.5	5	30	12
2N478	NPN	GP	2N2218	200	15	15				1.5	5	40	20
2N479	NPN	GP	2N2217	200	30	30				1.5	5	40	20
2N479A	NPN	GP	2N2217	200	30	30				1	5	40	20

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N480	NPN	GP	2N2217	200	45	45				1.5	5	40	20
2N480A	NPN	GP	2N2217	200	45	45				1	5	40	20
2N489	P-N	UJ	2N489	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N489A	P-N	UJ	2N489A	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N489B	P-N	UJ	2N489B	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N490	P-N	UJ	2N490	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N490A	P-N	UJ	2N490A	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N490B	P-N	UJ	2N490B	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N491	P-N	UJ	2N491	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N491A	P-N	UJ	2N491A	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N491B	P-N	UJ	2N491B	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N492	P-N	UJ	2N492	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N492A	P-N	UJ	2N492A	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N492B	P-N	UJ	2N492B	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N493	P-N	UJ	2N493	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N493A	P-N	UJ	2N493A	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N493B	P-N	UJ	2N493B	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N494	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N494A	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N494B	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N494C	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST									
2N495	PNP	SW	2N2944	150	25							15	
2N496	PNP	SW	2N2944	150	10		15-		15	.15	5	9	7.2
2N497	NPN	GP	2N2102	*4W	60	60	12-36		200				
2N497A	NPN	GP	2N2102	*5W	60	60	12-36		200				
2N498	NPN	GP	2N3036	*4W	100	100	12-36		200				
2N498A	NPN	GP	2N3036	*5W	100	100	12-36		200				
2N541	NPN	GP	2N2218	200	15					1.5	5	80	10
2N541A	NPN	GP	2N2218	200	15	15				1	5	80	8
2N542	NPN	GP	2N2219	200	30					1.5	5	80	10
2N542A	NPN	GP	2N2219	200	30	30				1	5	80	10
2N543	NPN	GP	2N2218	200	50	50	80-		1	1.5	5	80	10
2N543A	NPN	GP	2N2218	200	45	45				1	5	80	10
2N545	NPN	GP	2N2102	*5W	60	60	15-80		500	5	500		
2N546	NPN	GP	2N2102	*5W	30	30	15-80		500	3	500		
2N547	NPN	GP	2N2102	*5W	60	60	20-80		500	5	500		4
2N548	NPN	GP	2N2102	*5W	30	30	20-80		500	3	500		4
2N549	NPN	GP	2N2270	*5W	60	60	20-80		200	4	200		4
2N550	NPN	GP	2N2270	*5W	30	30	20-80		200	4	200		4
2N551	NPN	GP	2N2270	*5W	60	60	20-80		50	2	50		3

3

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N552	NPN	GP	2N2270	*5W	30	30	20-80	50	2	50		3
2N560	NPN	GP	2N1893	500	60	60	20-	100	.5	10		
2N619	NPN	GP		175	50	40	9-22	5	.5	8		
2N620	NPN	GP		175	50	35	18-44	5	.4	8		
2N621	NPN	GP		175	50	30	36-88	5	.3	8		
2N622	NPN	SW	2N2432	385	50	30						
2N656	NPN	GP	2N3036	*4W	60	60	30-90	200				
2N656A	NPN	GP	2N3036	*5W	60	60	30-90	200				
2N657	NPN	GP	2N3036	*4W	100	100	30-90	200				
2N657A	NPN	GP	2N3036	*5W	100	100	30-90	200				
2N696	NPN	GP	2N696	600	60		20-60	150	1.5	150		40
2N696A	NPN	GP	2N696	800	60	35	20-60	150	1.5	150	15	40
2N697	NPN	GP	2N697	600	60		40-120	150	1.5	150		40
2N697A	NPN	GP	2N697	800	60	35	40-120	150	1.5	150	25	50
2N698	NPN	GP	2N698	800	120		20-60	150	1.2	150	15	40
2N699	NPN	GP	2N699	600	120		40-120	150	5	150	35	50
2N699A	NPN	GP	2N699	800	120		40-120	150	5	150	35	50
2N699B	NPN	GP	2N699	870	120		40-120	150	1.2	50	35	60
2N702	NPN	GP	2N2220	300	25	25	20-60	10	.5	10		70
2N703	NPN	GP	2N2221	300	25	25	40-100	10	.5	10		70
2N706	NPN	SW		300	25		20-	10	.6	10		200
2N706A	NPN	SW		300	25		20-60	10	.6	10		200
2N706B	NPN	SW		300	25		20-60	10	.4	10		200
2N706C	NPN	SW		360	40		20-60	10	.4	10		200
2N707	NPN	RF		300	56		9-	10	.6	10		
2N707A	NPN	RF		500	70	40	9-50	10	.6	10		70
2N708	NPN	SW		360	40		30-120	10	.4	10		300
2N708A	NPN	SW		360	50		40-120	10	.15	10		300
2N709	NPN	SW		300	15	6	20-120	10	.3	3		600
2N709A	NPN	SW		300	15	6	30-90	10	.3	3		800
2N715	NPN	RF	2N4875	500	50	35	10-50	15	1.2	15		70
2N716	NPN	RF	2N4875	500	70	40	10-50	15	1.2	15		70
2N717	NPN	GP	2N717	400	60		20-60	150	1.5	150		40
2N718	NPN	GP	2N718	400	60		40-120	150	1.5	150		50
2N718A	NPN	GP	2N718A	500	75		40-120	150	1.5	150	30	60
2N719	NPN	GP	2N719	400	120		20-60	150	5	150	15	40
2N719A	NPN	GP	2N719A	500	120		20-60	150	1.2	50	15	40
2N720	NPN	GP	2N720	400	120		40-120	150	5	150	35	50
2N720A	NPN	GP	2N720A	500	120		40-120	150	5	150	30	50
2N721	PNP	GP	2N721	400	50		20-45	150	1.5	150	15	50

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N721A	PNP	GP	2N721	500	50		20-45	150	.5	150	15	50
2N722	PNP	GP	2N722	400	50		30-90	150	1.5	150	25	60
2N722A	PNP	GP	2N722	500	50		30-90	150	.5	150	25	60
2N726	PNP	SW	2N726	300	25	20	15-45	10	.6	10	15	140
2N727	PNP	SW	2N727	300	25	20	30-120	10	.6	10	30	140
2N728	NPN	GP	2N2217	*4W	15	15	20-200	10	.7	10		100
2N729	NPN	GP	2N2217	*4W	30	30	20-200	10	.7	10		100
2N730	NPN	GP	2N730	500	60		20-60	150	1.5	150		40
2N731	NPN	GP	2N731	500	60		40-120	150	1.5	150		25
2N734	NPN	GP	2N2221	500	80	60	15-50	5	1	10	20	
2N734A	NPN	GP	2N2221	500	80	60	15-50	5	.5	10	20	30
2N735	NPN	GP	2N956	500	80	60	30-100	5	1	10	40	
2N735A	NPN	GP	2N956	500	80	60	30-100	5	.5	10	40	60
2N736	NPN	GP	2N956	500	80	60	60-200	5	1	10	80	
2N736A	NPN	GP	2N956	500	80	60	60-200	5	.6	10	80	100
2N736B	NPN	GP	2N956	500	80	60	60-200	5	.5	10	80	100
2N738	NPN	GP	2N719	500	125	80	15-50	5	1	10	20	
2N738A	NPN	GP	2N719	500	125	80	15-50	5	.5	10	20	30
2N739	NPN	GP	2N720	500	125	80	30-100	5	1	10	40	
2N739A	NPN	GP	2N720	500	125	80	30-100	5	.5	10	40	60
2N740	NPN	GP	2N871	500	125	80	60-200	5			80	
2N740A	NPN	GP	2N871	500	125	80	60-200	5	.5	10	80	100
2N742	NPN	SW	2N2217	500	60	60	25-	10	.5	10		
2N742A	NPN	SW	2N2217	500	60	60	25-	10	.5	10		
2N743	NPN	SW		300	20	12	20-60	10	.35	10		200
2N743A	NPN	SW		360	40	15	20-60	10				500
2N744	NPN	SW		300	20	12	40-120	10	.35	10		300
2N744A	NPN	SW		360	40	15	40-120	10				500
2N745	NPN	GP	2N337	150	45	30	20-55	10			19	
2N746	NPN	GP	2N338	150	45	30	45-150	10			39	
2N747	NPN	SW	2N337A	200	25	25	30-90	10	.6	5		
2N748	NPN	SW	2N337A	200	30	30	20-40	10	.5	5		
2N749	NPN	GP	2N696	200	45	25	15-55	10			30	
2N751	NPN	GP	2N697	200	20	20	30-150	10			10	
2N753	NPN	SW		300	25	15	40-120	10	.6	10		200
2N752	NPN	GP	2N2221	500	85	45	40-	1	1.2	15	40	200
2N754	NPN	GP	2N1893	300	60		20-80	5	.8	10		30
2N755	NPN	GP	2N1893	300	100		20-80	5	.8	10		30
2N756	NPN	GP	2N2220	500	45	45			1	10	12	
2N756A	NPN	GP	2N2220	500	60	60			1	10	12	

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

3

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N757	NPN	GP	2N2221	500	45	45			1	10	18	
2N757A	NPN	GP	2N2221	500	60	60			1	10	18	
2N758	NPN	GP	2N2221	500	45	45			1	10	18	
2N758A	NPN	GP	2N2221	500	60	60			1	10	18	
2N758B	NPN	GP	2N2221	500	60	60	12-	1	.5	10	18	
2N759	NPN	GP	2N2222	500	45	45			1	10	36	
2N759A	NPN	GP	2N2222	500	60	60			1	10	36	
2N759B	NPN	GP	2N2222	500	60	60	25-	1	.5	10	36	
2N760	NPN	GP	2N2222	500	45	45			1	10	76	
2N760A	NPN	GP	2N2222	500	60	60			1	10	76	
2N760B	NPN	GP	2N2222	500	60	60			.5	10	76	
2N761	NPN	GP	2N2218A	500	50	30	20-55	10	1	10	19	
2N762	NPN	GP	2N2218A	500	50	30	45-150	10	1	10	39	
2N770	NPN	SW		150	20	15	12-60	20	.25	10		75
2N771	NPN	SW		150	20	15	30-150	20	.25	10		100
2N772	NPN	SW		150	25	25	20-	10	.25	10		75
2N773	NPN	GP		150	20	15	4-16	1.5			6	
2N774	NPN	GP		150	20	15	7-30	1.5			11	
2N775	NPN	GP		150	20	15	20-80	1.5			28	
2N776	NPN	GP		150	20	15	4-16	1.5			6	
2N777	NPN	GP		150	20	15	7-30	1.5			11	
2N778	NPN	GP		150	20	15	20-80	1.5			28	
2N780	NPN	GP	2N2220	*1W	45		35-140	.5	1	10		60
2N783	NPN	SW		300	40		20-60	10	.25	10		200
2N784	NPN	SW		300	30		25-	10	.19	10		200
2N784A	NPN	SW		350	40		25-150	10	.65	100		300
2N789	NPN	GP		150	45	30			1	5	9	
2N790	NPN	GP		150	45	30			1	5	18	
2N791	NPN	GP		150	45	30			1	5	18	
2N792	NPN	GP		150	45	30			1	5	36	
2N793	NPN	GP		150	45	30			1	5	76	
2N834	NPN	SW		300	40		25-	10	.25	10		350
2N834A	NPN	SW		360	40		25-	10	.25	10		500
2N835	NPN	SW		300	25	20	20-	10	.3	10		300
2N839	NPN	GP	2N2222	300	45	45	15-50	10	2	10	20	30
2N840	NPN	GP	2N2221A	300	45	45	30-100	10	2	10	40	30
2N841	NPN	GP	2N2222A	300	45	45	60-400	10	2	10	80	40
2N842	NPN	GP	2N2221	300	45	45	20-55	10	1.2	10	20	30
2N843	NPN	GP	2N2222	300	45	45	45-150	10	1.2	10	40	40
2N844	NPN	GP	2N718A	300	60		40-120	5	.8	10		50

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	● I_C (mA)	$V_{CE(sat)}$ MAX (V)	● I_C (mA)	h_{fe} ● 1 kHz MIN	f_T MIN (MHz)
2N845	NPN	GP	2N718A	300	100		40-120	5	.8	10		50
2N847	NPN	SW		200	20	15			1.5	10		
2N848	NPN	SW		200	40	25			1.5	10		
2N849	NPN	SW	2N849	300	25	15	20-60	10	.6	10		600
2N850	NPN	SW	2N850	300	25	15	40-120	10	.6	10		600
2N851	NPN	SW	2N851	300	20	12	20-60	10				300
2N852	NPN	SW	2N852	300	20	12	40-120	10				300
2N858	PNP	GP	2N2906	150	40	40	10-60	5	.15	5	15	5
2N859	PNP	GP	2N2906	150	40	40	25-100	5	.15	5	30	6
2N860	PNP	GP	2N2906	150	25	25	10-40	5	.15	5	15	6.5
2N861	PNP	GP	2N2906	150	25	25	25-75	5	.15	5	30	7.5
2N862	PNP	GP	2N2906	150	15	15	12-48	5	.15	5	20	8
2N863	PNP	GP	2N2906	150	15	15	25-100	5	.15	5	40	10
2N864	PNP	GP	2N2906	150	6	6	20-100	5	.1	5	25	16
2N864A	PNP	GP	2N2906	300	6	6	20-250	5	.1	5	25	16
2N865	PNP	GP	2N2906	150	10	6	45-125	5	.1	5	100	24
2N865A	PNP	GP	2N2906	300	10	10	45-400	5	.1	5	100	24
2N866	NPN	GP		500	30		15-45	150	1.5	150		40
2N867	NPN	GP		500	30		30-90	150	1.5	150		50
2N869	PNP	GP	2N2906	360	25	18	20-120	10	1	10		100
2N869A	PNP	GP	2N2906	360	25	18	40-120	30	.15	10		400
2N870	NPN	GP	2N870	500	100		40-120	150	1.2	50	30	50
2N871	NPN	GP	2N871	500	100		100-300	150	1.2	50	50	60
2N902	NPN	GP	2N2221	150	45	30			1	5	9	1
2N903	NPN	GP	2N2221	150	45	30			1	5	18	
2N904	NPN	GP	2N2221	150	45	30			1	5	18	
2N905	NPN	GP	2N2221	150	45	30			1	5	36	
2N906	NPN	GP	2N2221	150	45	30			1	5	76	
2N907	NPN	GP	2N2221	150	45	30	20-55	10			19	12
2N908	NPN	GP	2N2221	150	45	30	45-150	10			39	25
2N909	NPN	GP	2N2222	400	60		110-350	50			40	50
2N910	NPN	GP	2N910	500	100		75-	10			76	60
2N911	NPN	GP	2N911	500	100		35-	10	.4	10	36	50
2N912	NPN	GP	2N912	500	100		15-	10	.4	10	18	40
2N914	NPN	SW		360	40		30-120	10	.7	200		300
2N914A	NPN	SW		360	40		30-120	10	.4	200		300
2N915	NPN	GP	2N2222A	360	70	50	50-200	10	1	10	50	250
2N916	NPN	GP	2N2222A	360	45	25	50-200	10	.5	10	50	300
2N916A	NPN	GP	2N2222A	360	45	25	50-200	10	.5	10	50	300
2N917	NPN	RF	2N917	200	30	15	20-200	3	.5	3		500

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N917A	NPN	RF	2N917	200	30	15	20-200	3	.4	10		600
2N918	NPN	RF	2N918	200	30	15	20-	3	.4	10		600
2N919	NPN	SW		360	25	15	20-60	10	.2	10		200
2N920	NPN	SW		360	25	15	40-120	10	.2	10		200
2N921	NPN	SW		360	50	20	20-60	10	.3	10		200
2N922	NPN	SW		360	50	20	40-120	10	.3	10		200
2N923	PNP	GP	2N2906	250	40	25			.5	5	12	
2N924	PNP	GP	2N2906	250	40	25			.5	5	24	
2N925	PNP	GP	2N2906	250	50	40			.5	5	10	
2N926	PNP	GP	2N2906	250	50	40			.5	5	20	
2N927	PNP	GP	2N2906	250	70	60			.5	5	8	
2N928	PNP	GP	2N2906	250	70	60			.5	5	18	
2N929	NPN	GP	2N929	300	45	45	40-120	.01	1	10	60	30
2N929A	NPN	GP		500	60	45	40-120	.01	.5	10	60	45
2N930	NPN	GP	2N930	300	45	45	100-300	.01	1	10	150	30
2N930A	NPN	GP		500	60	45	100-300	.01	.5	10	150	45
2N930B	NPN	GP		500	60	45	100-300	.01	.5	10	150	45
2N935	PNP	GP	2N2907A	250	50	40	9-22		.3	5		
2N936	PNP	GP	2N2907A	250	50	35	18-44		.5	5		
2N937	PNP	GP	2N2907A	250	50	30	36-88		.6	5		
2N938	PNP	GP	2N2907A	250	40	35			.3	5	9	
2N939	PNP	GP	2N2907A	250	40	35			.3	5	18	
2N940	PNP	GP	2N2907A	250	40	35			.3	5	36	
2N941	PNP	GP	2N2907A	250	25		10-	1			25	16
2N942	PNP	GP	2N2907A	250	25						25	10
2N943	PNP	GP	2N2907A	250	40	18	10-	3UA			25	
2N944	PNP	GP	2N2907A	250	40	18	10-	4UA			25	
2N945	PNP	GP	2N2907A	250	50	50	10-	5UA			25	
2N946	PNP	GP	2N2907A	250	80	80	10-	5UA			25	
2N947	NPN	SW		360	20		20-	10	.4	5		200
2N956	NPN	GP	2N956	500	75		100-300	150	1.5	150	50	70
2N957	NPN	GP	2N2221	250	40	20	45-	10	1.5	10		200
2N958	NPN	SW		250	25	15	20-	10	.2	10		200
2N959	NPN	SW		250	25	15	40-	10	.2	10		200
2N978	PNP	GP	2N2906	330	30	20	15-60	150	1.5	150		40
2N981	NPN	GP	2N720A	500	80	80	36-	1	3	10	36	
2N986	NPN	GP		500	100							
2N988	NPN	GP	2N2221	300	20	10	20-120	10	.5	10		300
2N989	NPN	GP	2N2221	300	20	10	20-120	10	.5	10		300
2N995	PNP	SW		360	20	15	35-140	20	.2	20		100

TEXAS INSTRUMENTS
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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N995A	PNP	SW		360	20	15	35-140	20	.2	20		100
2N996	PNP	GP	2N2906	360	15	12	35-	20	.3	60		100
2N997	NPN	DA	2N997	500	75	40	7K-70K	100	1.6	100		
2N998	NPN	DA	2N998	500	100	60	1.6K-8K	10	1.2	50	1000	
2N999	NPN	DA	2N999	500	60	60	7K-70K	100	1.6	100		
2N1005	NPN	GP	2N2217	150	15	15	10-25	10	.6	10		
2N1006	NPN	GP	2N2218	150	15	15	25-150	10	.6	10	9	
2N1024	PNP	SW	2N3250	250	18							
2N1025	PNP	SW	2N3250	250	40						9	
2N1026	PNP	SW	2N3250	250	40						18	
2N1027	PNP	SW	2N3250	250	18						18	
2N1028	PNP	SW	2N3250	250	12						9	7.2
2N1034	PNP	GP		250	50	40			.5	8	9	
2N1035	PNP	GP		250	50	35			.4	8	18	
2N1036	PNP	GP		250	50	30			.3	8	34	
2N1037	PNP	GP		250	50	35			.5	8	9	
2N1051	NPN	GP	2N2218	500	40	40	25-	50	3	50	30	80
2N1052	NPN	GP		150	200		20-80	200	5	200		
2N1054	NPN	GP	2N3114	600	125	115	20-	200			15	8
2N1055	NPN	GP	2N3114	200	100	100	20-80	50	2	50		3
2N1060	NPN	GP	2N2217	250	40	40	17-	5	.3	5		
2N1074	NPN	GP	2N2218	250	50	40					9	
2N1075	NPN	GP	2N2218	250	50	35					18	
2N1076	NPN	GP	2N2218	250	50	30					36	
2N1077	NPN	GP	2N2218	250	50	35			1	8	9	
2N1082	NPN	GP	2N2221	200	25		10-50	10			10	7
2N1103	NPN	GP	2N2221	125	45	35	30-65	10	1.5	10	20	
2N1104	NPN	GP	2N2221	125	45	35	45-150	10	1.5	10	40	
2N1105	NPN	GP	2N698	800	60	60	12-36	200	5	200		
2N1106	NPN	GP	2N698	800	100	100	12-36	200	5	200		
2N1116	NPN	GP	2N2192	600	60	60	40-150	500	5	500		6
2N1117	NPN	GP	2N2193	600	60	60	40-150	200	4	200		4
2N1118	PNP	SW	2N3250	150	25						15	8
2N1118A	PNP	SW	2N3250	150	25		25-	15			15	8
2N1119	PNP	GP		150	10		15-	15	.15	5		7.2
2N1131	PNP	GP	2N1131	600	50	35	20-45	150	1.5	150	15	50
2N1131A	PNP	GP	2N1131	600	60	40	20-45	150	1.5	150	15	50
2N1132	PNP	GP	2N1132	600	50	35	30-90	150	1.5	150	25	60
2N1132A	PNP	GP	2N1132	600	60	40	30-90	150	1.5	150	25	60
2N1132B	PNP	GP	2N1132	600	70	45	30-90	150	1.5	150	25	60

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ $^*T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N1135	PNP	GP	2N2904	100	12	12						5.6
2N1135A	PNP	GP	2N2904	100	12	12						5.6
2N1139	NPN	GP	2N2218	100	15	15	20-200	10	.7	10		100
2N1149	NPN	GP	2N1149	150	45		9-20	1				
2N1150	NPN	GP	2N1150	150	45		18-40	1				
2N1151	NPN	GP	2N1151	150	45		18-90	1				
2N1152	NPN	GP	2N1152	150	45		36-90	1				
2N1153	NPN	GP	2N1153	150	45		76-333	1				
2N1154	NPN	GP	2N1154	750	50		9-	5				
2N1155	NPN	GP	2N1155	750	80		9-	5				
2N1156	NPN	GP	2N1156	750	120		9-	5				
2N1196	PNP	GP		350	70	70	5-30	2				
2N1197	PNP	GP		350	70	70	5-30	2				
2N1199	NPN	SW		150	20	15	12-60	20	.25	10		75
2N1199A	NPN	SW		150	20	15	12-60	20	.25	10		75
2N1200	NPN	RF		100	20	15	7-200	1.5			9	
2N1201	NPN	RF		100	20	15	7-200	1.5			9	
2N1219	PNP	SW	2N3250	250	30	25	18-	5				
2N1220	PNP	SW	2N3250	250	30	25	9-	5				
2N1221	PNP	SW	2N3250	250	30	25					18	
2N1222	PNP	SW	2N3250	250	30	25					9	
2N1223	PNP	SW	2N3250	250	40	40					6	
2N1228	PNP	GP	2N2904	400	15	15			.2	10	14	
2N1229	PNP	GP	2N2904	400	15	15			.2	10	28	
2N1230	PNP	GP	2N2904	400	35	35			.2	10	14	
2N1231	PNP	GP	2N2904	400	35	35			.2	10	28	
2N1232	PNP	GP	2N2905A	400	60	60			.2	10	14	
2N1233	PNP	GP	2N2905A	400	60	60			.2	10	28	
2N1234	PNP	GP	2N3494	400	110	110			.2	10	14	
2N1238	PNP	SW		1W	15	15			.2	10	14	
2N1239	PNP	SW		1W	15	15			.2	10	28	
2N1240	PNP	SW		1W	35	35			.2	10	14	
2N1241	PNP	SW		1W	35	35			.2	10	28	
2N1242	PNP	SW		1W	60	60			.2	10	14	
2N1243	PNP	SW		1W	60	60			.2	10	28	
2N1244	PNP	SW		1W	110	110			.2	10	14	
2N1247	NPN	GP	2N2222	30	6	6	15-	5UA				
2N1248	NPN	GP	2N2222	30	6	6	15-	.02				
2N1249	NPN	GP	2N2222	30	6	6	20-	.03				
2N1252	NPN	SW	2N2537	600	30		15-45	150	1.5	150		40

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N1252A	NPN	SW	2N2537	800	60	30	15-45	150	1.5	150		40
2N1253	NPN	SW	2N2537	600	30		30-90	150	1.5	150		50
2N1253A	NPN	SW	2N2537	800	60	30	30-90	150	1.5	150		50
2N1254	PNP	GP	2N1131	275	30	30	25-50	10	.3	10		30
2N1255	PNP	GP	2N1132	275	30	30	40-80	10	.3	10		50
2N1256	PNP	GP	2N1131	275	40	40	25-50	10	.3	10		30
2N1257	PNP	GP	2N1132	275	40	40	40-80	10	.3	10		50
2N1258	PNP	GP	2N2905	275	30	30	75-150	10	.6	10		50
2N1259	PNP	GP	2N2904	275	50	50	25-100	10	.3	10		40
2N1267	NPN	RF		150	20	15	4-16	1.5			6	
2N1268	NPN	RF		150	20	15	7-30	1.5			11	
2N1269	NPN	RF		150	20	15	20-80	1.5			28	
2N1270	NPN	RF		150	20	15	4-16	1.5			6	
2N1271	NPN	RF		150	20	15	7-30	1.5			11	
2N1272	NPN	RF		150	20	15	20-80	1.5			28	
2N1275	PNP	GP		250	100	80	9-25	1	.3	5		
2N1276	NPN	GP		150	40	30			1	5	9	
2N1277	NPN	GP		150	40	30			1	5	18	
2N1278	NPN	GP		150	40	30			1	5	37	
2N1279	NPN	GP		150	40	30			1	5	76	
2N1335	NPN	GP		800	120	45	10-150	30				70
2N1336	NPN	GP		800	120	45	10-150	30				70
2N1337	NPN	GP		800	120	45	10-150	30				70
2N1338	NPN	GP		800	80	25	10-150	30				70
2N1339	NPN	GP		800	120	50	10-150	30				70
2N1340	NPN	GP		800	120	50	10-150	30				70
2N1341	NPN	GP		800	120	50	10-150	30				70
2N1342	NPN	GP		800	150	65	10-150	30				70
2N1386	NPN	GP	2N2222	300	25	25	30-90	10	.6	5		
2N1387	NPN	GP	2N2222	300	30	30	20-40	10	.5	5		
2N1388	NPN	GP	2N2222	300	45	25	15-55	10			30	
2N1389	NPN	GP	2N2222	300	50	50			.8	5		24
2N1390	NPN	GP	2N2222	300	20	20	30-150	10			10	
2N1409	NPN	SW	2N2537	600	30	25	15-45	150				200
2N1409A	NPN	SW	2N2537	800	30	25	15-45	150				200
2N1410	NPN	SW	2N2537	600	45	30	30-90	150				130
2N1410A	NPN	SW	2N2537	800	30	30	30-90	150				130
2N1417	NPN	GP	2N2218	150	15	15					30	
2N1418	NPN	GP	2N2218	150	30	30					30	
2N1420	NPN	GP	2N1420	600	60		100-300	150	1.5	150		50

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TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N1420A	NPN	GP	2N1420	800	60		100-300	150	1.5	150		60
2N1428	PNP	GP		100	6	6	12-	5	.1	5	25	16
2N1429	PNP	GP	2N2904	100	6	6	12-	5	.1	5	25	16
2N1439	PNP	GP	2N2907A	400	50	50			.25	5	9	
2N1440	PNP	GP	2N2907A	400	60	50			.25	5	9	
2N1441	PNP	GP	2N2907A	400	50	35			.25	5	18	
2N1442	PNP	GP	2N2907A	400	50	30			.25	5	30	
2N1443	PNP	GP	2N2907	400	50	15			.25	5	50	
2N1444	NPN	GP		500	60	20	20-	250	1.5	250		
2N1469	PNP	GP	2N2906	250	40						36	
2N1472	NPN	SW		150	25	25	20-	10	.25	10		75
2N1474	PNP	GP	2N2906A	250	60						12	
2N1474A	PNP	GP	2N2906A	250	60						18	
2N1475	PNP	GP	2N2906A	250	60						36	
2N1476	PNP	GP	2N3495	250	100						12	
2N1477	PNP	GP	2N3495	250	100						30	
2N1491	NPN	GP	2N2218	*3W	30						15	
2N1492	NPN	GP	2N2192	*3W	60						15	
2N1493	NPN	GP	2N5059	*3W	100						15	
2N1507	NPN	GP	2N1507	600	60		100-300	150	1.5	150		50
2N1508	NPN	GP	2N2102	1W	100	55	20-60	600	3.6	600		50
2N1509	NPN	GP	2N2102	1W	60	35	20-60	600	3.6	600		50
2N1528	NPN	GP	2N2218	150	25						10	
2N1564	NPN	GP	2N2218	600	80	60	15-50	5	1	10	20	
2N1565	NPN	GP	2N2218	600	60	30	30-100	5	1	10	40	
2N1566	NPN	GP	2N1566	600	80	60	60-200	5	1	10	80	
2N1572	NPN	GP	2N698	600	125	80	15-50	5	1	10	20	
2N1573	NPN	GP	2N1893	600	125	80	30-100	5	1	10	40	
2N1574	NPN	GP	2N1890	600	125	80	60-200	5	1	10	80	
2N1586	NPN	GP		125	15	10	5-27	1	1.5	5	9	
2N1587	NPN	GP		125	30	20	5-27	1	1.5	5	9	
2N1588	NPN	GP		125	60	40	5-27	1	1.5	5	9	
2N1589	NPN	GP		125	15	10	20-75	1	1.5	5	25	
2N1590	NPN	GP		125	30	20	20-75	1	1.5	5	25	
2N1591	NPN	GP		125	60	40	20-75	1	1.5	5	25	
2N1592	NPN	GP		125	15	10	40-210	1	1.5	5	70	
2N1593	NPN	GP		125	30	20	40-210	1	1.5	5	70	
2N1594	NPN	GP		125	60	40	40-210	1	1.5	5	70	
2N1606	PNP	SW		100	10		6-30	15	.15	5		7.2
2N1607	PNP	SW		100	10		6-30	15	.15	5		10

TEXAS INSTRUMENTS
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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS V_{CBO} (V)	MAXIMUM RATINGS V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N1608	PNP	SW		100	10		6-30	15	.15	5		25
2N1613	NPN	GP	2N1613	800	75		40-120	150	1.5	150	30	60
2N1613A	NPN	GP	2N1613	1W	75		40-120	150	1	150	30	60
2N1613B	NPN	GP	2N2243	1W	120		40-120	150	.2	150	30	60
2N1615	NPN	GP	TIS101	600	100	100	25-	5	5	50		2
2N1623	PNP	GP	2N2904	250	50	20	9-40	1	.3	5		
2N1640	PNP	SW		250	30		6-	.1				
2N1641	PNP	SW		250	30		10-	.1				
2N1642	PNP	SW		250	30		15-	.1				
2N1643	PNP	SW		250	25		10-25	.1				
2N1644	NPN	GP	2N2218	*2W	60		40-120	150	1.5	150		50
2N1654	PNP	GP	2N3495	250	100	80	20-45	1	.3	5		
2N1655	PNP	GP	2N3495	250	125	100	10-20	1	.3	5		
2N1656	PNP	GP	2N3495	250	125	100	20-45	1	.3	5		
2N1663	NPN	SW		150	20	15	30-150	20	.25	10		100
2N1671	P-N	UJ	2N1671	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N1671A	P-N	UJ	2N1671A	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N1671B	P-N	UJ	2N1671B	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N1674	NPN	GP	2N2218	200	45	45			1.5	5	50	20
2N1676	PNP	SW		100	4.5				.1	5		16
2N1677	PNP	SW		100	4.5				.1	5	25	16
2N1679	NPN	GP	2N2102	1W	100	55	40-120	600	3.6	600		50
2N1680	NPN	GP	2N2102	1W	60	35	40-120	600	3.6	600		50
2N1682	NPN	SW	2N2537	500	25		20-	10	.6	10		200
2N1700	NPN	GP	2N2102	*5W	60		20-80	100	12.5	2.5	A	
2N1704	NPN	GP	2N2218	150	45	45	50-200	1	1	10	40	
2N1708	NPN	SW		*1W	25	12	20-	10	.22	10		200
2N1708A	NPN	SW		300	40		30-120	10	.22	10		300
2N1711	NPN	GP	2N1711	800	75		100-300	150	1.5	150	50	70
2N1711A	NPN	GP	2N1711	1W	75		100-300	150	1	150	50	70
2N1711B	NPN	GP	2N1711	1W	120		100-300	150	.2	150	50	70
2N1763	NPN	SW	2N2537	300	40	25			1.5	10		
2N1764	NPN	SW	2N2537	300	20	15			1.5	10		
2N1837	NPN	GP	2N2218	800	80	30	40-120	150	.8	150		140
2N1837A	NPN	GP	2N2218	800	80	30	40-120	150	.8	150		140
2N1837B	NPN	GP	2N2218	800	80	30	40-120	150	.8	150		140
2N1838	NPN	GP	2N2218	600	45	20	40-150	100	1.4	100		90
2N1839	NPN	GP	2N2217	600	45	20	12-50	100	1.4	150		90
2N1840	NPN	GP	2N2218	600	25	15	10-100	150	1.4	150		90
2N1889	NPN	GP	2N1889	800	100		40-120	150	5	150	30	50

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TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N1890	NPN	GP	2N1890	800	100		100-300	150	5	150	50	60
2N1893	NPN	GP	2N1893	800	120		40-120	150	5	150	30	50
2N1917	PNP	SW		250	25	8					25	16
2N1918	PNP	SW		250	25	8					25	10
2N1919	PNP	SW		250	40	18						
2N1920	PNP	SW		250	40	18						
2N1921	PNP	SW		250	50	50						
2N1922	PNP	SW		250	80	80						
2N1923	NPN	GP	2N2243	750	85	85	4-90		7	20	28	
2N1941	NPN	GP	2N2219A	600	45		30-150	10	1.5	5	40	60
2N1943	NPN	GP	2N2192	800	60	60	30-90	200	5	200	12	
2N1944	NPN	GP	2N2219A	600	20		150-450	1			100	60
2N1945	NPN	GP	2N2219A	600	30		150-450	1			100	60
2N1946	NPN	GP	2N2219A	600	40		150-450	1			100	60
2N1947	NPN	GP		600	20		500-800	100			100	60
2N1948	NPN	GP		600	30		500-800	100			100	60
2N1949	NPN	GP		600	40		500-800	100			100	60
2N1950	NPN	GP		600	20		250-500	100			75	60
2N1951	NPN	GP		600	30		250-500	100			75	60
2N1952	NPN	GP		600	40		250-500	100			75	60
2N1953	NPN	GP		600	20		15-150	10			28	40
2N1958	NPN	SW	2N2537	600	60		20-60	150	.45	150		100
2N1958A	NPN	SW	2N2537	600	60		20-60	150	.45	150		100
2N1959	NPN	SW		600	60		40-120	150	.45	150		
2N1959A	NPN	SW	2N2537	600	60		40-120	150	.45	150		100
2N1962	NPN	SW	2N2537	400	40		20-60	10	.25	10		200
2N1963	NPN	SW	2N2537	400	30		25-	10	.16	10		200
2N1964	NPN	SW	2N2539	400	60		20-60	150	.45	150		100
2N1965	NPN	SW	2N2539	400	60		40-120	150	.45	150		100
2N1972	NPN	GP	2N2219	600	60		110-350	50	2	50	40	50
2N1973	NPN	GP	2N1973	800	100		75-	10	1.2	50	76	60
2N1974	NPN	GP	2N1974	800	100		35-	10	1.2	50	36	50
2N1975	NPN	GP	2N1975	800	100		15-	10	1.2	50	18	40
2N1983	NPN	GP	2N2218	600	50	25					70	40
2N1984	NPN	GP	2N2217	600	50	25					35	40
2N1985	NPN	GP	2N2217	600	50	25					15	40
2N1986	NPN	GP	2N2219	600	50	25	60-240	150				40
2N1987	NPN	GP	2N2217	600	50	25	20-80	150				40
2N1988	NPN	GP	2N2218A	600	100	45	35-120	30	2	30	20	40
2N1989	NPN	GP	2N2217	600	100	45	20-60	30	2	30	10	40

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N1991	PNP	GP	2N2904	600	30	20	15-60	150	1.5	150		40
2N1992	NPN	GP	2N2221	350	15	15	30-120	1	.25	10		300
2N2002	PNP	SW		250	30	5						
2N2003	PNP	SW		250	30	5						
2N2004	PNP	SW		250	50	15	12-	1			15	
2N2005	PNP	SW		250	50	15						
2N2006	PNP	SW		250	60	35						
2N2007	PNP	SW		250	60	35						
2N2008	NPN	GP	2N3114	800	175	110	30-90	10	2.5	25	20	40
2N2017	NPN	GP	2N2270	1W	60	60	50-200	200			30	
2N2038	NPN	GP	2N2217	600	45	45	12-36	200	6	200		2
2N2039	NPN	GP	2N698	600	75	75	12-36	200	6	200		2
2N2040	NPN	GP	2N2218	600	45	45	30-90	200	6	200		2
2N2041	NPN	GP	2N1893	600	75	75	30-90	200	6	200		2
2N2049	NPN	GP	2N2219A	800	75		100-300	150	.4	10	75	50
2N2060	NPN	DU	2N2060	500	100		50-150	10	1.2	50	50	60
2N2060A	NPN	DU	2N2060	500	100	60	50-150	10	.6	50	50	60
2N2060B	NPN	DU	2N2060	500	100							
2N2086	NPN	SW		600	120		20-	150	.7	150		150
2N2087	NPN	SW		600	120		40-120	150	.5	150		150
2N2102	NPN	GP	2N2102	*5W	120	65	35-	10	.5	150	35	
2N2102A	NPN	GP	2N2102A	*5W	120	65	40-120	150	.3	150	30	
2N2104	PNP	SW	2N2904	800	50	35	25-80	150	1.5	150		60
2N2105	PNP	SW	2N2904	800	50	35	15-40	150	1.5	150		50
2N2106	NPN	GP	2N696	1W	60		12-36	200	5	200		
2N2107	NPN	GP	2N697	1W	60		30-90	200	2	200		
2N2108	NPN	GP	2N1711	1W	60		75-200	200	2	200		
2N2160	P-N	UJ	2N2160	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2161	NPN	SW	2N2222	200	55	35	60-160	10	1.5	10	75	
2N2162	PNP	SW	2N2946	150	30	30						14
2N2163	PNP	SW	2N2945	150	15	15						14
2N2164	PNP	SW	2N2944	150	12	8						24
2N2165	PNP	SW	2N2946	150	30	30						10
2N2166	PNP	SW	2N2945	150	15	15						10
2N2167	PNP	SW	2N2944	150	12	8						16
2N2175	PNP	GP		100	6	6	30-	.02				10
2N2176	PNP	GP		100	6	6	30-	.02				10
2N2177	PNP	GP		100	6	6	15-	5UA			50	
2N2178	PNP	GP		100	6	6	15-	5UA			50	
2N2181	PNP	SW	2N2945	150	25	25	10-	5				6

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	MAXIMUM RATINGS V_{CBO} (V)	MAXIMUM RATINGS V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2182	PNP	SW	2N2945	150	25	25	10-	5				6
2N2183	PNP	SW	2N2944	150	15	10	10-	5				6
2N2184	PNP	SW	2N2944	150	15	10	10-	5				6
2N2185	PNP	SW	2N2946	150	30	30						6.5
2N2186	PNP	SW	2N2946	150	30	30						6.5
2N2187	PNP	SW	2N2946	150	30	30						6.5
2N2192	NPN	GP	2N2192	800	60	40	100-300	150	.35	150		50
2N2192A	NPN	GP	2N2192A	800	60	40	100-300	150	.25	150		50
2N2192B	NPN	GP	2N2192A	800	60	40	100-300	150	.18	150		
2N2193	NPN	GP	2N2193	800	80	50	40-120	150	.35	150		50
2N2193A	NPN	GP	2N2193A	800	80	50	40-120	150	.25	150		50
2N2193B	NPN	GP	2N2193A	800	80	50	40-120	150	.18	150		
2N2194	NPN	GP	2N2194	800	60	40	20-60	150	.35	150		50
2N2194A	NPN	GP	2N2194A	800	60	40	20-60	150	.25	150		50
2N2194B	NPN	GP	2N2194A	800	60	40	20-60	150	.18	150		
2N2195	NPN	GP	2N2243	800	45	25	20-	150	.35	150		
2N2195A	NPN	GP	2N2243	800	45	25	20-	150	.25	150		
2N2195B	NPN	GP	2N2243	800	45	25	20-	150	.18	150		
2N2198	NPN	GP	2N2102	*8W	80	80	35-55	100	6	200		4
2N2205	NPN	SW		*1W	25	12	20-	10	.22	10		
2N2214	NPN	SW		250	25	15	25-	10	.2	10		200
2N2216	PNP	SW		*3W	150	100	25-120	50	5	50		50
2N2217	NPN	GP	2N2217	800	60	30	20-60	150	.4	150		250
2N2218	NPN	GP	2N2218	800	60	30	40-120	150	.4	150		250
2N2218A	NPN	GP	2N2218A	800	75	40	40-120	150	.3	150	30	250
2N2219	NPN	GP	2N2219	800	60	30	100-300	150	.4	150		250
2N2219A	NPN	GP	2N2219A	800	75	40	100-300	150	.3	150	50	300
2N2220	NPN	GP	2N2220	500	60	30	20-60	150	.4	150		250
2N2221	NPN	GP	2N2221	500	60	30	40-120	150	.4	150		250
2N2221A	NPN	GP	2N2221A	500	75	40	40-120	150	.3	150	30	250
2N2222	NPN	GP	2N2222	500	60	30	100-300	150	.4	150		250
2N2222A	NPN	GP	2N2222A	500	75	40	100-300	150	.3	150	50	300
2N2222B	NPN	GP	2N2222B	500	75	40	100-300	150	.3	150	50	300
2N2223	NPN	DU	2N2223	500	100		50-200	10	1.2	50	40	50
2N2223A	NPN	DU	2N2223A	500	100		50-200	10	1.2	50	40	50
2N2224	NPN	GP	2N2218A	800	65	40	35-115	10	.4	150		250
2N2236	NPN	GP	2N2218	575	40	20	15-60	100	.25	100		50
2N2237	NPN	GP	2N2218	575	40	20	40-125	100	.25	100		
2N2239	NPN	GP		1W	60		30-200	200	3	200		
2N2240	NPN	GP	2N2218	600	25	20	40-100	1	1	50		50

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2241	NPN	GP	2N2219A	600	25	20	100-200	1	1	50		50
2N2242	NPN	SW		360	40	15	40-120	10	.7	100		250
2N2243	NPN	GP	2N2243	800	120	80	40-120	150	.35	150		50
2N2243A	NPN	GP	2N2243A	800	120	80	40-120	150	.25	150		50
2N2244	NPN	GP	2N2220	500	20	20	5-15	2UA	.2	1	40	60
2N2245	NPN	GP	2N2220	500	20	20	10-30	2UA	.2	1	80	60
2N2246	NPN	GP	2N2220	500	20	20	5-15	2UA	.2	1	40	60
2N2247	NPN	GP	2N2220	500	45	45	5-15	2UA	.2	1	40	60
2N2248	NPN	GP	2N2220	500	45	45	10-30	2UA	.2	1	80	60
2N2249	NPN	GP	2N2221	500	45	45	20-60	2UA	.2	1	150	60
2N2250	NPN	GP	2N2220	500	25	20	5-15	2UA	.2	1	40	60
2N2251	NPN	GP	2N2220	500	25	20	10-30	2UA	.2	1	80	60
2N2252	NPN	GP	2N2221	500	25	20	20-60	2UA	.2	1	150	60
2N2253	NPN	GP	2N2220	500	45	50	5-15	2UA	.2	1	40	60
2N2254	NPN	GP	2N2220	500	45	50	10-30	2UA	.2	1	80	60
2N2255	NPN	GP	2N2221	500	45	50	20-60	2UA	.2	1	150	60
2N2256	NPN	SW		300	7		17-	10				
2N2257	NPN	SW		300	7		40-	10				
2N2270	NPN	GP	2N2270	*5W	60	45	30-	1	.9	150	50	
2N2272	NPN	GP	2N929	360	40		80-240	10	.7	200		
2N2274	PNP	SW	2N2946	150	25	25	10-	5				6
2N2275	PNP	SW	2N2946	150	25	25	10-	5				6
2N2276	PNP	SW	2N2944	150	15	10	10-	5				6
2N2277	PNP	SW	2N2944	150	15	10	10-	5				6
2N2278	PNP	SW	2N2945	150	15	15						7.6
2N2279	PNP	SW	2N2945	150	15	15						7.6
2N2280	PNP	SW	2N2944	150	10	6			.1	5		16
2N2297	NPN	GP	2N3036	800	80	35	40-120	150	.2	150		60
2N2303	PNP	GP	2N2303	600	50		75-200	150	1.5	150		60
2N2307	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2309	NPN	GP	2N2218	600	30	30	25-125	.2			40	
2N2310	NPN	GP		350	60	60	12-36	200	5	200		
2N2311	NPN	GP		350	100	100	12-36	200	5	200		
2N2312	NPN	GP		350	60	60	30-90	200	5	200		
2N2313	NPN	GP		350	100	100	30-90	200	5	200		
2N2314	NPN	GP		350	60		20-60	150	5	150	15	40
2N2315	NPN	GP		350	60		40-120	150	1.5	150	25	50
2N2316	NPN	GP		350	120		40-120	150	5	150	30	50
2N2317	NPN	GP		350	75		40-120	150	1.5	150	30	60
2N2318	NPN	SW		360	30		15-	.1	.35	20		300

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TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A=25°C$ *$T_C=25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2319	NPN	SW		300	30		15-	.1	.35	20		300
2N2320	NPN	SW		600	30		15-	.1	.35	20		300
2N2330	NPN	SW		800	30	20	50-	10				100
2N2331	NPN	SW	2N2432	500	30	20	50-	10				100
2N2332	PNP	SW		150	15	15						
2N2333	PNP	SW		150	15	5						
2N2334	PNP	SW		150	30	15						
2N2335	PNP	SW		150	30	15						
2N2336	PNP	SW		150	50	35						
2N2337	PNP	SW		150	50	35						
2N2349	NPN	GP	2N929	150	40	24	120-250	10	1.5	10	60	
2N2350	NPN	GP	2N2222A	400	60	40	100-300	150	.35	150		250
2N2350A	NPN	GP	2N2222A	400	60	40	100-300	150	.25	150		250
2N2351	NPN	GP	2N2193	400	80	50	40-120	150	.35	150		250
2N2351A	NPN	GP	2N2193	400	80	50	40-120	150	.25	150		250
2N2352	NPN	GP	2N2194	400	60	40	20-60	150	.35	150		250
2N2352A	NPN	GP	2N2194	400	60	40	20-60	150	.25	150		250
2N2353	NPN	GP	2N2221	400	45	25	20-	150	.35	150		250
2N2353A	NPN	GP	2N2221	400	45	25	20-	150	.25	150		250
2N2356	NPN	SW		600	25	7						50
2N2356A	NPN	SW		600	25	7						50
2N2364	NPN	SW		400	120	80	40-120	150	.35	150		50
2N2364A	NPN	SW		400	120	80	40-120	150	.25	150		50
2N2368	NPN	SW		360	40		20-60	10	.25	10		400
2N2369	NPN	SW		390	40		40-120	10	.25	10		500
2N2369A	NPN	SW		360	40		40-120	10	.35	10		500
2N2370	PNP	GP		200	15	15	15-	25U			15	
2N2371	PNP	GP		200	15	15	20-	25U			20	
2N2372	PNP	GP	2N3798	150	15	15	15-	25U			15	
2N2373	PNP	GP	2N3798	150	15	15	20-	25U			20	
2N2377	PNP	SW		150	25	25	10-100	5			15	8
2N2378	PNP	SW		150	10	10	15-	15				7.2
2N2380	NPN	GP	2N2193	600	80	40	20-120	150	1.3	150		100
2N2380A	NPN	GP	2N2193	600	80	40	20-120	150	1.3	150		100
2N2386	PCH	FE	2N2386	SEE FET INTERCHANGEABILITY LIST								
2N2386A	PCH	FE	2N2386A	SEE FET INTERCHANGEABILITY LIST								
2N2387	NPN	GP	2N2387	300	45	45	40-120	.01	1	10	60	30
2N2388	NPN	GP	2N2388	300	45	45	100-300	.01	1	10	150	30
2N2389	NPN	GP	2N2389	450	75		40-120	150	1.5	150	30	60
2N2390	NPN	GP	2N2390	450	75		100-300	150	1.5	150	50	70

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2391	PNP	GP		300	25	20	15-45	10	.6	10	15	140
2N2392	PNP	GP		300	25	20	30-90	10	.6	10	30	140
2N2393	PNP	GP	2N2393	450	50	35	20-45	150	1.5	150	15	50
2N2394	PNP	GP	2N2394	450	50	35	30-90	150	1.5	150	25	60
2N2395	NPN	GP	2N2395	450	60	40	20-60	150	1	150		40
2N2396	NPN	GP	2N2396	450	60	40	40-120	150	1	150		50
2N2397	NPN	SW		300	35	15	25-120	10	.3	10		200
2N2403	NPN	SW		1W	60	60	20-60	600	1.5	600		147
2N2404	NPN	SW		1W	60	60	40-120	600	1.5	600		147
2N2405	NPN	GP	2N1893	*5W	120	90	40-200	150	.5	150	50	
2N2410	NPN	SW	2N2410	800	60	30	30-120	10				200
2N2411	PNP	SW		300	25	20	20-60	10	.2	10		140
2N2412	PNP	SW		300	25	20	40-120	10	.2	10		140
2N2413	NPN	GP	2N2221	300	40	18	30-120	10	.4	10		300
2N2414	NPN	DU	2N2060	500	60		50-250	10	1.2	50	50	50
2N2417	P-N	UJ	2N489	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2417A	P-N	UJ	2N489A	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2417B	P-N	UJ	2N489B	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2418	P-N	UJ	2N490	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2418A	P-N	UJ	2N490A	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2418B	P-N	UJ	2N490B	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2419	P-N	UJ	2N491	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2419A	P-N	UJ	2N491A	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2419B	P-N	UJ	2N491B	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2420	P-N	UJ	2N492	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2420A	P-N	UJ	2N492A	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2420B	P-N	UJ	2N492B	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2421	P-N	UJ	2N493	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2421A	P-N	UJ	2N493A	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2421B	P-N	UJ	2N493B	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2422	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2424	PNP	SW		375	40	5	30-200	5	.3	15		
2N2425	PNP	SW		375	50	10	25-110	5	.3	15		
2N2427	NPN	SW		500	40	40	20-60	.01			40	50
2N2432	NPN	SW	2N2432	300	30	30	50-	1	.15	10		20
2N2432A	NPN	SW	2N2432A	300	45	45	50-	1	.15	10		20
2N2433	NPN	SW		500	75	45	40-120	150	1.5	150	30	80
2N2434	NPN	SW		500	75	45	100-300	150	1.5	150	50	90
2N2435	NPN	SW		500	120	80	40-120	150	3	150	30	80
2N2436	NPN	SW		500	120	80	100-300	150	3	150	50	90

TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2437	NPN	SW		500	100	75	15-	10	.2	10	18	70
2N2438	NPN	SW		500	100	75	35-	10	.4	50	36	80
2N2439	NPN	SW		500	100	75	75-	10	.4	50	76	90
2N2440	NPN	GP	2N2102	300	120	80	100-300	150	.4	50	50	90
2N2443	NPN	GP	2N2102	800	120	100	50-150	50	1.2	50	45	50
2N2452	NPN	GP		500	100							
2N2453	NPN	DU	2N2453	500	60	30	150-600	1	1	5	150	60
2N2453A	NPN	DU	2N2453	500	80	50	150-600	1	1	5	150	60
2N2459	NPN	GP		400	100	60	10-	.1	.3	10	40	100
2N2460	NPN	GP		400	100	60	20-	.1	.3	10	70	120
2N2461	NPN	GP		400	100	60	40-	.1	.3	10	115	140
2N2462	NPN	GP		400	100	60	60-	.1	.3	10	160	160
2N2463	NPN	GP		500	100	60	10-	.1	.3	10	40	100
2N2464	NPN	GP		500	100	60	20-	.1	.3	10	70	120
2N2465	NPN	GP		500	100	60	40-	.1	.3	10	115	140
2N2466	NPN	GP		500	100	60	60-	.1	.3	10	160	160
2N2475	NPN	SW		300	15	6	20-	50				600
2N2476	NPN	SW		*2W	60	20	20-	150	.4	150		250
2N2477	NPN	SW		*2W	60	20	40-	150	.4	150		250
2N2478	NPN	GP	2N2218	600	120	40	30-	150	.7	150		200
2N2479	NPN	GP	2N2218	600	80	40	30-120	150	.85	150	60	150
2N2480	NPN	DU	2N2060	300	75	40	30-350	1	1.3	50		50
2N2480A	NPN	DU	2N2060	300	80	40	50-200	1	1.2	50	50	50
2N2481	NPN	SW		400	40	15	40-120	10	.25	10		300
2N2483	NPN	GP	2N2483	360	60	60	40-120	.01	.35	1	80	12
2N2484	NPN	GP	2N2484	360	60	60	100-500	.01	.35	1	150	15
2N2484A	NPN	GP	2N2484	360	60	60	100-500	.01	.35	1	150	60
2N2497	PCH	FE	2N2497	SEE FET INTERCHANGEABILITY LIST								
2N2498	PCH	FE	2N2498	SEE FET INTERCHANGEABILITY LIST								
2N2499	PCH	FE	2N2499	SEE FET INTERCHANGEABILITY LIST								
2N2500	PCH	FE	2N2500	SEE FET INTERCHANGEABILITY LIST								
2N2501	NPN	SW	2N2537	360	40	20	50-150	10				350
2N2509	NPN	GP		400	125	80	25-	.01	1	5		45
2N2510	NPN	GP		400	100	65	150-500	10	1	5		45
2N2511	NPN	GP	2N3117	400	80	50	240-750	10	1	5		45
2N2514	NPN	GP		400	80	60	15-50	5	.5	10	20	30
2N2515	NPN	GP		400	80	60	30-100	5	.5	10	40	60
2N2516	NPN	GP		400	80	60	60-200	5	.5	10	80	100
2N2517	NPN	GP		400	125	80	15-50	5	.5	10	20	30
2N2518	NPN	GP		400	125	80	30-100	5	.5	10	40	60

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2519	NPN	GP		400	125	80	60-200	5	.5	10	80	100
2N2520	NPN	GP		400	60	60	12-	1	.5	10	18	
2N2521	NPN	GP		400	60	60	25-	1	.5	10	36	
2N2522	NPN	GP		400	60	60	50-	1	.5	10	76	
2N2523	NPN	GP	2N929	400	60	45	40-120	.01	.5	10	60	45
2N2524	NPN	GP	2N930	400	60	45	100-300	.01	.5	10	150	45
2N2529	NPN	GP		150	45	40	10-20	1	2	10	12	
2N2530	NPN	GP		150	45	40	12-35	1	2	10	18	
2N2531	NPN	GP		150	45	40	20-80	1	2	10	36	
2N2532	NPN	GP		150	45	40	45-185	1	2	10	76	
2N2533	NPN	GP		150	45	40	20-55	10	1.5	10	19	
2N2534	NPN	GP		150	45	40	45-150	10	1.5	10	39	
2N2537	NPN	SW	2N2537	800	60	30	50-150	150	.45	150		250
2N2538	NPN	SW	2N2538	800	60	30	100-300	150	.45	150		250
2N2539	NPN	SW	2N2539	500	60	30	50-150	150	.45	150		250
2N2540	NPN	SW	2N2540	500	60	30	100-300	150	.45	150		250
2N2551	PNP	GP		400	150	150	15-45	100	1.2	100		
2N2569	NPN	SW		300	20	5	50-	.1				100
2N2570	NPN	SW		300	20	5	50-	.1				100
2N2571	NPN	SW		300	20	15	50-	100				100
2N2572	NPN	SW		300	20	15	50-	100				
2N2586	NPN	GP	2N2586	300	60	45	120-360	.01	.5	10	150	
2N2590	PNP	GP		400	100	60	10-	.1	.4	10	40	50
2N2591	PNP	GP		400	100	60	20-	.1	.4	10	70	70
2N2592	PNP	GP		400	100	60	40-	.1	.4	10	115	90
2N2593	PNP	GP		400	100	60	60-	.1	.4	10	160	110
2N2594	NPN	GP	2N3036	*5W	80		50-150	100	1	200	15	40
2N2595	PNP	GP	2N3496	400	80	60	15-60	5	.5	10	20	30
2N2596	PNP	GP	2N3496	400	80	60	30-120	5	.5	10	40	40
2N2597	PNP	GP	2N3496	400	80	60	60-240	5	.5	10	80	60
2N2598	PNP	GP	2N3497	400	125	80	15-60	5	.5	10	20	30
2N2599	PNP	GP	2N3497	400	125	80	30-120	5	.5	10	40	40
2N2599A	PNP	GP	2N3497	400	125	100	30-120	5	.5	10	40	40
2N2600	PNP	GP	2N3497	400	125	80	60-240	5	.5	10	80	60
2N2600A	PNP	GP	2N3497	400	125	100	60-240	5	.5	10	80	60
2N2601	PNP	GP	2N3798	400	60	60	12-	1	.5	10	18	20
2N2602	PNP	GP	2N3798	400	60	60	25-	1	.5	10	36	40
2N2603	PNP	GP	2N3799	400	60	60	50-	1	.5	10	76	60
2N2604	PNP	GP	2N2604	400	60	45	40-	.01	.5	10	60	30
2N2605	PNP	GP	2N2605	400	60	45	100-	.01	.5	10	150	30

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2605A	PNP	GP	2N3799	400	60	45	50-200	1UA	.25	10	200	45
2N2606	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N2607	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N2608	PCH	FE	2N2608	SEE FET INTERCHANGEABILITY LIST								
2N2609	PCH	FE	2N2609	SEE FET INTERCHANGEABILITY LIST								
2N2610	NPN	GP		150	45	40			1	5	9	
2N2615	NPN	RF	2N918	300	30	15	20-200	3	.5	3		500
2N2616	NPN	RF	2N918	300	30	15	20-200	3	.4	10		600
2N2617	PNP	GP		250	25		15-80	20			25	
2N2618	NPN	GP	2N2219	600	60	40	25-	10			30	200
2N2631	NPN	GP		*8W		80	8-	200				
2N2639	NPN	DU	2N2639	300	45	45	50-300	.01	1	10	65	35
2N2640	NPN	DU	2N2640	300	45	45	50-300	.01	1	10	65	35
2N2641	NPN	DU	2N2641	300	45	45	50-300	.01	1	10	65	35
2N2642	NPN	DU	2N2642	300	45	45	100-300	.01	1	10	130	35
2N2643	NPN	DU	2N2643	300	45	45	100-300	.01	1	10	130	35
2N2644	NPN	DU	2N2644	300	45	45	100-300	.01	1	10	130	35
2N2645	NPN	GP	2N2222A	500	75		100-300	150	.4	10	75	50
2N2646	P-N	UJ	2N2646	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2647	P-N	UJ	2N2647	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2651	NPN	SW		360	40	20	25-	10	.25	10		350
2N2652	NPN	DU	2N2223A	300	100	60	50-200	1	1.2	50	50	60
2N2652A	NPN	DU	2N2223A	300	100	60	50-200	1	1.2	50	50	60
2N2656	NPN	GP	2N2222	360	25	15	40-160	.1	.5	10		250
2N2673	NPN	GP		250	60	45	8-22	1	1.5	5	9	
2N2674	NPN	GP		250	60	45	12-40	1	1.5	5	18	
2N2675	NPN	GP		250	60	45	22-76	1	1.5	5	37	
2N2676	NPN	GP	2N2222A	250	60	45	45-290	1	1.5	5	76	
2N2677	NPN	GP	2N2220	250	45	35	20-55	1	1.5	5	19	
2N2678	NPN	GP	2N2221	250	45	35	45-150	1	1.5	5	39	
2N2692	NPN	GP	2N2483	300	45	30	90-360	.1	.12	.1		42
2N2693	NPN	GP	2N2483	300	45	30	40-	.01	.12	.1		42
2N2694	NPN	GP	2N929	300	45	20	20-	.01	.12	.1		42
2N2695	PNP	GP	2N3485	360	25	25	30-130	50	.25	50	25	100
2N2708	NPN	RF	2N918	200	35	20	30-200	2			30	
2N2709	PNP	GP		240	50	35	10-22	.2	.4	8		
2N2710	NPN	SW		360	40	20	40-	10	.25	10		500
2N2711	NPN	RF		200	18	18	30-90	2				
2N2712	NPN	RF		200	18	18	75-225	2				
2N2713	NPN	GP	2N3705	360	18	18	30-90	2	.3	50		

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2714	NPN	GP	2N3704	360	18	18	75-225	2	.3	50		
2N2719	NPN	SW		300	25	8	30-	60	.4	60		200
2N2720	NPN	DU	2N2223	300	80	60	30-120	.1	1	10	30	80
2N2721	NPN	DU	2N2223A	300	80	60	30-120	.1	1	10	30	80
2N2722	NPN	DU	2N3680	300	45	45	50-250	1UA	1	10	100	100
2N2723	NPN	DA	2N998	500	80	60	25-105	10	1	10	1.5K	100
2N2724	NPN	DA	2N997	500	80	60	7K-50K	10	1	10	5K	100
2N2725	NPN	DA	2N998	500	45	45	2K-10K	.1	1	10	1.5K	100
2N2729	NPN	RF	2N918	300	30	15	20-200	3	.4	10		600
2N2715	NPN	GP		200	18	18	30-90	2			30	
2N2716	NPN	GP	TIS95	200	18	18	75-225	2			80	
2N2785	NPN	DA	2N998	500	60	40	2K-20K	100	1	15	600	10
2N2787	NPN	GP	2N2218	800	75	35	20-50	150	.4	150	15	250
2N2788	NPN	GP	2N2218A	800	75	35	40-120	150	.4	150	30	250
2N2789	NPN	GP	2N2219A	800	75	35	100-300	150	.4	150	80	250
2N2790	NPN	GP	2N2218	500	75	35	20-60	150	.4	150	15	250
2N2791	NPN	GP	2N2221A	500	75	35	40-120	150	.4	150	30	250
2N2792	NPN	GP	2N2222A	500	75	35	100-300	150	.4	150	80	250
2N2800	PNP	GP	2N2904	800	50	35	30-90	150	.4	150		120
2N2801	PNP	GP	2N2905	800	50	35	75-225	150	.4	150		120
2N2802	PNP	DU	2N2802	250	25	20	20-120	.1	.5	10	20	60
2N2803	PNP	DU	2N2803	250	25	20	20-120	.1	.5	10	20	60
2N2804	PNP	DU	2N2804	250	25	20	20-120	.1	.5	10	20	60
2N2805	PNP	DU	2N2805	250	25	20	40-120	.1	.5	10	40	60
2N2806	PNP	DU	2N2806	250	25	20	40-120	.1	.5	10	40	60
2N2807	PNP	DU	2N2807	250	25	20	40-120	.1	.5	10	40	60
2N2808	NPN	RF		300	30	10	20-120	2	.25	4	20	100
2N2808A	NPN	RF		200	30	10	20-120	2	.25	4	20	150
2N2809	NPN	RF		200	30	15	20-120	2	.25	4	20	600
2N2809A	NPN	RF		200	30	15	20-120	2	.25	4	20	1G
2N2810	NPN	RF		200	24	10	20-120	2	.25	4	20	600
2N2810A	NPN	RF		200	24	10	20-120	2	.25	4	20	1G
2N2831	NPN	GP	2N2221	360	40	12	25-	10	.25	10	40	250
2N2837	PNP	GP	2N2906	500	50	35	30-90	150	.4	150		120
2N2838	PNP	GP	2N2907	500	50	35	75-225	150	.4	150		120
2N2840	P-N	UJ	2N3980	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N2841	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N2842	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N2843	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N2844	PCH	FE		SEE FET INTERCHANGEABILITY LIST								

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ $^*T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2845	NPN	SW	2N2539	360	60	30	30-120	150	.4	150		250
2N2846	NPN	SW	2N2537	800	60	30	30-120	150	.4	150		250
2N2847	NPN	SW	2N2539	360	60	20	40-140	150	.4	150		250
2N2848	NPN	SW	2N2537	800	60	20	40-140	150	.4	150		250
2N2849	NPN	SW		850	100	80	100-300	1A	.4	1A		30
2N2850	NPN	SW		850	100	80	40-120	1A	.25	1A		30
2N2851	NPN	SW		850	100	80	40-120	1A	.4	1A		30
2N2852	NPN	SW		850	100	80	20-60	1A	.4	1A		30
2N2853	NPN	SW		850	60	40	40-	1A	1.5	5A		30
2N2854	NPN	SW		850	60	40	100-300	1A	.4	1A		30
2N2855	NPN	SW		850	60	40	40-120	1A	.4	1A		30
2N2856	NPN	SW		850	60	40	20-60	1A	.4	1A		30
2N2857	NPN	RF	2N3572	200	30	15	30-150	3			50	10
2N2858	NPN	GP	2N3036	600	100	80	20-60	1A	.3	1A		1
2N2859	NPN	GP		600	120	100	20-60	1A	.3	1A		1
2N2861	PNP	GP	2N2861	300	25	20	30-120	.01	.2	10	50	60
2N2862	PNP	GP	2N2862	300	25	20	12-120	.01	.2	10	25	45
2N2863	NPN	GP	2N2219	800	60	25	30-200	200	1	500		150
2N2864	NPN	GP	2N2219	800	60	25	30-200	200	1	500		150
2N2865	NPN	RF	2N3572	200	25	13	20-200	4	.4	10	20	600
2N2868	NPN	RF	2N699	800	60	40	40-120	150	.25	150		50
2N2871	PNP	SW		400	60	60	15-	1				.2
2N2872	PNP	SW		400	110	110	15-	1				.2
2N2883	NPN	RF	2N2883	800	40	20	20-	100	.5	100		400
2N2884	NPN	RF	2N2884	800	40	20	20-	100	.5	100		400
2N2885	NPN	SW		150	40	15	30-120	10	.4	10		300
2N2886	NPN	GP	2N2219	800	50	40	22-45	5	1.2	8		
2N2890	NPN	GP	2N3036	800	100	80	30-90	1A	.5	1A	30	30
2N2891	NPN	GP	2N3036	800	100	80	50-150	1A	.5	1A	50	30
2N2894	PNP	SW	2N2894	360	12	12	40-150	30	.15	10		400
2N2894A	PNP	SW	2N2894	360	12		40-	30				800
2N2895	NPN	GP	2N870	500	120	65	40-120	150	.6	150	50	120
2N2896	NPN	GP	2N720	500	140	90	60-200	150	.6	150	50	120
2N2897	NPN	GP	2N956	500	60	45	50-200	150	1	150	50	120
2N2898	NPN	GP		500	120	65	40-120	150	.6	150	50	120
2N2899	NPN	GP		500	140	90	60-200	150	.6	150	50	120
2N2900	NPN	GP		500	60	45	50-200	150	1	150	50	120
2N2901	NPN	SW		360	20	10	30-	10	.15	10		300
2N2903	NPN	DU	2N2917	200	60	30	125-625	1	1	5	150	60
2N2903A	NPN	DU	2N2915	200	60	30	125-625	1	1	5	150	60

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2904	PNP	GP	2N2904	600	60	40	40-120	150	.4	150		200
2N2904A	PNP	GP	2N2904A	600	60	60	40-120	150	.4	150		200
2N2905	PNP	GP	2N2905	600	60	40	100-300	150	.4	150		200
2N2905A	PNP	GP	2N2905A	600	60	60	100-300	150	.4	150		200
2N2906	PNP	GP	2N2906	400	60	40	40-120	150	.4	150		200
2N2906A	PNP	GP	2N2906A	400	60	60	40-120	150	.4	150		200
2N2907	PNP	GP	2N2907	400	60	40	100-300	150	.4	150		200
2N2907A	PNP	GP	2N2907A	400	60	60	100-300	150	.4	150		200
2N2909	NPN	GP	2N2221A	400	60	40	40-120	150	.25	150		50
2N2910	NPN	DU	2N2640	300	45	25	70-	.1	1	10	50	11
2N2911	NPN	SW		*5W	150	125	20-60	1A	.3	1A		1
2N2913	NPN	DU	2N2913	300	45	45	60-240	.01	.35	1		60
2N2914	NPN	DU	2N2914	300	45	45	150-600	.01	.35	1		60
2N2915	NPN	DU	2N2915	300	45	45	60-240	.01	.35	1		60
2N2915A	NPN	DU	2N2915A	300	45	45	60-240	.01	.35	1		60
2N2916	NPN	DU	2N2916	300	45	45	150-600	.01	.35	1		60
2N2916A	NPN	DU	2N2916A	300	45	45	150-600	.01	.35	1		•60
2N2917	NPN	DU	2N2917	300	45	45	60-240	.01	.35	1		60
2N2918	NPN	DU	2N2918	300	45	45	150-600	.01	.35	1		60
2N2919	NPN	DU	2N2919	300	60	60	60-240	.01	.35	1		60
2N2919A	NPN	DU	2N2919A	300	60	60	60-240	.01	.35	1		60
2N2920	NPN	DU	2N2920	300	60	60	150-600	.01	.35	1		60
2N2920A	NPN	DU	2N2920A	300	60	60	150-600	.01	.35	1		60
2N2921	NPN	GP		200	25	25					35	
2N2922	NPN	GP		200	25	25					55	
2N2923	NPN	GP	2N3710	360	25	25					90	
2N2924	NPN	GP	2N3710	360	25	25					150	
2N2925	NPN	GP	2N3711	360	25	25					235	
2N2926	NPN	GP	2N3708	200	25	25					35	
2N2927	PNP	GP	2N2904	800	25	25	30-130	50	.25	50	25	100
2N2936	NPN	GP	2N2484	300	60	55	100-300	.01	.3	2	150	30
2N2937	NPN	GP	2N2484	300	60	55	100-300	.01	.3	2	150	30
2N2938	NPN	SW		300	25	13	30-	50	.4	50		500
2N2939	NPN	RF		800	75	60	60-240	150	.75	150		150
2N2940	NPN	RF		800	120	80	60-240	150	.75	150		150
2N2941	NPN	RF		800	150	100	60-240	150				150
2N2944	PNP	SW	2N2944	400	15	10	80-	1				10
2N2944A	PNP	SW	2N2944A	400	15	10	100-	1				15
2N2945	PNP	SW	2N2945	400	25	20	40-	1				5
2N2945A	PNP	SW	2N2945A	400	25	20	100-	1				10

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T T_A=25°C *T_C=25°C (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N2946	PNP	SW	2N2946	400	40	35	30-	1				3
2N2946A	PNP	SW	2N2946A	400	40	35	50-	1				5
2N2954	PNP	RF	2N918	200	30	20	25-300	2			25	300
2N2958	PNP	GP	2N2218	*3W	60	20	40-120	150	.5	150		250
2N2959	PNP	GP	2N2219	*3W	60	20	100-300	150	.5	150		250
2N2960	PNP	GP	2N2219A	*3W	60	30	100-300	150	.5	150		250
2N2961	PNP	GP	2N2219A	*3W	60	30	100-300	150	.5	150		250
2N2967	NPN	SW		300	12	6	20-120	10	.3	3		400
2N2968	PNP	SW	2N3250	150	30	10	15-	.1	.6	10		8
2N2969	PNP	SW	2N3250	150	30	10	15-	.1	.6	10		8
2N2970	PNP	SW	2N3250	150	30	20	10-	.1	.8	10		4
2N2971	PNP	SW	2N3250	150	30	20	10-	.1	.8	10		4
2N2972	NPN	DU	2N2972	250	45	45	60-240	.01	.35	1		60
2N2973	NPN	DU	2N2973	250	45	45	150-600	.01	.35	1		60
2N2974	NPN	DU	2N2974	250	45	45	60-240	.01	.35	1		60
2N2975	NPN	DU	2N2975	250	45	45	150-600	.01	.35	1		60
2N2976	NPN	DU	2N2976	250	45	45	60-240	.01	.35	1		60
2N2977	NPN	DU	2N2977	250	45	45	150-600	.01	.35	1		60
2N2978	NPN	DU	2N2978	250	60	60	60-240	.01	.35	1		60
2N2979	NPN	DU	2N2979	250	60	60	150-600	.01	.35	1		60
2N2980	NPN	DU	2N2060	250	100	60	25-75	.01	1.2	50	50	60
2N2981	NPN	DU	2N2223	250	100	60	50-200	10	1.2	50	40	50
2N2982	NPN	DU	2N2223A	250	100	60	50-200	10	1.2	50	40	50
2N3009	NPN	SW		360	40	15	30-120	30	.18	30		350
2N3010	NPN	SW		300	15	6	25-125	10	.25	10		600
2N3011	NPN	SW		360	30	12	30-120	10	.2	10		400
2N3012	PNP	SW	2N3012	360	12	12	30-120	30	.2	30		400
2N3013	NPN	SW		360	40	15	30-120	30	.18	30		350
2N3014	NPN	SW		360	40	20	30-120	30	.18	10		350
2N3015	NPN	SW	2N3015	800	60	30	30-120	150	.4	150		250
2N3019	NPN	GP	2N2243A	800	140	80	100-300	150	.2	150	80	100
2N3020	NPN	GP	2N1893	800	140	80	40-120	150	.2	150	30	80
2N3033	NPN	SW		300	100				1	100		
2N3034	NPN	SW		300	70				1	100		
2N3035	NPN	SW		300	50				1	100		
2N3036	NPN	GP	2N3036	800	120	80	50-150	150	.25	150	40	50
2N3037	NPN	GP	2N3037	360	120	70	40-120	150	.2	10	30	50
2N3038	NPN	GP	2N3038	360	100	60	80-240	150	.2	10	60	50
2N3039	PNP	GP	2N3039	360	50	35	20-80	150			20	50
2N3040	PNP	GP	2N3040	360	40	30	40-160	150	.2	10	40	50

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3043	NPN	DU	2N3043	250	45	45	100-300	.01	1	10	130	30
2N3044	NPN	DU	2N3044	250	45	45	100-300	.01	1	10	130	30
2N3045	NPN	DU		250	45	45	100-300	.01	1	10	130	30
2N3046	NPN	DU		250	45	45	50-200	.01	1	10	65	30
2N3047	NPN	DU		250	45	45	50-200	.01	1	10	65	30
2N3048	NPN	DU		250	45	45	50-200	.01	1	10	65	30
2N3049	PNP	DU	2N3049	250	25	20	20-120	.01	.2	10	30	60
2N3050	PNP	DU	2N3050	250	25	20	20-120	.01	.2	10	30	60
2N3051	PNP	DU	2N3051	250	25	20	20-120	.01	.2	10	30	60
2N3052	NPN	DU	2N3052	250	35	15	25-130	10	.25	10		200
2N3053	NPN	GP	2N3053	*5W	60	40	50-250	150	1.4	150		100
2N3053A	NPN	GP	2N3053	*5W	80	60	50-250	150	.3	150		100
2N3056	NPN	GP		400	100	60	40-120	150	.25	150	30	80
2N3056A	NPN	GP		400	140	80	40-120	150	.2	150	30	80
2N3057	NPN	GP		400	100	60	100-300	150	.25	150	80	100
2N3057A	NPN	GP		400	140	80	100-300	150	.2	150	80	100
2N3058	PNP	SW	2N2944	400	6	6	40-120	100			40	
2N3059	PNP	SW	2N2944	400	10	10	100-300	.01			100	
2N3060	PNP	SW	2N2944	400	70	60	30-90	1			30	
2N3061	PNP	SW	2N2944	400	70	60	60-180	1			60	
2N3062	PNP	SW	2N2944	400	90	80	20-80	1			20	
2N3063	PNP	SW	2N2944	400	90	80	50-150	1			50	
2N3064	PNP	SW		400	200	110	15-45	1			15	
2N3065	PNP	SW		400	110	100	30-90	1			30	
2N3066	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N3067	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3068	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3069	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
2N3070	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N3071	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3072	PNP	GP	2N2904	800	60	60	30-130	50	.25	50	25	130
2N3073	PNP	GP	2N2906	360	60	60	30-130	50	.25	50	25	130
2N3077	NPN	GP	2N930	360	80	60	100-400	.01	.35	1	120	15
2N3078	NPN	GP	2N929	360	80	60	40-120	.01	.35	1	50	15
2N3081	PNP	GP	2N2904A	600	70	50	20-	500	.3	150		150
2N3082	NPN	SW	3N76	500	25	7	100-	.25				100
2N3083	NPN	SW	3N74	500	25	7	100-	.25				100
2N3084	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N3085	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N3086	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3087	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N3088	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3089	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3107	NPN	GP	2N2243	800	100	60	100-300	150	1	1A	60	70
2N3108	NPN	GP	2N1613	800	100	60	40-120	150	.25	150		60
2N3109	NPN	GP	2N697	800	80	40	100-300	150	1	1A	60	70
2N3110	NPN	GP	2N2243A	800	80	40	40-120	150	.25	150		60
2N3112	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3113	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3114	NPN	GP	2N3114	800	150	150	30-120	30	1	50	25	40
2N3115	NPN	GP	2N2221	400	60	20	40-120	150	.5	150		250
2N3116	NPN	GP	2N2222	400	60	20	100-300	150	.5	150		250
2N3117	NPN	GP	2N3117	360	60	60	250-500	.01	.35	1	400	60
2N3118	NPN	RF		1W	85	65	50-275	25				250
2N3119	NPN	GP		1W	100	80	50-200	100	.5	100		250
2N3121	PNP	GP	2N2906	360	45	45	30-130	50	.25	50	25	130
2N3120	PNP	GP	2N2904	800	45	45	30-130	50	.25	50	25	130
2N3122	NPN	GP	2N2218	800	50	30	25-100	300	1.5	300		60
2N3123	NPN	GP	2N2219	800	60	30	100-300	150	.4	150		400
2N3128	NPN	GP		150	20	20	50-150	.1	.25	1	75	60
2N3129	NPN	GP		150	45	45	100-300	10	.25	1	160	60
2N3130	NPN	GP		150	60	60	60-180	10	.25	1	110	60
2N3131	NPN	SW		150	40	15	30-120	10	.25	10		250
2N3135	PNP	GP	2N2906	400	50	35	40-120	150	.6	150		200
2N3134	PNP	GP	2N2905	600	50	35	100-300	150	.6	150		200
2N3133	PNP	GP	2N2904	600	50	35	40-120	150	.6	150		200
2N3136	PNP	GP	2N2907	400	50	35	100-300	150	.6	150		200
2N3137	NPN	GP	2N3014	600	40	20			.3	50		500
2N3153	NPN	SW	2N2432	300	15	15						30
2N3162	NPN	DU		300	45	25	50-200	10	.5	10		300
2N3209	PNP	SW	2N3576	360	20	20	30-120	30	.2	30		400
2N3210	NPN	SW	2N3724	360	40	15	30-120	10	.75	200		300
2N3211	NPN	SW	2N3724	360	40	15	50-150	10	.2	10		350
2N3217	PNP	SW	2N2944	400	15	10						1
2N3218	PNP	SW	2N2945	400	25	20						1
2N3219	PNP	SW	2N2945	400	40	35						1
2N3224	PNP	GP	2N3495	700	100	100	20-60	50			20	60
2N3225	PNP	GP	2N3495	700	100	100	40-120	50			40	80
2N3227	NPN	SW		360	40	20	100-300	10	.25	10		500
2N3241A	NPN	GP	2N2222	500	30	25					175	100

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3241	NPN	GP	2N2221	500	30	25	50-300	10			70	50
2N3242	NPN	GP	2N730	500	30	25	75-	10			100	50
2N3242A	NPN	GP	2N730	500	40	40					200	100
2N3244	PNP	SW	2N3244	1W	40	40	50-150	500	.3	150		175
2N3245	PNP	SW	2N3245	1W	50	50	30-90	500	.35	150		150
2N3246	NPN	GP	2N930A	350	60	45	200-600	.01	.5	5	200	60
2N3247	NPN	GP	2N930A	150	60	45	200-600	.01	.5	5	200	60
2N3248	PNP	SW	2N2894	360	15	12	50-150	.1	.125	10		250
2N3249	PNP	SW	2N2894	360	15	12	100-300	.1	.125	10		300
2N3250	PNP	SW	2N3250	360	50	40	50-150	10	.25	10	50	250
2N3250A	PNP	SW	2N3250A	360	60	60	50-150	10	.25	10	50	250
2N3251	PNP	SW	2N3251	360	50	40	100-300	10	.25	10	100	300
2N3251A	PNP	SW	2N3251A	360	60	60	100-300	10	.25	10	100	300
2N3252	NPN	SW	2N3252	1W	60	30	30-90	500	.3	150		200
2N3253	NPN	SW	2N3253	1W	75	40	25-75	375	.35	150		175
2N3261	NPN	SW		300	40	15	40-150	10	.35	100		600
2N3268	NPN	GP	2N2217	150	45	45	12-80	10	1	5	40	
2N3277	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3278	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3287	NPN	RF	2N918	200	40	20	15-100	2	.3	5	15	350
2N3288	NPN	RF	2N918	200	40	20	15-100	2	.3	5	15	350
2N3289	NPN	RF	2N918	200	30	15	10-150	2	.4	5	10	300
2N3290	NPN	RF	2N918	200	30	15	10-150	2	.4	5	10	300
2N3291	NPN	RF	2N4252	200	25		10-	2			10	250
2N3292	NPN	RF	2N4252	200	25		10-	2			10	250
2N3293	NPN	RF	2N4252	200	20		10-	2			10	250
2N3294	NPN	RF	2N4252	200	20		10-	2			10	250
2N3295	NPN	GP	2N2217	800	60		20-60	10	.5	150		200
2N3296	NPN	GP		700	60		5-50	40	.5	400		100
2N3298	NPN	GP	2N2222	•1W	25	15	80-240	10				200
2N3299	NPN	GP	2N2218	800	60	30	40-120	150	.22	150		250
2N3300	NPN	GP	2N2219	800	60	30	100-300	150	.22	150		250
2N3302	NPN	GP	2N2222	360	60	30	100-300	150	.22	150		250
2N3301	NPN	GP	2N2221	360	60	30	40-120	150	.22	150		250
2N3303	NPN	SW	2N3724	600	25	12	30-120	300	.33	300		450
2N3304	PNP	SW	2N3725	300	6	6	30-120	10	.16	10		500
2N3305	PNP	GP	2N2907	600	50	40	40-120	.1	.2	10	40	20
2N3306	PNP	GP	2N2907	600	50	40	100-300	.1	.2	10	70	20
2N3307	PNP	RF		200	40	35	40-250	2	.4	3	40	300
2N3308	PNP	RF		200	30	25	25-250	2	.4	3	25	300

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3309	NPN	RF	2N3866	800	50		5-100	30	.5	250		300
2N3309A	NPN	RF	2N3866	*5W	60		8-80	50	.5	250		300
2N3310	NPN	RF	2N918	300	35	15	10-	20	.5	20		300
2N3317	PNP	SW	2N2944	150	30	30						6.4
2N3318	PNP	SW	2N2944	150	15	15						7.6
2N3319	PNP	SW	2N2944	150	10	6						12
2N3326	NPN	GP	2N2218A	800	60	45	40-120	150	.4	150		250
2N3328	PCH	FE	2N3328	SEE FET INTERCHANGEABILITY LIST								
2N3329	PCH	FE	2N3329	SEE FET INTERCHANGEABILITY LIST								
2N3330	PCH	FE	2N3330	SEE FET INTERCHANGEABILITY LIST								
2N3331	PCH	FE	2N3331	SEE FET INTERCHANGEABILITY LIST								
2N3332	PCH	FE	2N3332	SEE FET INTERCHANGEABILITY LIST								
2N3333	PCH	FE	2N3333	SEE FET INTERCHANGEABILITY LIST								
2N3334	PCH	FE	2N3334	SEE FET INTERCHANGEABILITY LIST								
2N3335	PCH	FE	2N3335	SEE FET INTERCHANGEABILITY LIST								
2N3336	PCH	FE	2N3336	SEE FET INTERCHANGEABILITY LIST								
2N3337	NPN	RF	2N2883	300	40	40	30-300	4			30	400
2N3338	NPN	RF	2N2883	300	40	40	30-300	4			30	400
2N3339	NPN	RF	2N2883	300	40	40	30-300	4			30	400
2N3340	NPN	SW		400	30	20	40-	.01	.2	.01		70
2N3341	PNP	SW		400	30	20	40-	.01	.25	.01		50
2N3342	PNP	SW		250	20	8	30-	5	.1	5		
2N3343	PNP	SW		250	25	8	20-	.25				2
2N3344	PNP	SW		250	30	30	25-	1				2
2N3345	PNP	SW		250	50	50	15-	1				2
2N3346	PNP	SW		250	50	50	25-	1				2
2N3347	PNP	DU	2N3347	300	60	45	40-300	.01	.5	10	60	60
2N3348	PNP	DU	2N3348	300	60	45	40-300	.01	.5	10	60	60
2N3349	PNP	DU	2N3349	300	60	45	40-300	.01	.5	10	60	60
2N3350	PNP	DU	2N3350	300	60	45	100-300	.01	.5	10	150	60
2N3351	PNP	DU	2N3351	300	60	45	100-300	.01	.5	10	150	60
2N3352	PNP	DU	2N3352	300	60	45	100-300	.01	.5	10	150	60
2N3365	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N3366	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3367	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3368	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
2N3369	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3370	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3374	NPN	RF		*5W	80	80	10-	170	.3	150		230
2N3376	PCH	FE	2N3329	SEE FET INTERCHANGEABILITY LIST								

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3377	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3378	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3379	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3380	PCH	FE	2N3331	SEE FET INTERCHANGEABILITY LIST								
2N3381	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3382	PCH	FE	2N3994	SEE FET INTERCHANGEABILITY LIST								
2N3383	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3384	PCH	FE	2N3993	SEE FET INTERCHANGEABILITY LIST								
2N3385	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3386	PCH	FE	2N3993	SEE FET INTERCHANGEABILITY LIST								
2N3387	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3388	NPN	SW		600	125	100	60-	2.5	1	2.5		36
2N3389	NPN	SW		600	195	160	60-	7	1	7		36
2N3390	NPN	GP	TIS94	360	18	18	400-800	2			400	
2N3391	NPN	GP	A7T3391	360	25	25	250-500	2				
2N3391A	NPN	GP	A7T3391A	360	25	25	250-500	2				
2N3392	NPN	GP	A7T3392	360	25	25	150-300	2				
2N3393	NPN	GP	TIS95	360	25	25	90-180	2				
2N3394	NPN	GP	TIS96	360	25	25	55-110	2				
2N3395	NPN	GP	TIS94	360	25	25	150-500	2				
2N3396	NPN	GP	TIS94	360	25	25	90-500	2				
2N3397	NPN	GP	TIS94	360	25	25	55-500	2				
2N3398	NPN	GP	TIS94	360	25	25	55-800	2				
2N3401	PNP	SW	2N2944	250	25	25			.25	5	4	.1
2N3402	NPN	GP	2N3705	560	25	25	75-225	2	.3	50	75	
2N3403	NPN	GP	2N3704	560	25	25	180-540	2	.3	50	180	
2N3404	NPN	GP	2N3705	560	50	50	75-225	2	.3	50	75	
2N3405	NPN	GP	2N3704	560	50	50	180-540	2	.3	50	180	
2N3406	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3407	NPN	RF	2N918	200	35	18	10-100	10			10	300
2N3409	NPN	DU	2N2640	500	60	30	30-120	.1	.15	10		250
2N3410	NPN	DU	2N2639	500	60	30	20-100	.01	.15	10		250
2N3411	NPN	DU	2N2639	500	60	30	20-100	.01	.15	10		250
2N3413	PNP	GP		400	150	150	10-45	50	1.2	100		.25
2N3414	NPN	GP	2N3705	360	25	25	75-225	2	.3	50	75	
2N3415	NPN	GP	2N3704	360	25	25	180-540	2	.3	50	180	
2N3416	NPN	GP	2N3705	360	50	50	75-225	2	.3	50	75	
2N3417	NPN	GP	2N3704	360	50	50	180-540	2	.3	50	180	
2N3423	NPN	DU	D2T918	300	30	15	20-200	3	.4	10		600
2N3424	NPN	DU	D2T918	300	30	15	20-200	3	.4	10		600

TRANSISTOR INTERCHANGEABILITY
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2N3425	NPN	DU		300	40	15	30-120	10	.4	10	20	300
2N3426	NPN	SW	2N3724	600	25	12	30-120	300	.33	300		450
2N3436	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
2N3437	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N3438	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3439	NPN	GP		1W	450	350	40-160	20			25	15
2N3440	NPN	GP	2N5058	1W	300	250	40-160	20			25	15
2N3444	NPN	SW	2N3444	1W	80	50	20-60	500	.35	150		150
2N3450	NPN	SW	2N2243	600	120	60	40-120	150	.5	150		100
2N3451	PNP	SW	2N3576	300	6	6	30-120	10	.16	10		500
2N3452	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3453	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3454	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3455	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3456	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3457	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3458	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
2N3459	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N3460	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N3462	NPN	GP	2N930	300	50	35	100-300	.01	.35	5	150	10
2N3463	NPN	GP	2N2586	300	60	45	120-360	.01	.35	1	150	45
2N3464	NPN	GP	2N2270	*5W	60	40	35-100	200	1	200	30	50
2N3465	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3466	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3467	PNP	SW	2N3467	1W	40	40	40-120	500	.3	150		175
2N3468	PNP	SW	2N3468	1W	50	50	25-75	500	.35	150		150
2N3478	NPN	RF	2N3570	200	30	15	25-150	2			25	750
2N3479	P-N	UJ	2N1671A	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3480	P-N	UJ	2N2646	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3481	P-N	UJ	2N4853	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3482	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3483	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3484	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3485	PNP	GP	2N3485	400	60	40	40-120	150	.4	150		200
2N3485A	PNP	GP	2N3485A	400	60	60	40-120	150	.4	150		200
2N3486	PNP	GP	2N3486	400	60	40	100-300	150	.4	150		200
2N3486A	PNP	GP	2N3486A	400	60	60	100-300	150	.4	150		200
2N3493	NPN	SW		150	12	8	40-120	.5	.15	.01		400
2N3494	PNP	GP	2N3494	600	80	80	35-	100	.3	10	40	200
2N3495	PNP	GP	2N3495	600	120	120	35-	.1	.35	10	40	150

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2N3496	PNP	GP	2N3496	400	80	80	35-	100	.3	10	40	200
2N3497	PNP	GP	2N3497	400	120	120	35-	.1	.35	10	40	150
2N3498	NPN	GP	2N2102	1W	100	100	40-120	150	.2	10	50	150
2N3499	NPN	GP	2N2102	1W	100	100	100-300	150	.2	10	75	150
2N3500	NPN	GP	2N2102	1W	150	150	40-120	150	.2	10	50	150
2N3501	NPN	GP	2N2102	1W	150	150	100-300	150	.2	10	75	150
2N3502	PNP	GP	2N3502	700	45	45	115-300	50	.25	50	135	200
2N3503	PNP	GP	2N3503	700	60	60	115-300	50	.25	50	135	200
2N3504	PNP	GP	2N3504	400	45	45	115-300	50	.25	50	135	200
2N3505	PNP	GP	2N3505	400	60	60	115-300	50	.25	50	135	200
2N3506	NPN	SW		1W	60	40	40-200	1.5	1	1.5		60
2N3507	NPN	SW		1W	80	50	30-150	1.5	1	1.5		60
2N3508	NPN	SW	2N3724	400	40	20	40-120	10	.25	10		500
2N3509	NPN	SW	2N3724	400	40	20	100-300	10	.25	10		500
2N3510	NPN	SW	2N3724	360	40	10	25-150	150	.25	10		350
2N3511	NPN	SW	2N3724	360	40	15	30-120	150	.25	10		450
2N3512	NPN	SW	2N2537	800	60	35	10-	500	1	500		250
2N3513	NPN	DU	2N2640	250	80	40	50-200	1	1.2	50	50	50
2N3514	NPN	DU		250	80	40	50-200	1	1.2	50	50	50
2N3515	NPN	DU		250	80	40	50-200	1	1.2	50	50	50
2N3516	NPN	DU	2N2639	250	100	60	50-200	1	1.2	50	50	60
2N3517	NPN	DU		250	100	60	50-200	1	1.2	50	50	60
2N3518	NPN	DU		250	100	60	50-200	1	1.2	50	50	60
2N3519	NPN	DU		250	60	30	150-600	1	1	5	150	60
2N3520	NPN	DU		250	60	30	150-600	1	1	5	150	60
2N3521	NPN	DU	2N2643	300	70	55	100-300	.01	1	10		30
2N3522	NPN	DU	2N2643	250	70	55	100-300	.01	1	10		30
2N3523	NPN	DU		250	70	55	100-300	.01	1	10		30
2N3524	NPN	DU	2N2640	250	70	50	100-300	.01	1	10		30
2N3526	NPN	GP		800	130	120	30-120	30	1	50	25	40
2N3527	PNP	SW	2N2944	400	30	30	25-75	.1			100	5
2N3544	NPN	RF	2N3572	300	25		25-	10				600
2N3545	PNP	GP	2N3978	360	20	20	40-120	10	.2	10		250
2N3546	PNP	SW	2N3576	360	15	12	30-120	10	.15	10		700
2N3547	PNP	GP	2N3799	360	60	60	100-500	1	1	10	120	45
2N3548	PNP	GP	2N2604	400	60	45	100-300	.01	1	10	150	60
2N3549	PNP	GP	2N2604	400	60	60	100-500	.01	1	10	150	60
2N3550	PNP	SW	2N2944	400	60	45	200-600	.01	.9	5	300	60
2N3553	NPN	RF	2N3553	*7W	65	40	10-100	250	1	250		400
2N3554	NPN	SW	2N3554	800	60	30	25-100	750	.7	750		150

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3563	NPN	RF	TIS62	200	30	12	20-200	8			20	600
2N3564	NPN	RF	2N4996	200	30	15	20-	15	.3	20	20	400
2N3565	NPN	GP	A5T3565	200	30	25	150-600	1	.35	1		40
2N3566	NPN	GP	TIS97	300	40	30	150-600	10	1	100		40
2N3567	NPN	GP	A5T3567	300	80	40	40-120	150	.25	150		60
2N3568	NPN	GP	A5T3568	300	80	60	40-120	150	.25	150		60
2N3569	NPN	GP	A5T3569	300	80	40	100-300	150	.35	150		60
2N3570	NPN	RF	2N3570	200	30	15	20-150	5			20	150
2N3571	NPN	RF	2N3571	200	25	15	20-200	5			20	150
2N3572	NPN	RF	2N3572	200	25	13	20-300	5			20	100
2N3573	PCH	FE	2N3573	SEE FET INTERCHANGEABILITY LIST								
2N3574	PCH	FE	2N3574	SEE FET INTERCHANGEABILITY LIST								
2N3575	PCH	FE	2N3575	SEE FET INTERCHANGEABILITY LIST								
2N3576	PNP	SW	2N3576	360	20	15	40-120	10	.15	10		400
2N3578	PCH	FE	2N2608	SEE FET INTERCHANGEABILITY LIST								
2N3579	PNP	GP	2N3799	400	60	60	30-120	1	.5	5	30	80
2N3580	PNP	GP	2N3799	400	60	60	60-240	1	.5	5	60	80
2N3581	PNP	GP	2N3799	400	50	40	50-150	.1	.5	5	50	30
2N3582	PNP	GP	2N3799	400	50	40	100-300	.1	.5	5	100	30
2N3586	PNP	SW	3N108	125	45	45						.1
2N3587	NPN	DU	2N2640	300	60	45	80-500	1	1	10		80
2N3600	NPN	RF	2N4252	200	30	15	20-150	3			40	850
2N3608	PCH	FE	3N155	SEE FET INTERCHANGEABILITY LIST								
2N3609	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3610	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3631	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3633	NPN	SW		300	15	6	50-150	10	.21	3		1.3G
2N3634	PNP	GP	2N3634	1W	140	140	50-150	50	.5	50	40	150
2N3635	PNP	GP	2N3635	1W	140	140	100-300	50	.5	50	80	200
2N3636	PNP	GP	2N3636	1W	175	175	50-150	50	.5	50	40	150
2N3637	PNP	GP	2N3637	1W	175	175	100-300	50	.5	50	80	200
2N3638	PNP	SW	A5T3638	300	25	25	30-	50	.25	50		100
2N3638A	PNP	SW	A5T3638A	300	25	25	100-	50	.25	50		150
2N3639	PNP	SW		200	6	6	30-120	10	.16	10		500
2N3640	PNP	SW		200	12	12	30-120	10	.2	10		500
2N3641	NPN	RF	2N5449	350	60	30	40-120	150	.22	150		250
2N3642	NPN	RF	2N5449	350	60	45	40-120	150	.22	150		250
2N3643	NPN	RF	2N5449	350	60	30	100-300	150	.22	150		250
2N3644	PNP	SW	A5T3644	300	45	45	100-300	150	.4	150		200
2N3645	PNP	SW	A5T3645	300	60	60	100-300	150	.4	150		200

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3646	NPN	SW	A5T3903	200	40	15	30-120	30	.3	30		350
2N3647	NPN	SW		400	40	10	25-150	150	.25	10	20	350
2N3648	NPN	SW		400	40	15	30-120	150	.25	10	20	450
2N3659	NPN	GP	2N5058	*4W	220	170	20-	10			20	50
2N3660	PNP	GP	2N4030	*5W	40	30	25-100	500	1.2	500		25
2N3661	PNP	GP	2N4030	*5W	60	50	25-100	500	1.2	500		25
2N3662	NPN	RF	TIS62	200	18	12	20-	8	.6	10		700
2N3663	NPN	RF	TIS62	200	30	12	20-	8	.6	10		700
2N3664	NPN	RF		*5W	60	60	8-80	50	.75	250		300
2N3665	NPN	SW		*5W	120	80	40-120	150	.5	150		60
2N3666	NPN	SW		*5W	120	80	100-300	150	.5	150		60
2N3671	PNP	GP	2N2905	600	60	50	75-225	150	.4	150		200
2N3672	PNP	GP	2N2907	400	60	50	75-225	150	.4	150		200
2N3673	PNP	GP	2N3486A	350	60	50	75-225	150	.4	150		200
2N3677	PNP	SW	2N2944	400	30	20						5
2N3678	NPN	GP	2N2218A	800	75	55	40-120	150	.4	150		250
2N3679	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3680	NPN	DU	2N3680	300	60	50	150-600	.01	.7	10	300	60
2N3681	NPN	RF	2N3570	200	10	7	20-220	2	.37	4	20	1.3G
2N3682	NPN	RF	2N918	360	40	15	40-120	10			45	600
2N3683	NPN	RF	2N3570	200	30	12	20-150	8			30	1G
2N3684	NCH	FE	2N3822	SEE FET INTERCHANGEABILITY LIST								
2N3685	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3686	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3687	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3688	NPN	RF	TIS84	200	40	40	30-	4				400
2N3689	NPN	RF	TIS84	200	40	40	30-	4				400
2N3690	NPN	RF	TIS84	200	40	40	30-	4				400
2N3691	NPN	GP	TIS99	200	35	25	40-	10	.7	10	40	200
2N3692	NPN	GP	TIS98	200	35	25	100-	10	.7	10	100	200
2N3693	NPN	RF	2N4994	200	45	45	40-	10				200
2N3694	NPN	RF	2N4995	200	45	45	100-	10				200
2N3695	PCH	FE	2N3329	SEE FET INTERCHANGEABILITY LIST								
2N3696	PCH	FE	2N3329	SEE FET INTERCHANGEABILITY LIST								
2N3697	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3698	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3700	NPN	GP	2N720A	500	140	80	100-300	150	.2	150	80	100
2N3701	NPN	GP	2N720A	500	140	80	40-120	150	.2	150	30	80
2N3702	PNP	GP	2N3702	360	40	25	60-300	50	.25	50		100
2N3703	PNP	GP	2N3703	360	50	30	30-150	50	.25	50		100

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3704	NPN	GP	2N3704	360	50	30	100-300	50	.6	100		100
2N3705	NPN	GP	2N3705	360	50	30	50-150	50	.8	100		100
2N3706	NPN	GP	2N3706	360	40	20	30-600	50	1	100		100
2N3707	NPN	GP	2N3707	360	30	30	100-400	.1	1	10		100
2N3708	NPN	GP	2N3708	360	30	30	45-660	1	1	10	45	
2N3709	NPN	GP	2N3709	360	30	30	45-165	1	1	10	45	
2N3710	NPN	GP	2N3710	360	30	30	90-330	1	1	10	90	
2N3711	NPN	GP	2N3711	360	30	30	180-660	1	1	10	180	
2N3712	NPN	GP		800	150	150	30-150	30	2	50	25	40
2N3721	NPN	GP	2N3711	360	18	18	60-660	10				
2N3722	NPN	SW	2N3725	800	80	60	40-150	100	.22	100		300
2N3723	NPN	SW		800	100	80	40-150	100	.25	10		300
2N3724	NPN	SW	2N3724	800	50	30	60-150	100	.2	100		300
2N3724A	NPN	SW	2N3724A	1W	50	30	60-150	100	.2	100		300
2N3725	NPN	SW	2N3725	800	80	50	60-150	100	.26	100		300
2N3725A	NPN	SW	2N3725A	1W	80	50	60-150	100	.26	100		300
2N3726	PNP	DU	2N3810	400	45	45	135-350	1	.25	50	135	200
2N3727	PNP	DU	2N3810	400	45	45	135-350	1	.25	50	135	200
2N3728	NPN	DU	2N2060	450	60	30	80-280	150	.22	150	50	250
2N3729	NPN	DU	2N2060	450	60	30	80-280	150	.22	150	50	250
2N3734	NPN	SW	2N3734	1W	50	30	30-120	1A	.2	10		300
2N3734A	NPN	SW	2N3734	1W	50	30	30-120	1A	.9	1A		250
2N3735	NPN	SW	2N3735	1W	75	50	20-80	1A	.2	10		250
2N3735A	NPN	SW	2N3735	1W	75	50	20-80	1A	.9	1A		250
2N3736	NPN	SW		500	50	30	30-120	1A	.2	10		300
2N3736A	NPN	SW		500	50	30	30-120	1A	.9	1A		250
2N3737	NPN	SW		500	75	50	20-80	1A	.2	10		250
2N3737A	NPN	SW		500	75	50	20-80	1A	.9	1A		250
2N3742	NPN	GP	2N5058	1W	300	300	20-200	30	1	10	20	30
2N3743	PNP	GP		1W	300	300	25-250	30	5	10	30	30
2N3762	PNP	SW	2N3244	1W	40	40	30-120	1A	.1	10		180
2N3763	PNP	SW	2N3245	1W	60	60	20-80	1A	.1	10		150
2N3764	PNP	GP	2N3486	500	40	40	30-120	1A	.1	10		180
2N3765	PNP	GP	2N3486A	500	60	60	20-80	1A	.1	10		150
2N3774	PNP	GP	2N4030	*5W	40		20-60	200	.2	200		1
2N3775	PNP	GP	2N4030	*5W	60	60	20-60	200	.2	200		1
2N3776	PNP	GP		*5W	80	80	20-60	200	.2	200		1
2N3777	PNP	GP		*5W	100	100	20-60	200	.2	200		1
2N3778	PNP	GP		*5W	40	40	10-40	200	.2	200		1
2N3779	PNP	GP		*5W	60	60	10-40	200	.2	200		1

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3780	PNP	GP		*5W	80	80	10-40	200	.2	200		1
2N3781	PNP	GP		*5W	100	100	10-40	200	.2	200		1
2N3782	PNP	GP	2N4030	*5W	40	40	10-60	1A	.75	1A		1
2N3795	PNP	GP		*5W	120	120	12-36	10	.2	10		.5
2N3796	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3797	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3798	PNP	GP	2N3798	360	60	60	150-450	.5	.2	.1	150	30
2N3799	PNP	GP	2N3799	360	60	60	300-900	.5	.2	.1	300	30
2N3800	PNP	DU	2N3352	250	60	60	150-450	.1	.2	.1	150	100
2N3801	PNP	DU	2N3352	250	60	60	300-900	.1	.2	.1	300	100
2N3802	PNP	DU	2N3347	250	60	60	150-450	.1	.2	.1	150	100
2N3803	PNP	DU	2N3351	250	60	60	300-900	.1	.2	.1	300	100
2N3804	PNP	DU	2N3350	250	60	60	150-450	.1	.2	.1	150	100
2N3804A	PNP	DU	2N3350	250	60	60	150-450	.1	.2	.1	150	30
2N3805	PNP	DU	2N3350	250	60	60	300-900	.1	.2	.1	300	100
2N3805A	PNP	DU	2N3350	250	60	60	300-900	.1	.2	.1	300	30
2N3806	PNP	DU	2N3806	500	60	60	150-450	.1	.2	.1	150	100
2N3807	PNP	DU	2N3807	500	60	60	300-900	.1	.2	.1	300	100
2N3808	PNP	DU	2N3808	500	60	60	150-450	.1	.2	.1	150	100
2N3809	PNP	DU	2N3809	500	60	60	300-900	.1	.2	.1	300	100
2N3810	PNP	DU	2N3810	500	60	60	150-450	.1	.2	.1	150	100
2N3810A	PNP	DU	2N3810	500	60	60	150-450	.1	.2	.1	150	30
2N3811	PNP	DU	2N3811	500	60	60	300-900	.1	.2	.1	300	100
2N3811A	PNP	DU	2N3811	500	60	60	300-900	.1	.2	.1	300	30
2N3812	PNP	DU		350	60	60	150-450	.1	.2	.1	150	100
2N3813	PNP	DU		350	60	60	300-900	.1	.2	.1	300	100
2N3814	PNP	DU		350	60	60	150-450	.1	.2	.1	150	100
2N3815	PNP	DU		350	60	60	300-900	.1	.2	.1	300	100
2N3816	PNP	DU		350	60	60	150-450	.1	.2	.1	150	100
2N3816A	PNP	DU		250	60	60	150-450	.1	.2	.1	150	30
2N3817	PNP	DU		350	60	60	300-900	.1	.2	.1	300	100
2N3817A	PNP	DU		250	60	60	300-900	.1	.2	.1	300	30
2N3819	NCH	FE	2N3819	SEE FET INTERCHANGEABILITY LIST								
2N3820	PCH	FE	2N3820	SEE FET INTERCHANGEABILITY LIST								
2N3821	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3822	NCH	FE	2N3822	SEE FET INTERCHANGEABILITY LIST								
2N3823	NCH	FE	2N3823	SEE FET INTERCHANGEABILITY LIST								
2N3824	NCH	FE	2N3824	SEE FET INTERCHANGEABILITY LIST								
2N3825	NPN	RF		250	30	15	20-	2	.25	2		200
2N3826	NPN	RF	2N4994	360	60	45	40-160	10				200

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TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3827	NPN	RF	2N4997	360	60	45	100-400	10				200
2N3828	NPN	RF		300	40	40	30-200	12				360
2N3829	PNP	SW	2N3829	360	35	20	30-120	30	.18	10		350
2N3830	NPN	GP	2N2193	1W	80	50	30-	150	.3	150		200
2N3831	NPN	GP	2N2193	1W	70	40	35-	150	.3	150		200
2N3832	NPN	SW		200	15	6	25-125	2	.4	10		800
2N3838	N/P	GP		250	60	40	100-300	150	.4	150	60	200
2N3839	NPN	RF	2N3571	200	30	15	30-	3				200
2N3840	PNP	SW	2N2946	400	50	50	30-	.2	.1	5		6
2N3841	PNP	SW	2N2946	300	100	100	15-	.2	.12	5		1.5
2N3842	PNP	SW	2N2946	300	120	120	10-	1				1
2N3843	NPN	RF	TIS94	200	30	30	20-40	2	1	10		60
2N3843A	NPN	RF	TIS94	200	30	30	20-40	2	1	10		60
2N3844	NPN	RF	TIS94	200	30	30	35-70	2	1	10		90
2N3844A	NPN	RF	TIS94	200	30	30	35-70	2	1	10		90
2N3845	NPN	RF	TIS94	200	30	30	60-120	2	1	10		120
2N3845A	NPN	RF	TIS94	200	30	30	60-120	2	1	10		120
2N3854	NPN	RF	TIS94	200	18	18	35-70	2	.2	10		100
2N3854A	NPN	RF	TIS94	200	30	30	35-70	2	.2	10		100
2N3855	NPN	RF	TIS94	200	18	18	60-120	2	.2	10		130
2N3855A	NPN	RF	TIS94	200	30	30	60-120	2	.2	10		130
2N3856	NPN	RF	TIS94	200	18	18	100-200	2	.2	10		140
2N3856A	NPN	RF	TIS94	200	30	30	100-200	2	.2	10		140
2N3858	NPN	RF	TIS95	360	30	30	60-120	2	.125	10		90
2N3858A	NPN	RF	TIS95	360	60	60	60-120	2	.125	10		90
2N3859	NPN	RF	TIS95	360	30	30	100-200	2	.125	10		90
2N3859A	NPN	RF	TIS95	360	60	60	120-200	2	.125	10		90
2N3860	NPN	RF	TIS95	360	30	30	150-300	2	.125	10		90
2N3862	NPN	SW		360	50	20	50-150	10	.25	10		600
2N3866	NPN	RF	2N3866	•5W	55	30	10-200	50	1	100		500
2N3866A	NPN	RF	2N3866	•5W	55	30	25-200	50	1	100		800
2N3867	PNP	SW		1W	40	40	40-200	1.5	.75	1.5		60
2N3868	PNP	SW		1W	60	60	30-150	1.5	.75	1.5		60
2N3869	NPN	RF		800	40	20	20-150	30	.7	450		400
2N3877	NPN	GP	2N5550	360	70	70	20-	2	1	10		
2N3877A	NPN	GP	2N5550	360	85	85	20-	2	1	10		
2N3880	NPN	RF	2N3570	200	30	15	30-200	3			50	1.2G
2N3881	NPN	RF		600	60	35			1.5	150	50	70
2N3882	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3900	NPN	GP	2N3711	360	18	18	250-500	2			170	

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3900A	NPN	GP	2N3711	360	18	18	250-500	2			170	
2N3901	NPN	GP	2N3711	360	18	18	350-700	2			350	
2N3903	NPN	SW	2N3903	310	60	40	50-150	10	.2	10		250
2N3904	NPN	SW	2N3904	310	60	40	100-300	10	.2	10		300
2N3905	PNP	SW	2N3905	310	40	40	50-150	10	.25	10		200
2N3906	PNP	SW	2N3906	310	40	40	100-300	10	.25	10		250
2N3907	NPN	DU	2N2915	300	60	45	60-300	.01	.35	1		60
2N3908	NPN	DU	2N2916	300	60	60	100-500	.01	.35	1		60
2N3909	PCH	FE	2N3909	SEE FET INTERCHANGEABILITY LIST								
2N3910	PNP	SW	2N2946A	500	60	50	40-160	1	.3	10		4
2N3911	PNP	SW	2N2946A	500	60	40	60-240	1	.3	10		8
2N3910	PNP	SW	2N2946A	500	60	30	90-	1	.3	10		10
2N3913	PNP	SW		400	60	50	40-160	1	.3	10		4
2N3914	PNP	SW		400	60	40	60-240	1	.3	10		8
2N3915	PNP	SW		400	60	30	90-	1	.3	10		10
2N3916	NPN	GP		*5W	150	150	40-200	150	5	150	30	50
2N3921	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
2N3922	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3923	NPN	GP		800	150	150	30-120	25	1	25	20	40
2N3930	PNP	GP		400	180	180	80-300	10	.25	10	100	40
2N3931	PNP	GP	2N6937	700	180	180	80-300	10	.25	10	100	40
2N3932	NPN	RF	2N3571	200	30	20	40-150	2			50	750
2N3933	NPN	RF		200	40	30	60-200	2			60	750
2N3934	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
2N3935	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST								
2N3941	NPN	DU		300	60	45	400-1200	.01			300	200
2N3942	NPN	DU		300	60	45	400-1200	.01			300	200
2N3943	NPN	DU		500	60	45	400-1200	.01			300	200
2N3944	NPN	DU		500	60	45	400-1200	.01			300	200
2N3945	NPN	GP	2N2270	*5W	70	50	40-250	150	.5	150		60
2N3946	NPN	GP	2N2217	360	60	40	50-150	10	.3	50	50	250
2N3947	NPN	GP	2N2219	360	60	40	100-300	10	.3	50	100	300
2N3948	NPN	RF		1W	36	20	15-	50				700
2N3953	NPN	RF	2N3571	200	15	12	30-360	2			40	1.3G
2N3954	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N3955	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST								
2N3956	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
2N3957	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
2N3958	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
2N3959	NPN	SW		400	20	12	40-200	10	.3	30		1.3G

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A=25°C$ *$T_C=25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N3960	NPN	SW		400	20	12	40-200	10	.3	30		1.6G
2N3962	PNP	GP	2N3962	360	60	60	100-300	.01	.25	10	100	40
2N3963	PNP	GP	2N3963	360	80	80	100-300	.01	.25	10	100	40
2N3964	PNP	GP	2N3964	360	45	45	250-500	.01	.25	10	250	50
2N3965	PNP	GP	2N3965	360	60	60	250-500	.01	.25	10	250	50
2N3966	NCH	FE	2N3966	SEE FET INTERCHANGEABILITY LIST								
2N3967	NCH	FE	2N3822	SEE FET INTERCHANGEABILITY LIST								
2N3968	NCH	FE	2N3822	SEE FET INTERCHANGEABILITY LIST								
2N3969	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N3970	NCH	FE	2N3970	SEE FET INTERCHANGEABILITY LIST								
2N3971	NCH	FE	2N3971	SEE FET INTERCHANGEABILITY LIST								
2N3972	NCH	FE	2N3972	SEE FET INTERCHANGEABILITY LIST								
2N3973	NPN	SW	TIS133	360	60	30	35-100	10	.3	150		200
2N3974	NPN	SW	TIS133	360	60	30	55-200	10	.3	150		200
2N3975	NPN	SW	TIS133	360	60	30	35-100	10	.3	150		200
2N3976	NPN	SW	TIS133	360	60	30	55-200	10	.3	150		200
2N3977	PNP	SW	2N2944	400	15	10	40-	5	.1	5		1
2N3978	PNP	SW	2N2944	400	25	20	30-	5	.15	5		1
2N3979	PNP	SW	2N2944	400	40	35	20-	5	.15	5		1
2N3980	P-N	UJ	2N3980	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N3981	NPN	GP	2N2219	800	60	30	30-120	150	.4	150		250
2N3982	NPN	GP	2N2218	800	50	20	40-140	150	.4	150		250
2N3983	NPN	RF	TIS62	200	30	12	30-	4				500
2N3984	NPN	RF	TIS63	200	30	12	20-	4				400
2N3985	NPN	RF	TIS64	200	30	12	20-	4				300
2N3993	PCH	FE	2N3993	SEE FET INTERCHANGEABILITY LIST								
2N3994	PCH	FE	2N3994	SEE FET INTERCHANGEABILITY LIST								
2N4006	PNP	SW	2N2944A	400	10	6					40	20
2N4007	PNP	SW	2N2945A	400	20	15					30	15
2N4008	PNP	SW	2N2946A	400	35	30					20	15
2N4009	PNP	SW		400	10	6					40	20
2N4010	PNP	SW		400	20	15					30	15
2N4011	PNP	SW		400	35	30					20	15
2N4013	NPN	SW	2N4013	360	60	40	60-150	100				300
2N4014	NPN	SW	2N4014	360	80	50	60-150	100				300
2N4015	PNP	DU	2N3350	400	60	60	135-350	1	.25	50	135	200
2N4016	PNP	DU	2N3350	600	60	60	135-350	1	.25	50	135	200
2N4017	PNP	DU	2N3352	600	80	80	100-500	1				40
2N4018	PNP	DU	2N3352	400	60	60					100	7
2N4019	PNP	DU	2N3350	400	45	45					250	50

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N4020	PNP	DU	2N3350	400	45	45	200-500	.01	.25	10	250	50
2N4021	PNP	DU	2N3350	400	60	60	100-350	.01	.25	10	100	40
2N4022	PNP	DU	2N3350	400	60	60	250-500	.01	.25	10	250	50
2N4023	PNP	DU	2N3350	400	45	45	250-500	.01	.25	10	250	50
2N4024	PNP	DU	2N3350	400	60	60	100-350	.01	.25	10	100	40
2N4025	PNP	DU	2N3350	400	60	60	250-500	.01	.25	10	250	50
2N4026	PNP	GP	2N4026	500	60	60	40-120	100	1	1A		100
2N4027	PNP	GP	2N4027	500	80	80	40-120	100	.5	500		100
2N4028	PNP	GP	2N4028	500	60	60	100-300	100	1	1A		150
2N4029	PNP	GP	2N4029	500	80	80	100-300	100	.5	500		150
2N4030	PNP	GP	2N4030	800	60	60	40-120	100	1	1A		100
2N4031	PNP	GP	2N4031	800	80	80	40-120	100	.5	500		100
2N4032	PNP	GP	2N4032	800	60	60	100-300	100	1	1A		150
2N4033	PNP	GP	2N4033	800	80	80	100-300	100	.5	500		150
2N4034	PNP	GP	2N3250	360	40	40	70-200	10	.13	1	50	400
2N4035	PNP	GP	2N3250	360	40	40	150-300	10	.13	1	150	450
2N4036	PNP	GP	2N4030	*5W	90	65	40-140	150				60
2N4037	PNP	GP	2N2904	1W	60	40	50-250	150				60
2N4038	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4039	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4042	NPN	DU	2N3680	300	60	60	200-600	.01	.35	1		200
2N4043	NPN	DU	2N3680	300	45	45	80-800	.01	.35	1		150
2N4044	NPN	DU	2N3680	400	60	60	200-600	.01	.35	1		200
2N4045	NPN	DU	2N3680	400	45	45	80-800	.01	.35	1		150
2N4046	NPN	SW	2N3724	800	50	30	40-150	100				250
2N4047	NPN	SW	2N3725	800	80	50	40-150	100				250
2N4058	PNP	GP	2N4058	360	30	30	100-400	.1	.7	10		
2N4059	PNP	GP	2N4059	360	30	30	45-660	1	.7	10		
2N4060	PNP	GP	2N4060	360	30	30	45-165	1	.7	10		
2N4061	PNP	GP	2N4061	360	30	30	90-330	1	.7	10		
2N4062	PNP	GP	2N4062	360	30	30	180-660	1	.7	10		
2N4065	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST								
2N4066	PCH	FE	3N207	SEE FET INTERCHANGEABILITY LIST								
2N4067	PCH	FE	3N207	SEE FET INTERCHANGEABILITY LIST								
2N4068	NPN	GP	2N5059	500	150	150	30-	30				50
2N4074	NPN	GP		400	40	40						
2N4082	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4083	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4084	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
2N4085	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST								

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N4086	NPN	GP	TIS98	200	12	12	150-300	2			150	
2N4087	NPN	GP	TIS97	200	12	12	250-500	2			250	
2N4087A	NPN	GP	TIS97	200	12	12	250-500	2			250	
2N4088	PCH	FE	2N3331	SEE FET INTERCHANGEABILITY LIST								
2N4089	PCH	FE	2N3330	SEE FET INTERCHANGEABILITY LIST								
2N4090	PCH	FE	2N3329	SEE FET INTERCHANGEABILITY LIST								
2N4091	NCH	FE	2N4091	SEE FET INTERCHANGEABILITY LIST								
2N4092	NCH	FE	2N4092	SEE FET INTERCHANGEABILITY LIST								
2N4093	NCH	FE	2N4093	SEE FET INTERCHANGEABILITY LIST								
2N4094	NCH	FE	2N4856	SEE FET INTERCHANGEABILITY LIST								
2N4095	NCH	FE	2N4857	SEE FET INTERCHANGEABILITY LIST								
2N4099	NPN	DU		300	55	55	175-	1				150
2N4100	NPN	DU		400	55	55	175-	1				150
2N4104	NPN	GP	2N4104	300	60	60					1400	540
2N4117	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4117A	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4117A	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4118	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4119	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4120	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST								
2N4120A	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4121	PNP	GP	A5T2907	200	40	40	70-200	10				
2N4122	PNP	GP	A5T2907	200	40	40	150-300	10	.14	10		450
2N4123	NPN	SW	2N4123	310	40	30	50-150	2	.3	50	50	250
2N4124	NPN	SW	2N4124	310	40	30	120-360	2	.3	50	120	300
2N4125	PNP	SW	2N4125	310	30	30	50-150	2	.4	50	50	200
2N4126	PNP	SW	2N4126	310	25	25	120-360	2	.4	50	120	250
2N4134	NPN	RF	2N4252	200	30	30					200	350
2N4135	NPN	RF	2N4252	200	30	30					200	425
2N4138	NPN	SW	2N4138	300	30	30	50-	1				20
2N4139	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
2N4140	NPN	GP	TIS110	210	60	30	40-120	150	.4	150		250
2N4141	NPN	GP	A5T2222	200	60	30	100-300	150	.4	150		250
2N4142	PNP	GP	A5T2907	200	60	40	40-120	150	.4	150		200
2N4143	PNP	GP	A5T2907	200	60	40	100-300	150	.4	150		200
2N4207	PNP	SW		300	6	6	50-120	10				650
2N4208	PNP	SW		300	12	12	30-120	10				700
2N4209	PNP	SW		300	15	15	50-120	10				850
2N4220	NCH	FE	2N4220	SEE FET INTERCHANGEABILITY LIST								
2N4220A	NCH	FE		SEE FET INTERCHANGEABILITY LIST								

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N4221	NCH	FE	2N4221	SEE FET INTERCHANGEABILITY LIST								
2N4221A	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4222	NCH	FE	2N4222	SEE FET INTERCHANGEABILITY LIST								
2N4222A	NCH	FE	2N4222A	SEE FET INTERCHANGEABILITY LIST								
2N4223	NCH	FE	2N4223	SEE FET INTERCHANGEABILITY LIST								
2N4224	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4227	NPN	GP	TIS110	200	60	30	75-150	150	.4	150		250
2N4228	PNP	GP	A5T2907	200	60	40	75-150	150	.4	150		200
2N4248	PNP	GP	A5T4248	200	40	40	50-	.1	.25	10	50	40
2N4249	PNP	GP	A5T4249	200	60	60	100-300	.1	.25	10	100	40
2N4250	PNP	GP	A5T4250	200	40	40	250-900	.1	.25	10	250	50
2N4251	NPN	SW		250	15	10	100-	10				130
2N4252	NPN	RF	2N4252	200	30	18	50-	2				600
2N4253	NPN	RF	2N4253	200	30	18	30-	2				600
2N4254	NPN	RF	2N4996	250	30	18	50-	2				600
2N4255	NPN	RF	2N4997	250	30	18	30-150					600
2N4256	NPN	SW		360	30	30	100-500	2	.2	10		
2N4257	PNP	SW		200	6	6	30-120	10	.15	10		500
2N4258	PNP	SW		200	12	12	30-120	10	.15	10		700
2N4258A	PNP	SW		200	12	12	30-120	10	.15	10		700
2N4259	NPN	RF	2N4252	175	40	30					70	
2N4260	PNP	SW		200	15	15	30-150	10	.15	10	16	1.5G
2N4261	PNP	SW		200	15	15	30-150	10	.15	10	20	2G
2N4264	NPN	SW	2N3903	310	30	15	40-160	10	.22	10		300
2N4265	NPN	SW	2N3904	310	30	12	100-400	10	.22	10		300
2N4267	PCH	FE	3N160	SEE FET INTERCHANGEABILITY LIST								
2N4268	PCH	FE	3N160	SEE FET INTERCHANGEABILITY LIST								
2N4269	NPN	GP	2N5059	360	200	140	40-200	10				
2N4270	NPN	GP	2N5059	580	200	140	40-200	10				
2N4274	NPN	SW	A5T3903	200	30	12	30-120	10	.2	10		400
2N4275	NPN	SW	A5T3903	200	40	15	30-120	10	.2	10		400
2N4302	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
2N4303	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST								
2N4304	NCH	FE	2N5951	SEE FET INTERCHANGEABILITY LIST								
2N4313	PNP	SW		200	12	12	30-120	30	.19	30		700
2N4338	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
2N4339	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4340	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
2N4341	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
2N4342	PCH	FE	2N3994	SEE FET INTERCHANGEABILITY LIST								

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS			ELECTRICAL CHARACTERISTICS					
				P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N4343	PCH	FE	2N3993	SEE FET INTERCHANGEABILITY LIST								
2N4351	NCH	FE	3N169	SEE FET INTERCHANGEABILITY LIST								
2N4352	NCH	FE	3N160	SEE FET INTERCHANGEABILITY LIST								
2N4353	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST								
2N4354	PNP	GP	A5T2907	350	60	60	50-500	10	1	1A		100
2N4355	PNP	GP	A5T2907	350	60	60	100-400	10	1	1A		100
2N4356	PNP	GP	A5T2907	350	80	60	50-250	10	1	1A		100
2N4357	PNP	GP		400	240	240	80-300	10	.5	10	100	40
2N4358	PNP	GP		400	240	240	80-300	10	.5	10	100	40
2N4359	PNP	GP	2N3798	360	45	45	50-600	1	.25	10	50	
2N4360	PCH	FE	A5T5462	SEE FET INTERCHANGEABILITY LIST								
2N4381	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4382	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4383	NPN	GP		800	40	30	100-500	.01	.2	10	100	30
2N4384	NPN	GP	2N2484	500	40	30	100-500	.01	.2	10	100	30
2N4385	NPN	GP		800	40	30	40-500	.01	.2	10	100	30
2N4386	NPN	GP	2N2483	500	40	30	40-500	.01	.2	10	100	30
2N4389	PNP	SW	2N4423	200	12	12	30-180	10	.15	10		
2N4390	NPN	GP	2N3114	500	120	120	20-	2	.3	20		50
2N4391	NCH	FE	2N4391	SEE FET INTERCHANGEABILITY LIST								
2N4392	NCH	FE	2N4392	SEE FET INTERCHANGEABILITY LIST								
2N4393	NCH	FE	2N4393	SEE FET INTERCHANGEABILITY LIST								
2N4397	NPN	RF	2N4252	200	40	40	40-180	2			40	600
2N4400	NPN	SW	TIS110	310	60	40	50-150	150	.4	150	20	200
2N4401	NPN	SW	TIS111	310	60	40	100-300	150	.4	150	40	250
2N4402	PNP	SW	A5T2907	310	40	40	50-150	150	.4	150	30	150
2N4403	PNP	SW	A5T2907	310	40	40	100-300	150	.4	150	60	200
2N4404	PNP	GP		*5W	80	80	40-120	150	.15	10		200
2N4405	PNP	GP		*5W	80	80	100-300	150	.15	10		200
2N4406	PNP	GP		*5W	80	80	30-100	500	.2	150		150
2N4407	PNP	GP		*5W	80	80	80-250	500	.2	150		150
2N4409	NPN	GP	2N4409	310	80	50	60-400	1	.2	1		60
2N4410	NPN	GP	2N4410	310	120	80	60-400	1	.2	1		60
2N4411	PNP	RF		150	15	12	40-	.5				400
2N4412	PNP	GP		600	40	30	100-500	.01	.2	10	120	20
2N4412A	PNP	GP		600	60	60	100-500	.01	.2	10	120	20
2N4413	PNP	GP	2N3964	400	40	30	100-500	.01	.2	10	120	20
2N4413A	PNP	GP	2N3965	400	60	60	100-500	.01	.2	10	120	20
2N4414	PNP	GP		600	40	30	40-500	.01	.2	10	120	20
2N4414A	PNP	GP		600	60	60	40-500	.01	.2	10	120	20

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N4415	PNP	GP	2N3962	400	40	30	40-500	.01	.2	10	120	20
2N4415A	PNP	GP	2N3962	400	60	60	40-500	.01	.2	10	120	20
2N4416	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST								
2N4416A	NCH	FE	2N4416A	SEE FET INTERCHANGEABILITY LIST								
2N4417	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4418	NPN	SW		250	40	15	40-120	10	.25	10		500
2N4419	NPN	SW		250	30	12	30-	10	.25	10		400
2N4420	NPN	SW		250	40	20	30-120	30	.2	10		350
2N4421	NPN	SW		250	30	12	25-	30	.2	10		300
2N4422	NPN	SW		250	40	15	30-120	30	.2	30		350
2N4423	PNP	SW	2N4423	250	12	12	40-150	30	.2	30		400
2N4424	NPN	GP	2N3711	560	60	40	180-540	2	.3	50	180	
2N4425	NPN	GP	2N3711	560	60	40	180-540	2	.3	50	180	
2N4432	NPN	GP	2N1613	600	50	30	40-130	6			45	
2N4432A	NPN	GP	2N1420	600	50	30	80-150	6			90	
2N4436	NPN	GP	A5T2222	200	60	30	40-120	150	.22	150		250
2N4437	NPN	GP	A5T2222	200	60	30	100-300	150	.22	150		250
2N4438	NPN	GP	2N5058	1W	300	300	40-120	50	1	100		30
2N4439	NPN	GP		1W	300	300	100-240	50	1	100		30
2N4445	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4446	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4447	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4448	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4449	NPN	SW		300		40	40-	10	.18	10		500
2N4450	NPN	SW	2N2540	300	60	30	75-	10	.22	10		250
2N4451	PNP	SW	2N3829	300		12	40-	30	.25	30		400
2N4452	PNP	GP	2N3486A	350	45	45	115-300	50	.4	15	135	200
2N4453	PNP	SW	2N3829	300		18	40-	30	.25	30		400
2N4851	P-N	UJ	2N4851	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4852	P-N	UJ	2N4852	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4853	P-N	UJ	2N4853	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4854	N/P	DU	2N4854	300	60	40	50-	1				200
2N4855	N/P	DU	2N4855	300	60	40	25-	1				200
2N4856	NCH	FE	2N4856	SEE FET INTERCHANGEABILITY LIST								
2N4856A	NCH	FE	2N4856A	SEE FET INTERCHANGEABILITY LIST								
2N4857	NCH	FE	2N4857	SEE FET INTERCHANGEABILITY LIST								
2N4857A	NCH	FE	2N4857A	SEE FET INTERCHANGEABILITY LIST								
2N4858	NCH	FE	2N4858	SEE FET INTERCHANGEABILITY LIST								
2N4858A	NCH	FE	2N4858A	SEE FET INTERCHANGEABILITY LIST								
2N4859	NCH	FE	2N4859	SEE FET INTERCHANGEABILITY LIST								

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N4859A	NCH	FE	2N4859A	SEE FET INTERCHANGEABILITY LIST								
2N4860	NCH	FE	2N4860	SEE FET INTERCHANGEABILITY LIST								
2N4860A	NCH	FE	2N4860A	SEE FET INTERCHANGEABILITY LIST								
2N4861	NCH	FE	2N4861	SEE FET INTERCHANGEABILITY LIST								
2N4861A	NCH	FE	2N4861A	SEE FET INTERCHANGEABILITY LIST								
2N4867	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4868	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4869	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4870	P-N	UJ	2N4891	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4871	P-N	UJ	2N4891	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4872	PNP	SW		400	12	12	50-120	10	.13	1		900
2N4873	NPN	SW		360	40	15	110-150	10	.2	10		900
2N4874	NPN	RF	2N4874	720	30	20					200	900
2N4875	NPN	RF	2N4875	720	40	25					200	800
2N4876	NPN	RF	2N4876	720	40	30					200	650
2N4878	NPN	DU		300	60	60	200-600	.01	.35	1		200
2N4879	NPN	DU		300	55	55	150-600	.01	.35	1		150
2N4880	NPN	DU		300	45	45	80-800	.01	.35	1		150
2N4881	NCH	FE	2N6449	SEE FET INTERCHANGEABILITY LIST								
2N4882	NCH	FE	2N6449	SEE FET INTERCHANGEABILITY LIST								
2N4883	NCH	FE	2N6450	SEE FET INTERCHANGEABILITY LIST								
2N4884	NCH	FE	2N6450	SEE FET INTERCHANGEABILITY LIST								
2N4885	NCH	FE	2N6450	SEE FET INTERCHANGEABILITY LIST								
2N4886	NCH	FE	2N6450	SEE FET INTERCHANGEABILITY LIST								
2N4888	PNP	GP	A5T5401	300	150	150	30-	1	.5	10		30
2N4889	PNP	GP	A5T5401	300	150	150	70-	1	.5	10		40
2N4890	PNP	GP	2N2905	1W	60	40	50-250	150	1.4	150		100
2N4891	P-N	UJ	2N4891	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4892	P-N	UJ	2N4892	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4893	P-N	UJ	2N4893	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4894	P-N	UJ	2N4894	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4916	PNP	GP	A5T3905	200	30	30	70-200	10	.14	10		400
2N4917	PNP	GP	A5T3906	200	30	30	150-300	10	.14	10		450
2N4924	NPN	GP	2N3114	1W	100	100	40-200	150	.4	50		100
2N4925	NPN	GP	2N3114	1W	150	150	40-200	150	.4	50		100
2N4926	NPN	GP	2N5059	1W	200	200	20-200	30	2	30	25	30
2N4927	NPN	GP	2N5059	1W	250	250	20-200	30	2	30	25	30
2N4928	PNP	GP	2N3634	600	100	100	25-200	10	.5	10		100
2N4929	PNP	GP	2N3634	600	150	150	25-200	10	.5	10		100
2N4930	PNP	GP		600	200	200	20-200	10	5	10		20

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N4931	PNP	GP		600	250	250	20-200	10	5	10		20
2N4934	NPN	RF	2N3570	200	40	30	40-172	2				700
2N4935	NPN	RF	2N3570	200	50	40	60-200	2				700
2N4936	NPN	RF	2N3570	200	50	40	60-250	2			70	700
2N4937	PNP	DU		600	50	40	50-250	1			50	300
2N4938	PNP	DU		600	50	40	50-250	1			50	300
2N4939	PNP	DU		600	50	40	50-250	1			50	300
2N4940	PNP	DU		600	50	40	50-250	1			50	300
2N4941	PNP	DU		600	50	40	50-250	1			50	300
2N4942	PNP	DU		600	50	40	50-250	1			50	300
2N4944	NPN	GP	A5T2193	220	80	40	40-120	150	.25	150		60
2N4945	NPN	GP	A5T2193	220	60	40	40-120	150	.25	150		60
2N4946	NPN	GP	A5T2222	220	80	40	100-300	150	.25	150		60
2N4947	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4948	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4949	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N4951	NPN	GP	TIS110	360	60	30	60-200	150	.3	150		250
2N4952	NPN	GP	A5T2222	360	60	30	100-300	150	.3	150		250
2N4953	NPN	GP		360	60	30	200-600	150	.3	150		250
2N4957	PNP	RF	2N4260	200	30	30	20-40	2				1.2G
2N4958	PNP	RF	2N4260	200	30	30	20-40	2				1G
2N4959	PNP	RF	2N4260	200	30	30	20-40	2				1G
2N4960	NPN	GP		800	60	60	100-300	150	.7	10		250
2N4961	NPN	GP		500	80	80	100-300	150	.7	10		250
2N4962	NPN	GP		800	60	60	100-300	150	.7	10		250
2N4963	NPN	GP		500	80	80	100-300	150	.7	10		250
2N4964	PNP	GP	2N4058	200	50	40	30-120	.01	.4	10		60
2N4965	PNP	GP	2N4058	200	50	40	80-400	.01	.4	10		60
2N4966	NPN	GP	2N3707	200	50	40	40-200	.01				40
2N4967	NPN	GP	2N3707	200	50	40	100-600	.01				40
2N4968	NPN	GP	2N3707	200	30	25	40-200	.01				40
2N4969	NPN	GP	TIS110	200	50	30	40-120	150	.4	150		200
2N4970	NPN	GP	A5T2222	200	50	30	100-350	150	.4	150		200
2N4971	PNP	GP	A5T2907	200	50	40	40-120	150	.4	150		200
2N4972	PNP	GP	A5T2907	200	50	40	100-300	150	.4	150		200
2N4973	PNP	RF		200	20	15	20-	3	.5	10		
2N4974	PNP	DA		800	40	30	5K-9K	1UA			25K	175
2N4975	PNP	DA		800	40	30	1K-4K	1UA			15K	175
2N4977	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4978	NCH	FE		SEE FET INTERCHANGEABILITY LIST								

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N4979	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N4980	PNP	SW	2N2946A	400	30	30	60-300	1				10
2N4981	PNP	SW		400	30	50	40-200	1				5
2N4982	PNP	SW		400	70	70	30-150	1				3
2N4994	NPN	RF	2N4994	360	60	45	40-160	10				200
2N4995	NPN	RF	2N4995	360	60	45	100-400	10				200
2N4996	NPN	RF	2N4996	250	30	18	50-	2				600
2N4997	NPN	RF	2N4997	250	30	18	30-	2				600
2N5010	NPN	GP		*2W	500		30-180	25	1.4	25		
2N5011	NPN	GP		*2W	600		30-180	25	1.5	25		
2N5012	NPN	GP		*2W	700		30-180	25	1.6	25		
2N5013	NPN	GP		*2W	800		30-180	20	1.6	20		
2N5014	NPN	GP		*2W	900		30-180	20	1.6	20		
2N5015	NPN	GP		*2W	1K		30-180	20	1.8	20		
2N5018	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5019	PCH	FE	2N3993	SEE FET INTERCHANGEABILITY LIST								
2N5020	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5021	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5022	PNP	SW		1W	50	50	25-100	500	.2	100		
2N5023	PNP	SW		1W	30	30	40-100	500	.17	100		
2N5024	NPN	RF	2N3570	200	20	10	25-	10			13	13G
2N5027	NPN	SW		320		30	50-150	150	.45	150		
2N5028	NPN	SW		320		30	100-300	150	.45	150		
2N5029	NPN	SW		320		15	40-120	10	.25	10		
2N5030	NPN	SW		320		12	30-	10	.25	10		
2N5031	NPN	RF	2N3571	200	15	10	25-300	1				
2N5032	NPN	RF	2N3571	200	15	10	25-300	1				
2N5033	PCH	FE	A5T5460	SEE FET INTERCHANGEABILITY LIST								
2N5040	PNP	GP	A5T4026	300	25	25	30-	150	1	500		80
2N5041	PNP	GP	A5T4026	300	40	40	40-150	150	.5	500		100
2N5042	PNP	GP	2N4030	800	40	40	40-150	150	1.1	500		100
2N5045	NCH	FE	2N5045	SEE FET INTERCHANGEABILITY LIST								
2N5046	NCH	FE	2N5046	SEE FET INTERCHANGEABILITY LIST								
2N5047	NCH	FE	2N5047	SEE FET INTERCHANGEABILITY LIST								
2N5053	NPN	RF	2N3572	200	30	15	25-150	2				13G
2N5054	NPN	RF	2N3572	200	30	15	25-150	2				13G
2N5055	PNP	SW	2N4423	200	12	12	30-100	30	.19	30		550
2N5056	PNP	SW	2N3829	360	15	15	30-100	30	.13	1		
2N5057	PNP	SW	2N3829	360	15	15	40-100	30	.13	1		
2N5058	NPN	GP	2N5058	1W	300	300	35-150	30				

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N5059	NPN	GP	2N5059	1W	250	250	30-150	30				
2N5060		CR	2N5060	SCR - SEE POWER DATA BOOK								
2N5061		CR	2N5061	SCR - SEE POWER DATA BOOK								
2N5062		CR	2N5062	SCR - SEE POWER DATA BOOK								
2N5063		CR	2N5063	SCR - SEE POWER DATA BOOK								
2N5064		CR	2N5064	SCR - SEE POWER DATA BOOK								
2N5065	NPN	SW		600	25	15	50-120	300	.23	100		550
2N5066	NPN	SW	2N2432A	400	30	20						5
2N5078	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST								
2N5079	NPN	GP	2N956	400	60	30	100-300	150	.2	150		400
2N5080	NPN	GP		400	60	30	200-500	150	.2	150		500
2N5081	NPN	GP	2N2484	360	70	50	100-400	1	.2	10	100	600
2N5082	NPN	GP	2N2484	360	60	30	100-400	1	.2	10	100	600
2N5086	PNP	GP	2N5086	310	50	50	150-500	.1	.3	10	150	40
2N5087	PNP	GP	2N5087	310	50	50	250-800	.1	.3	10	250	40
2N5088	NPN	GP	TIS94	310	35	30	300-900	.1	.5	10	350	50
2N5089	NPN	GP	TIS94	310	30	25	400-1200	.1	.5	10	450	50
2N5103	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5104	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5105	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST								
2N5106	NPN	GP		800	60	30	100-300	150	.22	150		250
2N5107	NPN	GP		360	60	30	100-300	150	.22	150		250
2N5114	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5115	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5116	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5117	PNP	DU		400	45	45	100-300	.01				100
2N5118	PNP	DU		400	45	45	100-300	.01				100
2N5119	PNP	DU		400	45	45	50-800	.01				100
2N5120	PNP	DU		300	45	45	100-300	.01				100
2N5121	PNP	DU		300	45	45	100-300	.01				100
2N5122	PNP	DU		300	45	45	50-800	.01				100
2N5123	PNP	DU		400	45	45	100-300	.01				100
2N5124	PNP	DU		400	45	45	100-300	.01				100
2N5125	PNP	DU		400	45	45	50-800	.01				100
2N5126	NPN	RF	TIS98	200	20	20	20-350	4	2	10		300
2N5127	NPN	RF	TIS98	200	20	12	15-300	2	.3	10		150
2N5128	NPN	RF	2N5451	300	15	12	35-350	50	.25	150		200
2N5129	NPN	RF	2N5451	200	15	12	35-350	50	.25	150		200
2N5130	NPN	RF	2N5451	200	30	12	15-250	8	.6	10		450
2N5131	NPN	GP	TIS98	200	20	15	30-500	10	1	10		100

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2N5132	NPN	RF	2N5451	200	20	20	30-400	10	2	10		200
2N5133	NPN	GP	A5T3708	200	20	18	60-1000	1	.4	1		40
2N5134	NPN	SW	A5T3903	200	20	10	60-150	10	.25	10		250
2N5135	NPN	GP	A5T3708	300	30	25	50-600	10	1	100		40
2N5136	NPN	GP	2N5451	300	30	20	20-400	150	.25	150		40
2N5137	NPN	GP	2N5451	220	30	20	20-400	150	.25	150		40
2N5138	PNP	GP	A5T4058	200	30	30	50-800	.1	.3	10		30
2N5139	PNP	SW	A5T4126	200	20	20	40-	10	.2	10		300
2N5140	PNP	SW		200	5	5	20-140	10	.2	10		400
2N5141	PNP	SW	2N4423	200	6	6	25-	10	.2	10		300
2N5142	PNP	SW	A5T3644	300	20	20	30-	50	.5	50		100
2N5143	PNP	SW	A5T3644	200	20	20	30-	50	.5	50		100
2N5144	NPN	SW		360	50	30	60-150	100	.2	100		300
2N5145	NPN	SW		800	50	30	60-150	100	.2	100		300
2N5158	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5159	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5163	NCH	FE	2N5246	SEE FET INTERCHANGEABILITY LIST								
2N5172	NPN	GP	A7T5172	360	25	25	100-500	10	.25	10	100	
2N5174	NPN	GP	2N5550	360	90	75	40-600	10	.95	10	40	
2N5175	NPN	GP	2N5550	200	130	100	55-160	10	.95	10	55	
2N5176	NPN	GP	2N5550	200	130	100	140-300	10	.95	10	140	
2N5179	NPN	RF	2N3572	200	20	12	25-250	3	.4	10	25	900
2N5180	NPN	RF	2N3572	180	30	15	20-200	2				650
2N5181	NPN	RF		180	45		27-	1				400
2N5182	NPN	RF		180	35		27-	1				400
2N5183	NPN	GP	2N956	500	18	18	75-	10			70	62
2N5184	NPN	GP	2N5059	500		120	10-	50				
2N5185	NPN	GP		1W		120	10-	50				50
2N5186	NPN	SW		300	10		25-	10	.3	10		
2N5187	NPN	SW		1W	25		30-	10	.25	10		
2N5188	NPN	SW	2N2537	800	60		25-	150	.5	150		
2N5189	NPN	SW	2N3724	1W	60		15-	1A	1	1A		
2N5196	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5197	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
2N5198	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST								
2N5199	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
2N5200	NPN	GP		300	20	20	50-150	10	.5	50		900
2N5201	NPN	GP		300	20	20	75-150	10	.5	50		1.1G
2N5208	PNP	RF		310	30	25	20-120	2				300
2N5209	NPN	GP	2N5209	310	50	50	100-300	.1	.7	10	150	30

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N5210	NPN	GP	2N5210	310	50	50	200-600	.1	.7	10	250	30
2N5219	NPN	GP	2N5219	310	20	15	35-500	2	.4	10	35	150
2N5220	NPN	GP	2N5220	310	15	15	30-600	50	.5	150	30	100
2N5221	PNP	GP	2N5221	310	15	15	30-600	50	.5	150	30	100
2N5222	NPN	RF	2N5222	310	20	15	50-1500	4	1	4	20	450
2N5223	NPN	GP	2N5223	310	25	20	50-800	2	.7	10	50	150
2N5224	NPN	SW	2N3903	310	25	12	40-400	10	.35	10		250
2N5225	NPN	GP	2N5225	310	25	25	30-600	50	.8	100	30	50
2N5226	PNP	GP	2N5226	310	25	25	30-600	50	.8	100	30	50
2N5227	PNP	GP	2N5227	310	30	30	50-700	2	.4	10	50	100
2N5228	PNP	SW		310	5	5	30-	10	.4	10		300
2N5230	PNP	SW	2N2945A	400	30	20	50-	.1				
2N5231	PNP	SW	2N2946A	400	50	30	50-	.1				
2N5232	NPN	GP	TIS95	360	70	50	250-500	2	.125	10	250	
2N5232A	NPN	GP	TIS95	360	70	50	250-500	2	.125	10	250	
2N5233	NPN	GP	TIS95	330	80	60	100-300	10	.125	10	100	
2N5234	NPN	GP	TIS94	330	80	60	250-500	10	.125	10	250	
2N5235	NPN	GP		330	80	60	400-800	10	.125	10	400	
2N5236	NPN	RF		600	40	20	30-120	50	.2	50		500
2N5242	PNP	SW		500	20		25-100	500	.2	100		170
2N5243	PNP	SW		500	30		25-100	500	.2	100		170
2N5244	PNP	SW		360		40	150-300	10	.12	10		450
2N5245	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST								
2N5246	NCH	FE	2N5246	SEE FET INTERCHANGEABILITY LIST								
2N5247	NCH	FE	2N5247	SEE FET INTERCHANGEABILITY LIST								
2N5248	NCH	FE	2N5248	SEE FET INTERCHANGEABILITY LIST								
2N5249	NPN	GP	TIS94	360	70	50	400-800	2	.125	10	400	
2N5249A	NPN	GP	TIS94	360	70	50	400-800	2	.125	10	400	
2N5252	NPN	GP	2N5058	*7W	300	300	40-120	100	1	200		30
2N5253	NPN	GP		*7W	300	300	80-250	100	1	200		30
2N5262	NPN	GP		1W	75	50	35-	100	.8	1A		
2N5265	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5266	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5267	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5268	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5269	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5270	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5272	NPN	SW		360	40	20	100-400	10	.25	10		500
2N5276	NPN	SW		360	25	15	30-90	1	.2	20		600
2N5277	NCH	FE		SEE FET INTERCHANGEABILITY LIST								

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N5278	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5279	NPN	GP		*5W	400	300	40-160	20	.5	50		15
2N5281	PNP	GP	2N3636	*2W	175	150	20-200	1	2	10		20
2N5282	PNP	GP		*2W	325	300	20-200	1	2	10		20
2N5292	PNP	SW		*1W		12	40-100	30	.12	10		800
2N5305	NPN	DA		400	25	25	2000-20K	2	1.4	200	2000	
2N5306	NPN	DA	2N5525	400	25	25	7K-70K	2	1.4	200	7K	
2N5306A	NPN	DA	2N5525	400	25	25	7K-70K	2	1.4	200	7K	
2N5307	NPN	DA		400	40	40	2K-20K	2	1.4	200	2K	
2N5308	NPN	DA	2N5525	400	40	40	7K-70K	2	1.4	200	7K	
2N5308	NPN	DA	2N5525	400	40	40	7K-70K	2	1.4	200	7K	
2N5309	NPN	GP	2N3710	360	70	50	60-120	.01	.125	10	66	
2N5310	NPN	GP	2N3707	360	70	50	100-300	.01	.125	10	110	
2N5311	NPN	GP	TIS94	330	70	50	250-500	.01	.125	10		
2N5332	PNP	SW		360	20	12	20-80	1	.2	20		600
2N5354	PNP	GP	2N3703	360	25	25	40-120	50	.25	50	32	
2N5355	PNP	GP	2N3702	360	25	25	100-300	50	.25	50	80	
2N5356	PNP	GP		360	25	25	250-500	50	.25	50	200	
2N5358	NCH	FE	2N5358	SEE FET INTERCHANGEABILITY LIST								
2N5359	NCH	FE	2N5359	SEE FET INTERCHANGEABILITY LIST								
2N5360	NCH	FE	2N5360	SEE FET INTERCHANGEABILITY LIST								
2N5361	NCH	FE	2N5361	SEE FET INTERCHANGEABILITY LIST								
2N5362	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST								
2N5363	NCH	FE	2N5363	SEE FET INTERCHANGEABILITY LIST								
2N5364	NCH	FE	2N5364	SEE FET INTERCHANGEABILITY LIST								
2N5365	PNP	GP	2N3703	360	40	40	40-120	50	.25	50	32	
2N5366	PNP	GP	2N3702	360	40	40	100-300	50	.25	50	80	
2N5367	PNP	GP		360	40	40	250-500	50	.25	50	200	
2N5368	NPN	GP	TIS110	360	40	30	60-200	150	.3	150		250
2N5369	NPN	GP	TIS111	360	40	30	100-300	150	.3	150		250
2N5370	NPN	GP	TIS110	360	40	30	200-600	150	.3	150		250
2N5371	NPN	GP	TIS111	360	40	30	60-600	150	.3	150		250
2N5372	PNP	GP	2N5448	360	60	30	40-120	150	.3	150		150
2N5373	PNP	GP	A5T2907	360	60	30	100-300	150	.3	150		150
2N5374	PNP	GP	A5T2907	360	60	30	200-400	150	.3	150		150
2N5375	PNP	GP	2N5447	360	40	30	40-400	150	.3	150		150
2N5376	NPN	GP	TIS97	360	60	30	100-500	.01	.2	10	120	300
2N5377	NPN	GP	TIS98	360	60	30	40-200	.01	.2	10	100	300
2N5378	PNP	GP	A5T4058	360	40	30	100-500	.01	.2	10	120	200
2N5379	PNP	GP	A5T4060	360	40	30	40-200	.01	.2	10	100	200

TEXAS INSTRUMENTS
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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N5380	NPN	SW	A5T3903	310	60	40	50-150	10	.2	10		250
2N5381	NPN	SW	A5T3904	310	60	40	100-300	10	.2	10		300
2N5382	PNP	SW	A5T3905	310	40	40	50-150	10	.25	10		200
2N5383	PNP	SW	A5T3906	310	40	40	100-300	10	.25	10		250
2N5391	NCH	FE	2N5359	SEE FET INTERCHANGEABILITY LIST								
2N5392	NCH	FE	2N5361	SEE FET INTERCHANGEABILITY LIST								
2N5393	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST								
2N5394	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST								
2N5395	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST								
2N5396	NCH	FE	2N5363	SEE FET INTERCHANGEABILITY LIST								
2N5397	NCH	FE	2N5397	SEE FET INTERCHANGEABILITY LIST								
2N5398	NCH	FE	2N5398	SEE FET INTERCHANGEABILITY LIST								
2N5399	NPN	SW		360	25	15	30-90	1	.2	20		600
2N5400	PNP	GP	2N5400	310	130	120	40-180	10	.2	10	30	100
2N5401	PNP	GP	2N5401	310	160	150	60-240	10	.2	10	40	100
2N5413	NPN	SW	2N3724	1W	60	40	25-100	2A	.25	150		
2N5414	NPN	SW	2N3725	1W	80	50	25-100	2A	.25	150		
2N5415	PNP	GP	2N3636	1W	200	200	30-150	50				15
2N5416	PNP	GP		1W	350	300	30-120	50				15
2N5417	NPN	SW		500	40	35	80-250	150	.55	150		250
2N5418	NPN	GP	2N3705	400	25	25	40-120	50	.25	50		
2N5419	NPN	GP	2N3704	400	25	25	100-300	50	.25	50		
2N5420	NPN	GP	2N3706	400	25	25	250-500	50	.25	50		
2N5431	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N5432	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5433	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5434	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5447	PNP	GP	2N5447	360	40	25	60-300	50	.25	50		100
2N5448	PNP	GP	2N5448	360	50	30	30-150	50	.25	50		100
2N5449	NPN	GP	2N5449	360	50	30	100-300	50	.6	100		100
2N5450	NPN	GP	2N5450	360	50	30	50-150	50	.8	100		100
2N5451	NPN	GP	2N5451	360	40	20	30-600	50	1	100		100
2N5452	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
2N5453	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
2N5454	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST								
2N5455	PNP	SW		340	15	15	30-120	30	.5	300		450
2N5456	PNP	SW		340	25	25	30-120	30	.55	300		450
2N5457	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
2N5458	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST								
2N5459	NCH	FE	2N5951	SEE FET INTERCHANGEABILITY LIST								

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS			ELECTRICAL CHARACTERISTICS						
				P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	h_{FE} MIN	MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N5460	PCH	FE	2N5460	SEE FET INTERCHANGEABILITY LIST									
2N5461	PCH	FE	2N5461	SEE FET INTERCHANGEABILITY LIST									
2N5462	PCH	FE	2N5462	SEE FET INTERCHANGEABILITY LIST									
2N5463	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5464	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5465	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5471	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5472	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5473	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5474	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5475	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5476	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5484	NCH	FE	2N5246	SEE FET INTERCHANGEABILITY LIST									
2N5485	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST									
2N5486	NCH	FE	2N5247	SEE FET INTERCHANGEABILITY LIST									
2N5505	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5506	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5507	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5508	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5509	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5514	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5515	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5516	PCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST									
2N5517	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST									
2N5518	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST									
2N5519	NCH	FE	2N5045	SEE FET INTERCHANGEABILITY LIST									
2N5520	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5521	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST									
2N5522	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST									
2N5523	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST									
2N5524	NCH	FE	2N5045	SEE FET INTERCHANGEABILITY LIST									
2N5525	NPN	DA	2N5525	360	40	30	5K-		10	1	50		200
2N5526	NPN	DA	2N5526	360	40	30	1K-		10	1	50		200
2N5543	NCH	FE	2N6449	SEE FET INTERCHANGEABILITY LIST									
2N5544	NCH	FE	2N6450	SEE FET INTERCHANGEABILITY LIST									
2N5545	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST									
2N5546	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST									
2N5547	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST									
2N5548	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
2N5549	NCH	FE	2N5549	SEE FET INTERCHANGEABILITY LIST									

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS V_{CBO} (V)	MAXIMUM RATINGS V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N5550	NPN	GP	2N5550	310	160	140	60-250	10	.15	10	50	100
2N5551	NPN	GP	2N5551	310	180	160	80-250	10	.15	10	50	100
2N5555	NCH	FE	2N5949	SEE FET INTERCHANGEABILITY LIST								
2N5558	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST								
2N5556	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
2N5557	NCH	FE	2N5361	SEE FET INTERCHANGEABILITY LIST								
2N5561	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5562	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
2N5563	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
2N5564	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5565	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5566	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5581	NPN	GP	2N2221A	*2W	75	40	40-120	150	.3	150		250
2N5582	NPN	GP	2N2222A	*2W	75	40	100-300	150	.3	150		300
2N5583	PNP	RF		*5W	30	30	25-100	100	.8	100		1.3G
2N5592	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5593	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5594	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5638	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST								
2N5639	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST								
2N5640	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST								
2N5647	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5648	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5649	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5651	NPN	RF	2N3570	150	20	15	30-300	3				2G
2N5652	NPN	RF	2N3570	150	20	15	30-300	3				2G
2N5653	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST								
2N5654	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST								
2N5668	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
2N5669	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST								
2N5670	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST								
2N5690	NPN	RF	2N3570	150	20	15	30-300	3				2G
2N5716	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5717	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5718	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
2N5769	NPN	SW		625	40	15	40-120	10	.5	10		500
2N5770	NPN	RF	2N4996	625	30	15	20-	3	.4	10		900
2N5771	PNP	SW		625	15	15	50-120	10	.18	10		850
2N5772	NPN	SW		625	40	15	30-120	30	.3	30		350
2N5777	NPN	DA		200	25	25	2500-					

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N5778	NPN	DA		200	40	40	2500-					
2N5779	NPN	DA		200	25	25	5000-					
2N5780	NPN	DA		200	40	40	5000-					
2N5793	NPN	DU		500	75	40	40-120	150	.9	300		
2N5794	NPN	DU		500	75	40	100-300	150	.9	300		
2N5795	NPN	DU		500	60	60	40-120	150	1.6	500		
2N5796	NPN	DU		500	60	60	100-300	150	1.6	500		
2N5797	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5798	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5799	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5800	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5801	NCH	FE	2N4858	SEE FET INTERCHANGEABILITY LIST								
2N5802	NCH	FE	2N5549	SEE FET INTERCHANGEABILITY LIST								
2N5803	NCH	FE	2N5549	SEE FET INTERCHANGEABILITY LIST								
2N5810	NPN	GP	A5T2222	500	35	25	60-200	2	.75	500		100
2N5811	PNP	GP	A5T2907	500	35	25	60-200	2	.75	500		100
2N5812	NPN	GP		500	35	25	150-500	2	.75	500		135
2N5813	PNP	GP		500	35	25	150-500	2	.75	500		135
2N5814	NPN	GP	A5T2222	500	50	40	60-120	2	.75	500		100
2N5815	PNP	GP	A5T2907	500	50	40	60-120	2	.75	500		100
2N5816	NPN	GP	A5T2222	500	50	40	100-200	2	.75	500		120
2N5817	PNP	GP	A5T2907	500	50	40	100-200	2	.75	500		120
2N5818	NPN	GP		500	50	40	150-300	2	.75	500		135
2N5819	PNP	GP		500	50	40	150-300	2	.75	500		135
2N5820	NPN	GP		500	70	60	60-120	2	.75	500		100
2N5821	PNP	GP	A5T2907	500	70	60	60-120	2	.75	500		100
2N5822	NPN	GP		500	70	60	100-200	2	.75	500		120
2N5823	PNP	GP	A5T2907	500	70	60	100-200	2	.75	500		120
2N5824	NPN	GP	TIS99	360	50	40	60-120	2	.125	10	60	90
2N5825	NPN	GP	TIS98	360	50	40	100-200	2	.125	10	100	90
2N5826	NPN	GP	TIS98	360	50	40	150-300	2	.125	10	150	90
2N5827	NPN	GP	TIS97	360	50	40	250-500	2	.125	10	250	90
2N5828	NPN	GP	TIS97	360	50	40	400-800	2	.125	10	400	90
2N5829	PNP	RF	2N4260	200	30	30	20-150	2				
2N5830	NPN	GP	A5T2243	310	120	100	80-500	10	.25	50	60	
2N5831	NPN	GP		310	160	140	80-250	10	.25	50	60	
2N5832	NPN	GP		310	160	140	175-500	10	.25	50	125	
2N5833	NPN	GP		310	200	180	50-250	10	.25	50	50	
2N5835	NPN	SW		200	15	10	25-	10				
2N5836	NPN	SW		*2W	15	10	25-	50				

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N5837	NPN	SW		*2W	10	5	25-	100				
2N5841	NPN	RF		350	20	10	25-200	25				
2N5842	NPN	RF		350	20	10	25-250	25				
2N5843	PNP	DU	2N3347	500	50	40	50-150	.1				
2N5844	PNP	DU	2N3350	500	50	40	100-300	.1				
2N5845	NPN	SW		500	50	40	25-150	500	.6	500		200
2N5845A	NPN	SW		500	50	40	35-150	500	.5	500		250
2N5851	NPN	RF	2N3572	200	30	15	40-	10				800
2N5852	NPN	RF	2N3571	200	30	15	40-	10				1.1G
2N5855	PNP	GP	A5T4030	750	60	60	50-300	150	.4	150		
2N5856	NPN	GP	A5T2192	750	60	60	50-300	150	.4	150		
2N5857	PNP	GP	A5T4030	750	80	80	50-300	150	.4	150		
2N5858	NPN	GP	A5T2243	750	80	80	50-300	150	.4	150		
2N5902	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5903	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5904	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5905	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5906	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5907	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5908	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5909	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5910	PNP	SW		200	20	20	30-120	10	.5	50		700
2N5911	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5912	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
2N5943	NPN	RF		1W	40	30	25-300	50	.2	100	25	
2N5949	NCH	FE	2N5949	SEE FET INTERCHANGEABILITY LIST								
2N5950	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST								
2N5951	NCH	FE	2N5951	SEE FET INTERCHANGEABILITY LIST								
2N5952	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST								
2N5953	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
2N5961	NPN	GP	TIS94	200		60	150-950	10				
2N5962	NPN	GP		200		45	600-1550	10				
2N5963	NPN	GP		200		30	1200-2200	10				
2N5998	NPN	GP	2N3710	400	35	25	150-300	10	.25	50	150	140
2N5999	PNP	GP	2N4061	400	35	25	150-300	10	.25	50	150	140
2N6000	NPN	SW	A5T3904	400	35	25	100-300	10	.08	10	70	150
2N6001	PNP	SW	A5T3906	400	35	25	100-300	10	.1	10	85	225
2N6002	NPN	SW		400	35	25	250-500	10	.08	10	175	165
2N6003	PNP	SW		400	35	25	250-500	10	.1	10	235	250
2N6004	NPN	GP	TIS111	400	50	40	100-300	10	.08	10	70	150

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS V_{CBO} (V)	MAXIMUM RATINGS V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N6005	PNP	GP	A5T2907	400	50	40	100-300	10	.1	10	85	225
2N6006	NPN	GP		400	50	40	250-500	10	.08	10	175	165
2N6007	PNP	GP		400	50	40	250-500	10	.1	10	235	250
2N6008	NPN	GP	2N3711	400	35	25	250-500	10	.25	50	250	140
2N6009	PNP	GP	2N4062	400	35	25	250-500	10	.25	50	250	140
2N6010	NPN	GP	A5T2222	500	50	40	100-300	10	.05	10	65	350
2N6011	PNP	GP	A5T2907	500	50	40	100-300	10	.08	10	90	75
2N6012	NPN	GP		500	50	40	250-500	10	.05	10	155	500
2N6013	PNP	GP		500	50	40	250-500	10	.08	10	225	120
2N6014	NPN	GP		500	70	60	100-300	10	.05	10	65	105
2N6015	PNP	GP	A5T2907	500	70	60	100-300	10	.08	10	90	75
2N6016	NPN	GP		500	70	60	250-500	10	.05	10	155	150
2N6017	PNP	GP		500	70	60	250-500	10	.08	10	225	120
2N6027	PUT	UJ	A7T6027	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6028	PUT	UJ	A7T6087	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6067	PNP	SW		625	50	40	25-150	500	.6	500	150	
2N6076	PNP	GP	2N4061	360	25	25	100-500	10	.25	10	100	
2N6085	NPN	DU	2N2917	300	45	45	60-240	.01	.35	1		60
2N6086	NPN	DU	2N2918	300	45	45	150-600	.01	.35	1		60
2N6087	NPN	DU	2N2915	300	45	45	60-240	.01	.35	1		60
2N6088	NPN	DU	2N2916	300	45	45	150-600	.01	.35	1		60
2N6089	NPN	DU	2N2917	300	45	45	60-240	.01	.35	1		60
2N6090	NPN	DU	2N2918	300	45	45	150-600	.01	.35	1		60
2N6091	NPN	DU	2N2919	300	60	60	60-240	.01	.35	1		60
2N6092	NPN	DU	2N2920	300	60	60	150-600	.01	.35			60
2N6027	PUT	UJ	A7T6027	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6028	PUT	UJ	A7T6028	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6114	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6115	P-N	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6116	PUT	UJ	2N6116	SEE DATA SHEET ON 2N6116								
2N6117	PUT	UJ	2N6117	SEE DATA SHEET ON 2N6117								
2N6118	PUT	UJ	2N6118	SEE DATA SHEET ON 2N6118								
2N6119	PUT	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6120	PUT	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6137	PUT	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6138	PUT	UJ		SEE UNIJUNCTION INTERCHANGEABILITY LIST								
2N6218	NPN	GP	A5T5058	500	300	300	20-	20	1	10	20	50
2N6219	NPN	GP	A5T5058	500	250	250	20-	20	1	10	20	50
2N6220	NPN	GP	TIS100	500	200	200	20-	20	2	20	20	50
2N6221	NPN	GP	TIS101	500	150	150	20-	20	2.3	20	20	50

TEXAS INSTRUMENTS
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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2N6222	NPN	GP		360	60	60	75	200	2	.125	10	75	
2N6223	PNP	GP	TIS93	360	60	60	75	200	2	.25	10	75	
2N6224	NPN	GP		360	60	60	150	300	2	.125	10	150	
2N6225	PNP	GP	TIS93	360	60	60	150	300	2	.25	10	150	
2N6449	NCH	FE	2N6449	SEE FET INTERCHANGEABILITY LIST									
2N6450	NCH	FE	2N6450	SEE FET INTERCHANGEABILITY LIST									
2N6451	NCH	FE	2N6451	SEE FET INTERCHANGEABILITY LIST									
2N6452	NCH	FE	2N6452	SEE FET INTERCHANGEABILITY LIST									
2N6453	NCH	FE	2N6453	SEE FET INTERCHANGEABILITY LIST									
2N6454	NCH	FE	2N6454	SEE FET INTERCHANGEABILITY LIST									
3N34	NPN	SW	3N34	125	30								
3N35	NPN	SW	3N35	125	30	30						25	
3N35A	NPN	SW	3N35	125	30	30						10	
3N62	NPN	SW	3N79	100	10								
3N63	NPN	SW	3N79	100	10								
3N64	NPN	SW	3N77	100	10								
3N65	NPN	SW	3N79	100									
3N66	NPN	SW	3N78	100									
3N67	NPN	SW	3N77	100									
3N68	NPN	SW	3N79	100	10								
3N68A	NPN	SW	3N79	100	10								
3N69	NPN	SW	3N78	100	10								
3N70	NPN	SW	3N77	100	10								
3N71	NPN	SW	3N77	100	15	8	40		2				100
3N72	NPN	SW	3N78	100	15	8	40		2				100
3N73	NPN	SW	3N79	100	15	8	40		2				100
3N74	NPN	SW	3N74	300	50								30
3N75	NPN	SW	3N75	300	50								30
3N76	NPN	SW	3N76	300	50								30
3N77	NPN	SW	3N77	300	40								30
3N78	NPN	SW	3N78	200	40								30
3N79	NPN	SW	3N79	300	40								30
3N87	NPN	SW	3N77	200	20	10	5		.5				100
3N88	NPN	SW	3N78	200	20	10	5		.5				
3N89	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N90	PNP	SW	3N110	300	50								6
3N91	PNP	SW	3N111	300	50								6
3N92	PNP	SW	3N111	300	50								6
3N93	PNP	SW	3N108	300	50								6
3N94	PNP	SW	3N109	300	50								6

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF REGISTERED TYPES

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
3N95	PNP	SW	3N109	300	50								
3N96	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N97	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N98	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N99	NCH	FE	3N128	SEE FET INTERCHANGEABILITY LIST									
3N100	PNP	SW	3N110	300	20								
3N101	PNP	SW	3N110	300	30								
3N102	PNP	SW	3N110	300	40								
3N103	PNP	SW	3N111	300	50								
3N104	PNP	SW	3N111	300	60								
3N105	PNP	SW	3N111	300	20								
3N106	PNP	SW	3N111	300	40								
3N107	PNP	SW	3N109	300	60								
3N108	PNP	SW	3N108	300	50								12
3N109	PNP	SW	3N109	300	50								12
3N110	PNP	SW	3N110	300	50								12
3N111	PNP	SW	3N111	300	50								12
3N112	PNP	SW		200	50								6
3N113	PNP	SW		200	50								6
3N114	PNP	SW	3N110	200	30								12
3N117	PNP	SW	3N110	300	50								12
3N116	PNP	SW	3N111	300	30								12
3N118	PNP	SW	3N111	300	50								12
3N119	PNP	SW	3N111	300	50								12
3N120	NPN	SW		200	30								40
3N121	NPN	SW		200	30								40
3N123	PNP	SW		100	30								
3N124	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N125	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N126	NCH	FE	3N206	SEE FET INTERCHANGEABILITY LIST									
3N127	NPN	SW		200	30	20							40
3N128	NCH	FE	3N128	SEE FET INTERCHANGEABILITY LIST									
3N129	PNP	SW	3N110	300	20								
3N130	PNP	SW	3N110	300	30								
3N131	PNP	SW	3N110	300	40								
3N132	PNP	SW	3N108	300	50								
3N133	PNP	SW	3N108	300	60								
3N134	PNP	SW	3N110	300	20								
3N135	PNP	SW	3N110	300	40								
3N136	PNP	SW	3N108	300	60								

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TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
3N138	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N139	NCH	FE	3N203	SEE FET INTERCHANGEABILITY LIST									
3N140	NCH	FE	3N201	SEE FET INTERCHANGEABILITY LIST									
3N141	NCH	FE	3N201	SEE FET INTERCHANGEABILITY LIST									
3N142	NCH	FE	3N201	SEE FET INTERCHANGEABILITY LIST									
3N143	NCH	FE	3N128	SEE FET INTERCHANGEABILITY LIST									
3N145	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST									
3N146	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST									
3N147	PCH	FE	3N208	SEE FET INTERCHANGEABILITY LIST									
3N148	PCH	FE	3N208	SEE FET INTERCHANGEABILITY LIST									
3N149	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
3N150	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
3N151	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N152	NCH	FE	3N128	SEE FET INTERCHANGEABILITY LIST									
3N153	NCH	FE	3N153	SEE FET INTERCHANGEABILITY LIST									
3N154	NCH	FE	3N128	SEE FET INTERCHANGEABILITY LIST									
3N155	PCH	FE	3N155	SEE FET INTERCHANGEABILITY LIST									
3N155A	PCH	FE	3N155A	SEE FET INTERCHANGEABILITY LIST									
3N156	PCH	FE	3N156	SEE FET INTERCHANGEABILITY LIST									
3N156A	PCH	FE	3N156A	SEE FET INTERCHANGEABILITY LIST									
3N157	PCH	FE	3N157	SEE FET INTERCHANGEABILITY LIST									
3N157A	PCH	FE	3N157A	SEE FET INTERCHANGEABILITY LIST									
3N158	PCH	FE	3N158	SEE FET INTERCHANGEABILITY LIST									
3N158A	PCH	FE	3N158A	SEE FET INTERCHANGEABILITY LIST									
3N159	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N160	PCH	FE	3N160	SEE FET INTERCHANGEABILITY LIST									
3N161	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
3N162	PCH	FE	3N162	SEE FET INTERCHANGEABILITY LIST									
3N163	PCH	FE	3N163	SEE FET INTERCHANGEABILITY LIST									
3N164	PCH	FE	3N164	SEE FET INTERCHANGEABILITY LIST									
3N165	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N166	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N167	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N168	PCH	FE	3N160	SEE FET INTERCHANGEABILITY LIST									
3N169	NCH	FE	3N169	SEE FET INTERCHANGEABILITY LIST									
3N170	NCH	FE	3N170	SEE FET INTERCHANGEABILITY LIST									
3N171	NCH	FE	3N171	SEE FET INTERCHANGEABILITY LIST									
3N172	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
3N173	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
3N174	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST									

TYPE NUMBER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
3N175	NCH	FE	3N170	SEE FET INTERCHANGEABILITY LIST									
3N176	NCH	FE	3N170	SEE FET INTERCHANGEABILITY LIST									
3N177	NCH	FE	3N171	SEE FET INTERCHANGEABILITY LIST									
3N178	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N179	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N180	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST									
3N181	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N182	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N183	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N184	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N185	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N186	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N188	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N189	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N190	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N191	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N192	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N193	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
3N200	NCH	FE	3N201	SEE FET INTERCHANGEABILITY LIST									
3N201	NCH	FE	3N201	SEE FET INTERCHANGEABILITY LIST									
3N202	NCH	FE	3N202	SEE FET INTERCHANGEABILITY LIST									
3N203	NCH	FE	3N203	SEE FET INTERCHANGEABILITY LIST									
3N204	NCH	FE	3N204	SEE FET INTERCHANGEABILITY LIST									
3N205	NCH	FE	3N205	SEE FET INTERCHANGEABILITY LIST									
3N206	NCH	FE	3N206	SEE FET INTERCHANGEABILITY LIST									
3N207	PCH	FE	3N207	SEE FET INTERCHANGEABILITY LIST									
3N208	PCH	FE	3N208	SEE FET INTERCHANGEABILITY LIST									
3N211	NCH	FE	3N211	SEE FET INTERCHANGEABILITY LIST									
3N212	NCH	FE	3N212	SEE FET INTERCHANGEABILITY LIST									
3N213	NCH	FE	3N213	SEE FET INTERCHANGEABILITY LIST									
3N214	NCH	FE	3N214	SEE FET INTERCHANGEABILITY LIST									
3N215	NCH	FE	3N215	SEE FET INTERCHANGEABILITY LIST									
3N216	NCH	FE	3N216	SEE FET INTERCHANGEABILITY LIST									
3N217	NCH	FE	3N217	SEE FET INTERCHANGEABILITY LIST									

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
2243TP	TI	NPN	GP	A5T2243	625	120	80	40-120	150	.35	150		50
2484TP	TI	NPN	GP	A5T3707	360	60	60	100-500	.01	.35	1	150	60
2925TP	TI	NPN	GP	A5T3711	360	25	25					235	
3245TP	TI	PNP	SW		625	50	50	30-90	500	.6	500		150
3390TP	TI	NPN	GP	TIS97	360	18	18	400-800	2			400	
3391TP	TI	NPN	GP	A5T3391	360	25	25	250-500	2				
3392TP	TI	NPN	GP	A5T3392	360	25	25	150-300	2				
3405TP	TI	NPN	GP	2N5449	360	50	50	180-540	2	.3	50	180	
3415TP	TI	NPN	GP	2N5449	360	25	25	180-540	2	.3	50	180	
3417TP	TI	NPN	GP	2N5449	360	50	50	180-540	2	.3	50	180	
3504TP	TI	PNP	GP	A5T2907	360	45	45	100-300	150	.4	150	135	200
3563TP	TI	NPN	RF	TIS62	360	30	12	20-200	8			20	600
3564TP	TI	NPN	RF	2N4996	360	30	15	20-	15	.3	20	20	400
3565TP	TI	NPN	GP	A5T3565	360	30	25	150-600	1	.35	1		40
3566TP	TI	NPN	GP	A5T2222	360	40	30	150-600	10	1	100		40
3567TP	TI	NPN	GP	A5T2222	360	80	40	40-120	150	.25	150		60
3568TP	TI	NPN	GP	A5T2222	300	80	60	40-120	150	.25	150		60
3570TP	TI	NPN	RF	A5T3571	360	30	15	20-150	5			20	1500
3571TP	TI	NPN	RF	A5T3571	360	25	15	20-200	5			20	1200
3638TP	TI	PNP	SW	A5T3638	300	25	25	30-	50	.25	50		100
3640TP	TI	PNP	SW	2N4423	360	12	12	30-120	10	.2	10		500
3641TP	TI	NPN	RF	2N5449	360	60	30	40-120	150	.22	150		250
3643TP	TI	NPN	RF	2N5449	360	60	30	100-300	150	.22	150		250
3646TP	TI	NPN	SW	A5T3903	360	40	15	30-120	30	.3	30		350
3663TP	TI	NPN	RF	TIS62	200	30	12	20-	8	.6	10		700
3724TP	TI	NPN	SW	TIS133	625	50	30	60-150	100	.3	100		300
40082	RC	NPN	RF		*5W								
40084	RC	NPN	GP	2N2222	500	60	40	50-250	150	1.4	150		
40231	RC	NPN	GP	2N2221	500	18	18					55	
40232	RC	NPN	GP	2N2222	500	18	18					90	
40233	RC	NPN	GP	2N2222	500	18	18					90	
40234	RC	NPN	GP	2N2221	500	18	18			.2	50	35	
40235	RC	NPN	RF	2N4252	180	45		40-170	1				
40236	RC	NPN	RF	2N4252	180	45		40-275	1				
40237	RC	NPN	RF	2N4252	180	45		27-275	1				
40238	RC	NPN	RF	2N4252	180	45		40-170	1				
40239	RC	NPN	RF	2N4252	180	45		27-100	1				
40240	RC	NPN	RF	2N4252	180	45		27-275	1				
40242	RC	NPN	RF	2N4252	180	45		40-170	1				
40243	RC	NPN	RF	2N4252	180	45		40-170	1				

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
40244	RC	NPN	RF	2N4252	180	45	45	27-170	1				
40245	RC	NPN	RF	2N4252	180	45	45	70-275	1				
40246	RC	NPN	RF	2N4252	180	45	45	27-90	1				
40290	RC	NPN	RF	2N4252	*7W		15						
40294	RC	NPN	RF	2N3571	200	30	15	30-150	3				
40295	RC	NPN	RF	2N918	200	35	20	30-200	2				
40296	RC	NPN	RF	2N3571	200	30	15	30-150	3				
40305	RC	NPN	RF		*7W	65	40	10-	150	1	250		
4030TP	TI	PNP	GP	A5T4026	625	60	60	40-120	100	.5	500		100
40309	RC	NPN	GP	2N2270	1W		18	70-350	50				
40311	RC	NPN	GP	2N2270	1W		30	70-350	50				
40314	RC	NPN	GP	2N2102	1W		40	35-150	50	1.4	150		
40315	RC	NPN	GP	2N2270	1W		35	70-350	50				
40317	RC	NPN	GP	2N2270	1W		40	40-200	10				
40319	RC	PNP	GP	2N4030	1W		40	35-200	50				
40320	RC	NPN	GP	2N2270	1W		40	40-200	10				
40321	RC	NPN	GP	2N5058	1W		300	25-200	20				
40323	RC	NPN	GP	2N2270	1W		18	70-350	50				
40326	RC	NPN	GP	2N2270	1W		40	40-200	10				
40327	RC	NPN	GP	2N5058	1W		300	40-250	20				
40346	RC	NPN	GP	2N3114	1W		175	25-	10	.5	10		10
40347	RC	NPN	GP	2N2270	1W	60	40	25-100	450	1	450		
40348	RC	NPN	GP	2N2102	1W	90	65	30-100	300	.75	300		
40349	RC	NPN	GP		1W		140	25-100	150	.5	150		
40354	RC	NPN	GP		500		150			5	1		50
40355	RC	NPN	GP	2N5059	1W		150			5	1		50
40360	RC	NPN	GP	2N2102	1W		70	40-200	10	1.4	150		
40361	RC	NPN	GP	2N2102	1W		70	70-350	50	1.4	150		
40362	RC	PNP	GP	2N4032	1W		70	35-200	50	1.4	150		
40366	RC	NPN	GP	2N2102	1W		65	40-120	150	.5	150		
40367	RC	NPN	GP	2N2102	1W	100	55	35-100	200	1.4	200		
40385	RC	NPN	GP		1W	450	350	40-160	20	.5	4		
40397	RC	NPN	GP		500		25	165-600	10	.25	10		50
40398	RC	NPN	GP	2N2222	500		25	175-300	10	.25	10		50
40399	RC	NPN	GP		500		18	165-600	10	.2	5	165	50
40400	RC	NPN	GP	2N2222	500		18	75-300	10	.2	5	75	50
40405	RC	NPN	RF		300		16	20-	100				300
40406	RC	PNP	GP	2N4030	1W		50	30-200	.1				
40407	RC	NPN	GP	2N2270	1W		50	40-200	1				
40408	RC	NPN	GP	2N2102	1W		90	40-200	10	1.4	150		

TEXAS INSTRUMENTS
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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
40412	RC	NPN	GP		1W		250	40-	30				10
40413	RC	NPN	RF	2N918	200	35	20	30-200	2				
40414	RC	NPN	RF	2N3571	200	30	15	30-150	3				
40450	RC	NPN	GP	2N2221	1W	30	25	100-200	10			100	50
40451	RC	NPN	GP	2N2222	1W	40	40	125-300	10			125	50
40452	RC	NPN	GP	2N2222	1W		40	75-300	10			75	50
40453	RC	NPN	GP		1W		25	165-600	10	.25	10		50
40454	RC	NPN	GP	2N2222	1W		25	75-300	10	.25	10		50
40455	RC	NPN	GP		1W		18	165-300	10	.2	5	165	50
40456	RC	NPN	GP	2N2222	1W		18	75-300	10	.2	5	75	50
40458	RC	NPN	GP	2N2222A	500	60	40	100-300	10	.3	15	75	150
40459	RC	NPN	GP	2N2222A	1W	60	40	100-300	10	.3	15	75	150
40467A	RC	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
40468	RC	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
40468A	RC	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
40472	RC	NPN	RF	TIS126	180	45		40-170	1				
40473	RC	NPN	RF	TIS126	180	45		40-275	1				
40474	RC	NPN	RF	TIS126	180	45		27-275	1				
40475	RC	NPN	RF	TIS126	180	45		40-170	1				
40476	RC	NPN	RF	TIS126	180	45		27-100	1				
40477	RC	NPN	RF	TIS126	180	45		27-275	1				
40478	RC	NPN	RF	TIS126	180	45		40-170	1				
40479	RC	NPN	RF	TIS126	180	45		40-170	1				
40480	RC	NPN	RF	TIS126	180	45		27-275	1				
40481	RC	NPN	RF	TIS126	180	45		70-275	1				
40482	RC	NPN	RF	TIS126	180	45		27-90	1				
404TP	TI	PNP	SW	A5T404	360	25	24	30-400	12	.15	12		
404ATP	TI	PNP	SW	A5T404A	360	40	35	30-400	12	.15	12		
40517	RC	NPN	RF	2N3571	200	30	15	30-150	3				1G
40518	RC	NPN	RF	2N3571	200	30	15	30-150	3				1G
40519	RC	NPN	RF		1W		16	20-	50				300
40537	RC	PNP	GP	2N4030	1W		55	50-300	50	1.1	50		
40538	RC	PNP	GP	2N4030	1W		55	15-90	500	2	500		
40539	RC	NPN	GP	2N2270	1W		55	15-90	500	2	500		
40544	RC	NPN	GP	2N2270	*7W		50	35-200	50	1	150		
40559	RC	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
40559A	RC	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
40577	RC	NPN	RF		3W		60	50-275	100				250
40578	RC	NPN	RF	2N3866	*5W	55	30	10-200	50	1	100		500
40581	RC	NPN	RF		180	45		70-275	1				

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS			ELECTRICAL CHARACTERISTICS						
					P_T $T_A = 25°C$ *$T_C = 25°C$	V_{CBO}	V_{CEO}	h_{FE}		$V_{CE(sat)}$		h_{fe} @ 1 kHz	f_T
								MIN MAX	@ I_C	MAX	@ I_C	MIN	MIN
					(mW)	(V)	(V)		(mA)	(V)	(mA)		(MHz)
40582	RC	NPN	RF		180	45		27-90	1				
40600	RC	NCH	FE	3N211	SEE FET INTERCHANGEABILITY LIST								
40601	RC	NCH	FE	3N211	SEE FET INTERCHANGEABILITY LIST								
40602	RC	NCH	FE	3N211	SEE FET INTERCHANGEABILITY LIST								
40603	RC	NCH	FE	3N211	SEE FET INTERCHANGEABILITY LIST								
40604	RC	NCH	FE	3N211	SEE FET INTERCHANGEABILITY LIST								
40608	RC	NPN	RF		800	40		35-120	50	1	50		700
40611	RC	NPN	GP	2N2270	1W		25	70-500	59				
40616	RC	NPN	GP	2N2270	1W		32	70-500	50				
40634	RC	PNP	GP	2N4030	1W		75	50-250	150	.8	150		
40635	RC	NPN	GP	2N2270	1W		95	50-250	150	.8	150		
40637	RC	NPN	RF		300		30						300
40673	RC	NCH	FE	3N211	SEE FET INTERCHANGEABILITY LIST								
4248TP	TI	PNP	GP	A5T4248	360	40	40	50-	.1	.25	10	50	40
4274TP	TI	NPN	SW	A5T3903	360	30	12	30-120	10	.2	10		400
4360TP	TI	PCH	FE	A5T5462	SEE FET INTERCHANGEABILITY LIST								
4400TP	TI	NPN	SW	A5T2222	360	60	40	50-150	150	.4	150	20	200
4401TP	TI	NPN	SW	A5T2222	360	60	40	100-300	150	.4	150	40	250
4402TP	TI	PNP	SW	A5T2907	360	40	40	50-150	150	.4	150	30	150
4409TP	TI	NPN	GP	2N4409	360	80	50	60-400	1	.2	1		60
4410TP	TI	NPN	GP	2N4410	360	120	80	60-400	1	.2	1		60
4888TP	TI	PNP	GP	A5T5401	360	150	150	30-	1	.5	10		30
4916TP	TI	PNP	GP	A5T3905	360	30	30	70-200	10	.14	10		400
4917TP	TI	PNP	GP	A5T3906	360	30	30	150-300	10	.14	10		450
5033TP	TI	PCH	FE	A5T5460	SEE FET INTERCHANGEABILITY LIST								
5088TP	TI	NPN	GP	TIS94	310	35	30	300-900	.1	.5	10	350	50
5089TP	TI	NPN	GP	TIS94	310	30	25	400-1200	.1	.5	10	450	50
5172TP	TI	NPN	GP	A5T5172	360	25	25	100-500	10	.25	10	100	
5209TP	TI	NPN	GP	A5T5209	360	50	50	100-300	.1	.7	10	150	30
5210TP	TI	NPN	GP	A5T5210	360	50	50	200-600	.1	.7	10	250	30
5400TP	TI	PNP	GP	A5T5400	360	130	120	40-180	10	.2	10	30	100
A5T404	TI	PNP	SW	A5T404	625	25	24	30-400	12	.15	12		
A5T404A	TI	PNP	SW	A5T404A	625	40	35	30-400	12	.15	12		
A5T2192	TI	NPN	GP	A5T2192	625	60	40	100-300	150	.35	150		50
A5T2193	TI	NPN	GP	A5T2193	625	80	50	40-120	150	.35	150		50
A5T2222	TI	NPN	GP	A5T2222	625	60	30	100-300	150	.4	150		250
A5T2243	TI	NPN	GP	A5T2243	625	120	80	40-120	150	.25	150		
A5T2907	TI	PNP	GP	A5T2907	625	60	40	100-300	150	.4	150		200
A5T3391	TI	NPN	GP	A5T3391	625	25	25	250-500	2				
A5T3391A	TI	NPN	GP	A5T3391A	625	25	25	250-500	2				

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A5T3392	TI	NPN	GP	A5T3392	625	25	25	150-300	2				
A5T3504	TI	PNP	GP	A5T3504	625	45	45	100-300	150	.4	150	135	200
A5T3505	TI	PNP	GP	A5T3505	625	60	60	100-300	150	.4	150	135	200
A5T3565	TI	NPN	GP	A5T3565	625	30	25	150-600	1	.35	1	120	40
A5T3571	TI	NPN	RF	A5T3571	625	25	15	20-200	5			20	1200
A5T3572	TI	NPN	RF	A5T3572	625	25	13	20-350	5			20	1G
A5T3638	TI	PNP	GP	A5T3638	625	25	25	30-	50	.25	50		100
A5T3638A	TI	PNP	GP	A5T3638A	625	25	25	100-	50	.25	50		150
A5T3644	TI	PNP	GP	A5T3644	625	45	45	100-300	150	.4	150	100	200
A5T3645	TI	PNP	GP	A5T3645	625	60	60	100-300	150	.4	150	100	200
A5T3707	TI	NPN	GP	A5T3707	625	30	30	100-400	.1	1	10	100	
A5T3708	TI	NPN	GP	A5T3708	625	30	30	45-660	1	1	10	45	
A5T3709	TI	NPN	GP	A5T3709	625	30	30	45-165	1	1	10	45	
A5T3710	TI	NPN	GP	A5T3710	625	30	30	90-330	1	1	10	90	
A5T3711	TI	NPN	GP	A5T3711	625	30	30	180-660	1	1	10	180	
A5T3821	TI	NCH	FE	A5T3821	SEE FET INTERCHANGEABILITY LIST								
A5T3822	TI	NCH	FE	A5T3822	SEE FET INTERCHANGEABILITY LIST								
A5T3823	TI	NCH	FE	A5T3823	SEE FET INTERCHANGEABILITY LIST								
A5T3824	TI	NCH	FE	A5T3824	SEE FET INTERCHANGEABILITY LIST								
A5T3903	TI	NPN	SW	A5T3903	625	60	40	50-150	10	.2	10	50	250
A5T3904	TI	NPN	SW	A5T3904	625	60	40	100-300	10	.2	10	100	300
A5T3905	TI	PNP	SW	A5T3905	625	40	40	50-150	10	.25	10	50	200
A5T3906	TI	PNP	SW	A5T3906	625	40	40	100-300	10	.25	10	100	250
A5T4026	TI	PNP	GP	A5T4026	625	60	60	40-120	100	.5	500		100
A5T4027	TI	PNP	GP	A5T4027	625	80	80	40-120	100	.5	500		100
A5T4028	TI	PNP	GP	A5T4028	625	60	60	100-300	100	.5	500		150
A5T4029	TI	PNP	GP	A5T4029	625	80	80	100-300	100	.5	500		150
A5T4058	TI	PNP	GP	A5T4058	625	30	30	100-400	.1	.7	10	100	
A5T4059	TI	PNP	GP	A5T4059	625	30	30	45-660	1	.7	10	45	
A5T4060	TI	PNP	GP	A5T4060	625	30	30	45-165	1	.7	10	45	
A5T4061	TI	PNP	GP	A5T4061	625	30	30	90-330	1	.7	10	90	
A5T4062	TI	PNP	GP	A5T4062	625	30	30	180-660	1	.7	10	180	
A5T4123	TI	NPN	SW	A5T4123	625	40	30	50-150	2	.3	50	50	250
A5T4124	TI	NPN	SW	A5T4124	625	30	25	120-360	2	.3	50	120	300
A5T4125	TI	PNP	SW	A5T4125	625	30	30	50-150	2	.4	50	50	200
A5T4126	TI	PNP	SW	A5T4126	625	25	25	120-360	2	.4	50	120	250
A5T4248	TI	PNP	GP	A5T4248	625	40	40	50-	.1	.25	10	50	40
A5T4249	TI	PNP	GP	A5T4249	625	60	60	100-300	.1	.25	10	100	40
A5T4250	TI	PNP	GP	A5T4250	625	40	40	250-700	.1	.25	10	250	50
A5T4260	TI	PNP	RF	A5T4260	200	20	15	30-	10	.35	10		1600

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TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
A5T4261	TI	PNP	RF	A5T4261	200	20	15	30-	10	.35	10		2G
A5T4402	TI	PNP	SW	A5T4402	625	40	40	50-150	150	.4	150	30	150
A5T4403	TI	PNP	SW	A5T4403	625	40	40	100-300	150	.4	150	60	200
A5T4409	TI	NPN	GP	A5T4409	625	80	50	60-400	1	.2	1		60
A5T4410	TI	NPN	GP	A5T4410	625	120	80	60-400	1	.2	1		60
A5T5058	TI	NPN	GP	A5T5058	800	300	300	35-150	30	1	30		30
A5T5059	TI	NPN	GP	A5T5059	800	250	250	30-150	30	1	30		30
A5T5086	TI	PNP	GP	A5T5086	625	50	50	150-500	.1	.3	10	150	40
A5T5087	TI	PNP	GP	A5T5087	625	50	50	250-800	.1	.3	10	250	40
A5T5172	TI	NPN	GP	A5T5172	625	25	25	100-500	10	.25	10	100	
A5T5209	TI	NPN	GP	A5T5209	625	50	50	100-300	.1	.7	10	150	30
A5T5210	TI	NPN	GP	A5T5210	625	50	50	200-600	.1	.7	10	250	30
A5T5219	TI	NPN	GP	A5T5219	625	20	15	35-500	2	.4	10	35	150
A5T5220	TI	NPN	GP	A5T5220	625	15	15	30-600	50	.5	150	30	100
A5T5221	TI	PNP	GP	A5T5221	625	15	15	30-600	50	.5	150	30	100
A5T5223	TI	NPN	GP	A5T5223	625	25	20	50-800	2	.7	10	50	150
A5T5225	TI	NPN	GP	A5T5225	625	25	25	30-600	50	.8	100	30	50
A5T5226	TI	PNP	GP	A5T5226	625	25	25	30-600	50	.8	100	30	50
A5T5227	TI	PNP	GP	A5T5227	625	30	30	50-700	2	.4	10	50	100
A5T5400	TI	PNP	GP	A5T5400	625	130	120	40-180	10	.2	10	30	100
A5T5401	TI	PNP	GP	A5T5401	625	160	150	60-240	10	.2	10	40	100
A5T5460	TI	PCH	FE	A5T5460	SEE FET INTERCHANGEABILITY LIST								
A5T5461	TI	PCH	FE	A5T5461	SEE FET INTERCHANGEABILITY LIST								
A5T5462	TI	PCH	FE	A5T5462	SEE FET INTERCHANGEABILITY LIST								
A5T5550	TI	NPN	GP	A5T5550	625	160	140	60-250	10	.15	10	50	100
A5T5551	TI	NPN	GP	A5T5551	625	180	160	80-250	10	.15	10	50	100
A5T6116	TI		UJ	A5T6116	SEE DATA SHEET ON A5T6116								
A5T6117	TI		UJ	A5T6117	SEE DATA SHEET ON A5T6117								
A5T6118	TI		UJ	A5T6118	SEE DATA SHEET ON A5T6118								
A5T6449		NCH	FE	A5T6449	SEE FET INTERCHANGEABILITY LIST								
A5T6450		NCH	FE	A5T6450	SEE FET INTERCHANGEABILITY LIST								
A6T5222	TI	NPN	RF	A6T5222	625	20	15	20-1500	4	1	4	20	450
A7T3391	TI	NPN	GP	A7T3391	625	25	25	250-500	2				
A7T3391A	TI	NPN	GP	A7T3391A	625	25	25	250-500	2			20	600
A7T3392	TI	NPN	GP	A7T3392	625	25	25	150-300	2				
A7T5172	TI	NPN	GP	A7T5172	625	25	25	100-500	10	.25	10	100	
A5T6116	TI	PUT	UJ	A5T6116	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
A5T6117	TI	PUT	UJ	A5T6117	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
A5T6118	TI	PUT	UJ	A5T6118	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
A7T6027	TI	PUT	UJ	A7T6027	SEE UNIJUNCTION INTERCHANGEABILITY LIST								

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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
A7T6028	TI	PUT	UJ	A7T6028	SEE UNIJUNCTION INTERCHANGEABILITY LIST									
A8T404	TI	PNP	SW	A8T404	625	25	24	30	400	12	.15	12		
A8T404A	TI	PNP	SW	A8T404A	625	40	35	30	400	12	.15	12		
A8T3702	TI	PNP	GP	A8T3702	625	40	25	60	300	50	.25	50		100
A8T3703	TI	PNP	GP	A8T3703	625	50	30	30	150	50	.25	50		100
A8T3704	TI	NPN	GP	A8T3704	625	50	30	100	300	50	.6	100		100
A8T3705	TI	NPN	GP	A8T3705	625	50	30	50	150	50	.8	100		100
A8T3706	TI	NPN	GP	A8T3706	625	40	20	30	600	50	1	100		100
A8T3707	TI	NPN	GP	A8T3707	625	30	30	100	400	.1	1	10	100	
A8T3708	TI	NPN	GP	A8T3708	625	30	30	45	660	1	1	10	45	
A8T3709	TI	NPN	GP	A8T3709	625	30	30	45	165	1	1	10	45	
A8T3710	TI	NPN	GP	A8T3710	625	30	30	90	330	1	1	10	90	
A8T3711	TI	NPN	GP	A8T3711	625	30	30	180	660	1	1	10	180	
A8T4026	TI	PNP	GP	A8T4026	625	60	60	40	120	100	.5	500		100
A8T4027	TI	PNP	GP	A8T4027	625	80	80	40	120	100	.5	500		100
A8T4028	TI	PNP	GP	A8T4028	625	60	60	100	300	100	.5	500		150
A8T4029	TI	PNP	GP	A8T4029	625	80	80	100	300	100	.5	500		150
A8T4058	TI	PNP	GP	A8T4058	625	30	30	100	400	.1	.7	10	100	
A8T4059	TI	PNP	GP	A8T4059	625	30	30	45	660	1	.7	10	45	
A8T4060	TI	PNP	GP	A8T4060	625	30	30	45	165	1	.7	10	45	
A8T4061	TI	PNP	GP	A8T4061	625	30	30	90	330	1	.7	10	90	
A8T4062	TI	PNP	GP	A8T4062	625	30	30	180	660	1	.7	10	180	
A8T5172	TI	NPN	GP	A8T5172	625	25	25	100	500	10	.25	10	100	
C103A	GE		SC	TIC46	SCR - SEE POWER DATA BOOK									
C103Y	GE		SC	TIC44	SCR - SEE POWER DATA BOOK									
C103YY	GE		SC	TIC45	SCR - SEE POWER DATA BOOK									
C413N	CR	NCH	FE	2N6451	SEE FET INTERCHANGEABILITY LIST									
C680	CR	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
C681	CR	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
C682	CR	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST									
C683	CR	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST									
C684	CR	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
C685	CR	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
C6690	CR	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
C6691	CR	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
C6692	CR	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
CM600	CR	NCH	FE	2N4857	SEE FET INTERCHANGEABILITY LIST									
CM601	CR	NCH	FE	2N4856	SEE FET INTERCHANGEABILITY LIST									
CM602	CR	NCH	FE	2N4856	SEE FET INTERCHANGEABILITY LIST									
CM603	CR	NCH	FE	2N4856	SEE FET INTERCHANGEABILITY LIST									

TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
CM640	CR	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
CM641	CR	NCH	FE	2N4858	SEE FET INTERCHANGEABILITY LIST								
CM642	CR	NCH	FE	2N4858	SEE FET INTERCHANGEABILITY LIST								
CM643	CR	NCH	FE	2N4857	SEE FET INTERCHANGEABILITY LIST								
CM644	CR	NCH	FE	2N4858	SEE FET INTERCHANGEABILITY LIST								
CM645	CR	NCH	FE	2N4857	SEE FET INTERCHANGEABILITY LIST								
CM646	CR	NCH	FE	2N4856	SEE FET INTERCHANGEABILITY LIST								
CM647	CR	NCH	FE	2N4856	SEE FET INTERCHANGEABILITY LIST								
CM697	CR	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
CMX740	CR	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
D16G6	GE	NPN	RF	TIS62	200	30	12						500
D16P1	GE	NPN	DA	2N5525	400	18	12	2K-	5	1.4	200		60
D29E1	GE	PNP	GP	TIS91	500	35	25	60-200	2	.75	500		100
D29E2	GE	PNP	GP	TIS91	500	35	25	150-500	2	.75	500		135
D29E4	GE	PNP	GP	TIS91	500	50	40	60-120	2	.75	500		80
D29E5	GE	PNP	GP	TIS91	500	50	40	100-200	2	.75	500		120
D29E6	GE	PNP	GP	TIS91	500	50	40	150-300	2	.75	500		135
D29E7	GE	PNP	GP		500	50	40	250-500	2	.75	500		135
D29E9	GE	PNP	GP	TIS91	500	70	60	60-120	2	.75	500		80
D29E10	GE	PNP	GP	TIS91	500	70	60	100-200	2	.75	500		120
D29F1	GE	PNP	GP	2N4060	360	40	40	60-120	2	.25	10		
D29F2	GE	PNP	GP	2N4061	360	40	40	100-200	2	.25	10		
D29F3	GE	PNP	GP	2N4061	360	40	40	150-300	2	.25	10		
D29F4	GE	PNP	GP	2N4062	360	40	40	250-500	2	.25	10		
D29F5	GE	PNP	GP	2N4060	360	60	60	60-120	2	.25	10		
D29F6	GE	PNP	GP	2N4061	360	60	60	100-200	2	.25	10		
D29F7	GE	PNP	GP	2N4061	360	60	60	150-300	2	.25	10		
D2T918	TI	NPN	DU	D2T918	400	30	15	50-	1	.2	10		600
D2T2218	TI	NPN	DU	D2T2218		60	30	100-300	150	.4	150		250
D2T2218A	TI	NPN	DU	D2T2218A		75	40	100-300	150	.3	150		300
D2T2219	TI	NPN	DU	D2T2219		60	30	100-300	150	.4	150		250
D2T2219A	TI	NPN	DU	D2T2219A		75	40	100-300	150	.3	150		300
D2T2905	TI	PNP	DU	D2T2905		60	40	100-300	150	.4	150		200
D2T2905A	TI	PNP	DU	D2T2905A		60	60	100-300	150	.4	150		200
D32K1	GE	NPN	SW	TIS113	500	30	25	50-200	100	.2	100		275
D32P1	GE	NPN	RF	2N4994	360	40	30	40-80	2	.15	10		115
D32P2	GE	NPN	RF	2N4994	360	40	30	60-120	2	.15	10		125
D32P3	GE	NPN	RF	2N4995	360	40	30	100-200	2	.15	10		150
D32P4	GE	NPN	RF	2N4995	360	40	30	150-300	2	.15	10		175
D33D21	GE	NPN	GP	TIS90	500	35	25	60-200	2	.75	500		100

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D33D22	GE	NPN	GP	TIS90	500	35	25	150-500	2	.75	500		135
D33D24	GE	NPN	GP	TIS90	500	50	40	60-120	2	.75	500		80
D33D25	GE	NPN	GP	TIS90	500	50	40	100-200	2	.75	500		120
D33D26	GE	NPN	GP	TIS90	500	50	40	150-300	2	.75	500		135
D33D27	GE	NPN	GP		500	50	40	250-500	2	.75	500		150
D33D29	GE	NPN	GP	TIS90	500	70	60	60-120	2	.75	500		80
D33D30	GE	NPN	GP	TIS90	500	70	60	100-200	2	.75	500		120
D33K2	GE	NPN	SW	TIS133	500	50	40	50-200	100	.2	100		275
DU4339	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
DU4340	IN	NCH	FE	2N5047	SEE FET INTERCHANGEABILITY LIST								
E100	IN	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST								
E101	IN	NCH	FE	A5T3821	SEE FET INTERCHANGEABILITY LIST								
E102	IN	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
E103	IN	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST								
E108	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
E109	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
E110	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
E111	IN	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST								
E112	IN	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST								
E113	IN	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST								
E300	IN	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST								
EN697	F	NPN	GP	A5T2193	300	60	30	40-120	150	1.5	150	25	50
EN706	F	NPN	SW		200	25	15	20-	10	.6	10		200
EN708	F	NPN	SW		200	40	15	30-120	10	.4	10		300
EN718A	F	NPN	GP	A5T2193	300	75	40	40-120	150	1.3	150	25	60
EN722	F	PNP	GP	2N5448	200	50	35	30-90	150	1.5	150	25	60
EN744	F	NPN	SW		200	20	12	40-120	10	.2	10		900
EN870	F	NPN	GP	A5T2243	220	100	60	40-120	150	5	150	30	50
EN871	F	NPN	GP	A5T2192	220	100	60	100-300	150	5	150	50	60
EN914	F	NPN	SW		200	40	15	30-120	10	.25	10		300
EN915	F	NPN	RF	2N4994	200	70	50	50-200	10	1	10	50	250
EN916	F	NPN	RF	2N4995	200	45	25	50-200	10	.5	10	50	300
EN918	F	NPN	RF	TIS62	200	30	15	20-	3	.4	10		600
EN930	F	NPN	GP	A5T3707	200	45	45	100-300	.01		.12510	150	90
EN956	F	NPN	GP	A5T2222	220	75	40	100-300	150	1.5	150	50	70
EN1132	F	PNP	GP	A5T2907	300	50	35	30-90	150	1.5	150		60
EN1613	F	NPN	GP	A5T2193	300	75	40	40-120	150	1.5	150	25	60
EN1711	F	NPN	GP	A5T2222	300	75	40	100-300	150	1.5	150	50	70
EN2219	F	NPN	GP	A5T2222	200	60	30	100-300	150	1.6	500		250
EN2222	F	NPN	GP	A5T2222	200	60	30	100-300	150	.4	150		250

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TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
EN2369A	F	NPN	SW		200	40	15	40-	10	.2	10		500
EN2484	F	NPN	GP	A5T3707	200	60	60	100-500	.01	.35	1	150	60
EN2894A	F	PNP	SW	2N4423	200	12	12	40-120	30	.19	30		800
EN2905	F	PNP	GP	A5T2907	300	60	40	100-300	150	.4	150		200
EN2907	F	PNP	GP	A5T2907	200	60	40	100-300	150	.4	150		150
EN3009	F	NPN	SW	2N3903	200	40	15	30-120	30	.18	30		350
EN3011	F	NPN	SW	2N3903	200	30	12	30-120	10	.2	10		400
EN3013	F	NPN	SW	2N3903	200	40	15	30-120	30	.18	30		350
EN3014	F	NPN	SW	2N3903	200	40	20	30-120	30	.18	30		350
EN3250	F	PNP	SW		200	40	40	50-150	10	.25	10		250
EN3502	F	PNP	GP	A5T3504	300	45	45	100-300	150	.4	150		150
EN3504	F	PNP	GP	A5T3504	200	45	45	100-300	150	.4	150		150
EN3962	F	PNP	GP	A5T4061	200	60	60	100-450	1	.25	1	100	
FE0654A	F	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST								
FE0654B	F	NCH	FE	2N5951	SEE FET INTERCHANGEABILITY LIST								
FE3819	F	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
FE5245	F	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST								
FE5246	F	NCH	FE	2N5246	SEE FET INTERCHANGEABILITY LIST								
FE5247	F	NCH	FE	2N5247	SEE FET INTERCHANGEABILITY LIST								
FE5457	F	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
FE5458	F	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST								
FE5459	F	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST								
FE5484	F	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
FE5485	F	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST								
FE5486	F	NCH	FE	2N5949	SEE FET INTERCHANGEABILITY LIST								
FT0654A	F	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
FT0654B	F	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
FT0654C	F	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
FT0654D	F	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
FT701	F	PCH	FE	3N207	SEE FET INTERCHANGEABILITY LIST								
FT703	F	PCH	FE	3N160	SEE FET INTERCHANGEABILITY LIST								
FT704	F	PCH	FE	3N163	SEE FET INTERCHANGEABILITY LIST								
FT3567	F	NPN	GP		500	80	40	40-120	150	.25	150		60
FT3568	F	NPN	GP		500	80	60	40-120	150	.25	150		60
FT3569	F	NPN	GP		500	80	40	100-300	150	.25	150		
FT3641	F	NPN	RF	TIS110	450	60	30	40-120	150	.22	150		250
FT3642	F	NPN	RF	TIS110	450	60	45	40-120	150	.22	150		250
FT3643	F	NPN	RF	A5T2222	450	60	30	100-300	150	.22	150		250
FT3644	F	PNP	GP	A5T3644	450	45	45	100-300	150	.4	150		200
FT3645	F	PNP	GP	A5T3645	450	60	60	100-300	150	.4	150		200

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FT3722	F	NPN	SW	TIS133	500	80	60	40-150	100	.22	100		300
FT3820	F	PCH	FE	A5T5460	SEE FET INTERCHANGEABILITY LIST								
FT4354	F	PNP	GP	A5T4026	350	60	60	50-500	10	.15	150		100
FT4355	F	PNP	GP	A5T4028	350	60	60	100-400	10	.15	150		100
FT4356	F	PNP	GP	A5T4027	350	80	80	50-250	10	.15	150		100
FT5040	F	PNP	GP	A5T4026	500	25	25	30-	150	.25	150		80
FT5041	F	PNP	GP	A5T4026	500	40	40	40-150	150	.25	150		100
GBC107	GE	NPN	GP	TIS97	400	20	20	40-	.01	.25	10	125	140
GBC108	GE	NPN	GP	A5T3707	400	20	20	110-	2	.25	10	125	140
GBC109	GE	NPN	GP	A5T3707	400	20	20	110-	2	.25	10	240	140
GET706	GE	NPN	SW		360	25	15	20-	10	.25	10		200
GET708	GE	NPN	SW		360	40	15	30-120	10	.25	10		300
GET914	GE	NPN	SW		360	40	15	30-120	10	.25	10		300
GET929	GE	NPN	GP	A5T3709	360	70	50	60-120	.01		.12510		90
GET930	GE	NPN	GP	A5T3707	360	70	50	100-300	.01		.12510		90
GET2221	GE	NPN	GP	TIS110	360	60	30	40-120	150	.3	150		250
GET2221A	GE	NPN	GP	TIS110	360	75	40	40-120	150	.3	150		250
GET2222	GE	NPN	GP	A5T2222	360	60	30	100-300	150	.3	150		250
GET2222A	GE	NPN	GP	A5T2222	360	75	40	100-300	150	.3	150		250
GET2369	GE	NPN	SW		360	40	15	40-120	10	.25	10		350
GET2484	GE	NPN	GP	A5T3707	360	60	60	100-	.01	.35	1	150	60
GET2904	GE	PNP	GP	A5T2907	360	60	40	40-120	150	.4	150		200
GET2905	GE	PNP	GP	A5T2907	360	60	40	100-300	150	.4	150		200
GET2906	GE	PNP	GP	A5T2907	360	60	40	40-120	150	.4	150		200
GET2907	GE	PNP	GP	A5T2907	360	60	40	100-300	150	.4	150		200
GET3013	GE	NPN	SW	A7T3903	360	40	15	30-120	30	.18	30		350
GET3014	GE	NPN	SW	A7T3903	360	40	20	30-120	30	.18	30		350
GET3563	GE	NPN	RF	TIS63	250	30	12	20-200	8				600
GET3638	GE	PNP	GP	A5T3638	360	25	25	30-	50	.25	50	25	
GET3638A	GE	PNP	GP	A5T3638A	360	25	25	100-	50	.25	50	100	
GET3646	GE	NPN	SW	A7T3903	360	40	15	30-120	30	.2	30		350
GET5305	GE	NPN	DA		400	25	25	2K-20K	2	1.6	200	2K	60
GET5306	GE	NPN	DA	2N5525	400	25	25	7K-70K	2	1.6	200	7K	60
GET5306A	GE	NPN	DA	2N5525	400	25	25	7K-70K	2	1.6	200	7K	60
GET5307	GE	NPN	DA		400	40	40	2K-20K	2	1.6	200	2K	60
GET5308	GE	NPN	DA	2N5525	400	40	40	7K-70K	2	1.6	200	7K	60
GET5308A	GE	NPN	DA	2N5525	400	40	40	7K-70K	2	1.6	200	7K	60
IMF3954	IN	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
IMF3954A	IN	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
IMF3955	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A=25°C$ *$T_C=25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
IMF3955A	IN	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST									
IMF3956	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST									
IMF3957	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST									
IMF3958	IN	NCH	FE	2N5045	SEE FET INTERCHANGEABILITY LIST									
IT108	IN	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST									
IT109	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
IT1700	IN	PCH	FE	3N163	SEE FET INTERCHANGEABILITY LIST									
IT1701	IN	PCH	FE	3N163	SEE FET INTERCHANGEABILITY LIST									
IT1702	IN	PCH	FE	3N163	SEE FET INTERCHANGEABILITY LIST									
IT1750	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
IT2700	IN	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
IT2701	IN	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
ITE3066	IN	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST									
ITE3067	IN	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST									
ITE3068	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
ITE4117	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
ITE4118	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
ITE4119	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
ITE4338	IN	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST									
ITE4339	IN	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST									
ITE4340	IN	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST									
ITE4341	IN	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST									
ITE4391	IN	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST									
ITE4392	IN	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST									
ITE4393	IN	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST									
ITE4416	IN	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST									
ITE4867	IN	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST									
ITE4868	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
ITE4869	IN	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST									
KE3684	IN	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST									
KE3685	IN	NCH	FE	A5T3821	SEE FET INTERCHANGEABILITY LIST									
KE3686	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
KE3687	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
KE3823	IN	NCH	FE	A5T3823	SEE FET INTERCHANGEABILITY LIST									
KE3970	IN	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST									
KE3971	IN	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST									
KE3972	IN	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST									
KE4091	IN	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST									
KE4092	IN	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST									
KE4093	IN	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST									

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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
KE4220	IN	NCH	FE	A5T3821	SEE FET INTERCHANGEABILITY LIST									
KE4221	IN	NCH	FE	A5T3822	SEE FET INTERCHANGEABILITY LIST									
KE4222	IN	NCH	FE	A5T3822	SEE FET INTERCHANGEABILITY LIST									
KE4223	IN	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST									
KE4224	IN	NCH	FE	2N5949	SEE FET INTERCHANGEABILITY LIST									
KE4391	IN	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST									
KE4392	IN	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST									
KE4393	IN	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST									
KE4416	IN	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST									
KE4856	IN	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST									
KE4857	IN	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST									
KE4858	IN	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST									
KE4859	IN	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST									
KE4860	IN	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST									
KE4861	IN	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST									
KE5103	IN	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST									
KE5104	IN	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST									
KE5105	IN	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST									
M100	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
M101	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
M103	SI	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
M104	SI	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
M106	SI	PCH	FE	3N208	SEE FET INTERCHANGEABILITY LIST									
M107	SI	PCH	FE	3N208	SEE FET INTERCHANGEABILITY LIST									
M108	SI	PCH	FE	3N207	SEE FET INTERCHANGEABILITY LIST									
M113	SI	PCH	FE	3N156	SEE FET INTERCHANGEABILITY LIST									
M114	SI	PCH	FE	3N160	SEE FET INTERCHANGEABILITY LIST									
M116	SI	NCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
M117	SI	NCH	FE	3N160	SEE FET INTERCHANGEABILITY LIST									
M119	SI	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
M511	SI	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
M511A	SI	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
M517	SI	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
MD708	M	NPN	DU		400	40	15	40	200	10	.2	10		300
MD708A	M	NPN	DU		400	40	15	40	200	10	.2	10		300
MD708B	M	NPN	DU		400	40	15	40	200	10	.2	10		300
MD918	M	NPN	DU	D2T918	400	30	15	50		1	.2	10		600
MD918A	M	NPN	DU	D2T918	400	30	15	50		1	.2	10		600
MD918B	M	NPN	DU	D2T918	400	30	15	50		1	.2	10		600
MD984	M	PNP	DU	D2T2905	600	40	20	25		10	.3	10		250

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MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
MD986	M	N/P	DU	2N4854	600	40	15	25-	10	.3	10		200
MD1120	M	NPN	DU	D2T2219	600	60	30	50-200	10	.1	10		250
MD1121	M	NPN	DU	D2T2219	600	60	30	50-200	10	.1	10		250
MD1122	M	NPN	DU	D2T2219	600	60	30	50-200	10	.1	10		250
MD1126	M	NPN	DU		400	40	15	30-	10	.4	10		300
MD1127	M	NPN	DU		400	40	15	30-	10	.25	10		300
MD1128	M	NPN	DU		400	40	15	25-	10	.3	10		350
MD1129	M	NPN	DU	D2T2219	600	60	30	100-300	.1	.1	10		200
MD1130	M	PNP	DU	D2T2905	600	60	40	100-300	.1	.25	10		200
MD1131	M	NPN	DU	D2T918	400	30	15	50-	1	.4	10		600
MD1132	M	NPN	DU	D2T918	400	30	15	50-	1	.4	10		600
MD1134	M	NPN	DU	D2T918	600	40	15	50-	10	.25	10		500
MD2218	M	NPN	DU	D2T2219	600	60	30	40-120	150	.4	150		200
MD2218A	M	NPN	DU	D2T2219	600	75	40	40-120	150	.3	150		200
MD2219	M	NPN	DU	D2T2219	600	60	30	40-120	150	.4	150		200
MD2219A	M	NPN	DU	D2T2219	600	75	40	40-120	150	.3	150		200
MD2369	M	NPN	DU		600	40	15	40-140	10	.25	10		500
MD2369A	M	NPN	DU		600	40	15	40-140	10	.25	10		500
MD2369B	M	NPN	DU		600	40	15	40-140	10	.25	10		500
MD2904	M	PNP	DU	D2T2905	600	60	40	40-120	150	.4	150		200
MD2904A	M	PNP	DU	D2T2905	600	60	60	40-120	150	.4	150		200
MD2905	M	PNP	DU	D2T2905	600	60	40	100-300	150	.4	150		200
MD2905A	M	PNP	DU	D2T2905	600	60	40	100-300	150	.4	150		200
MD3250	M	PNP	DU	2N3347	600	50	40	50-150	.1	.25	10	50	200
MD3250A	M	PNP	DU	2N3347	600	50	40	50-150	.1	.25	10	50	200
MD3251	M	PNP	DU	2N3350	600	50	40	100-300	.1	.25	10	100	
MD3251A	M	PNP	DU	2N3350	600	50	40	100-300	.1	.25	10	100	
MD3467	M	PNP	DU		600	40	40	20-	500	.35	500		150
MD3725	M	NPN	DU		600	65	40	50-150	100	.26	100		250
MD3762	M	PNP	DU		600	40	40	20-	1A	1	1A		150
MD4957	M	PNP	DU		400	30	30	20-150	2				1G
MD5000	M	PNP	DU		400	20	15	20-	3	.4	10		600
MD5000A	M	PNP	DU		400	20	15	20-	3	.4	10		600
MD5000B	M	PNP	DU		400	20	15	20-	3	.4	10		600
MD6001	M	N/P	DU	2N4855	600	60	30	40-120	150	.4	150		200
MD6002	M	N/P	DU	2N4854	600	60	30	100-300	150	.4	150		200
MD6003	M	N/P	DU	2N4854	600	50	30	70-	150	.4	150		200
MEM511	GI	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST								
MEM511C	GI	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST								
MEM517	GI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								

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MEM517A	GI	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM517C	GI	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM520	GI	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST									
MEM520C	GI	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST									
MEM550	GI	PCH	FE	3N208	SEE FET INTERCHANGEABILITY LIST									
MEM550C	GI	PCH	FE	3N207	SEE FET INTERCHANGEABILITY LIST									
MEM551	GI	PCH	FE	3N208	SEE FET INTERCHANGEABILITY LIST									
MEM551C	GI	PCH	FE	3N207	SEE FET INTERCHANGEABILITY LIST									
MEM554	GI	NCH	FE	3N201	SEE FET INTERCHANGEABILITY LIST									
MEM554C	GI	NCH	FE	3N201	SEE FET INTERCHANGEABILITY LIST									
MEM556	GI	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST									
MEM556C	GI	PCH	FE	3N174	SEE FET INTERCHANGEABILITY LIST									
MEM557	GI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM557C	GI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM560	GI	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
MEM560C	GI	PCH	FE	3N161	SEE FET INTERCHANGEABILITY LIST									
MEM562	GI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM562C	GI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM563	GI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM564C	GI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM571C	GI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM575	GI	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM614	GI	NCH	FE	3N203	SEE FET INTERCHANGEABILITY LIST									
MEM655	GI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MEM660	GI	NCH	FE	3N214	SEE FET INTERCHANGEABILITY LIST									
MF3304	M	PNP	SW		200	18	12	30-120		10	.23	10		600
MFE2000	M	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST									
MFE2001	M	NCH	FE	2N5247	SEE FET INTERCHANGEABILITY LIST									
MFE2004	M	NCH	FE	2N4860	SEE FET INTERCHANGEABILITY LIST									
MFE2005	M	NCH	FE	2N4859	SEE FET INTERCHANGEABILITY LIST									
MFE2006	M	NCH	FE	2N4859	SEE FET INTERCHANGEABILITY LIST									
MFE2007	M	NCH	FE	2N4860	SEE FET INTERCHANGEABILITY LIST									
MFE2008	M	NCH	FE	2N4859	SEE FET INTERCHANGEABILITY LIST									
MFE2009	M	NCH	FE	2N4859	SEE FET INTERCHANGEABILITY LIST									
MFE2010	M	NCH	FE	2N4859	SEE FET INTERCHANGEABILITY LIST									
MFE2011	M	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE2012	M	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE2093	M	NCH	FE	2N5358	SEE FET INTERCHANGEABILITY LIST									
MFE2094	M	NCH	FE	2N5359	SEE FET INTERCHANGEABILITY LIST									
MFE2095	M	NCH	FE	2N5360	SEE FET INTERCHANGEABILITY LIST									

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TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN	h_{FE} MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
MFE2133	M	NCH	FE	2N4860	SEE FET INTERCHANGEABILITY LIST									
MFE3001	M	NCH	FE	3N128	SEE FET INTERCHANGEABILITY LIST									
MFE3002	M	NCH	FE	3N169	SEE FET INTERCHANGEABILITY LIST									
MFE3003	M	PCH	FE	3N156	SEE FET INTERCHANGEABILITY LIST									
MFE3004	M	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE3005	M	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE3006	M	NCH	FE	3N203	SEE FET INTERCHANGEABILITY LIST									
MFE3007	M	NCH	FE	3N201	SEE FET INTERCHANGEABILITY LIST									
MFE3008	M	NCH	FE	3N203	SEE FET INTERCHANGEABILITY LIST									
MFE3020	M	PCH	FE	3N207	SEE FET INTERCHANGEABILITY LIST									
MFE3021	M	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE4007	M	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE4008	M	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE4009	M	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE4010	M	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE4011	M	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MFE4012	M	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
MJ420	M	NPN	GP	2N5059	800	275	250	25	250	30	.5	30		15
MJ421	M	NPN	GP	2N5058	800	350	325	25	250	30	5	30		15
MJ8100	M	PNP	GP		10W	60	60	25	180	2A	.7	2A		30
MJ8101	M	PNP	GP		10W	80	80	25	180	2A	.7	2A		30
MM709	M	NPN	SW		400	15	8	15	120	10	.35	3		300
MM1803	M	NPN	RF		800	50	25	40	160	50	.3	50	50	
MM1812	M	NPN	GP	2N5059	1W	175	175	40	300	100	.6	100		
MM1941	M	NPN	RF		300	30	20	25		10				600
MM2258	M	NPN	GP	2N5059	1W	120	120	35		50	.4	25		150
MM2259	M	NPN	GP	2N5059	1W	175	175	50		50	.4	25		150
MM2260	M	NPN	GP	2N5059	1W	175	175	50		50	.4	25		150
MM2483	M	NPN	GP	2N2483	360	60	60	40	120	.01	.35	1	80	60
MM2484	M	NPN	GP	2N2484	360	60	60	100	500	.01	.35	1	150	60
MM2894	M	PNP	SW	2N2894	360	15	12	40	150	30	.2	30		400
MM3000	M	NPN	GP	2N5059	1W		100	20		10				150
MM3001	M	NPN	GP	2N5059	1W		150	20		10				150
MM3002	M	NPN	GP	2N5059	1W		200	20		10				150
MM3003	M	NPN	GP	2N5059	1W		250	20		10				150
MM3008	M	NPN	GP	2N3114	1W		120	30		30				50
MM3009	M	NPN	GP	2N5059	1W		180	30		30				50
MM3724	M	NPN	SW	2N3724	1W		30	25	150	500	.6	500		200
MM3725	M	NPN	SW	2N3725	1W		50	25	150	500	.6	500		200
MM3726	M	PNP	SW		1W		50	30	120	500	.6	500		200

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MM3903	M	NPN	SW		360	60	40	50-150	10	.2	10	50	250
MM3904	M	NPN	SW		360	60	40	100-300	10	.2	10	100	300
MM3905	M	PNP	SW		360	40	40	50-150	10	.25	10	50	200
MM3906	M	PNP	SW		360	40	40	100-300	10	.25	10	100	250
MM4000	M	PNP	GP	2N3634	1W	100	100	20-	10	.6	10		
MM4001	M	PNP	GP	2N3635	1W	150	150	20-	10	.6	10		
MM4002	M	PNP	GP		1W	200	200	20-	10	.6	10		
MM4003	M	PNP	GP		1W	250	250	20-	10	.6	10		
MM4018	M	PNP	RF		800	40	20	10-	50				900
MM4019	M	PNP	RF		800	60	40	10-	250	1	250		750
MM4048	M	PNP	GP	2N3798	360	45	45	150-450	.5	.25	.5		100
MM4049	M	PNP	RF		200	15	10	20-80	25				2G
MM4052	M	PNP	SW		500		30	15-	150			20	12
MM4645	M	PNP	GP		*5W	200	200	20-	500	1	500		40
MM4646	M	PNP	GP		*5W	300	300	20-	500	1.2	500		40
MM4647	M	PNP	GP		*5W	400	400	20-	500	1.5	500		30
MM5005	M	PNP	GP	2N4030	1.5	80	60	50-250	150	.5	150		30
MM5006	M	PNP	GP		1.5	100	80	50-250	200	.5	150		30
MM5007	M	PNP	GP		1.5	120	100	50-250	250	.5	150		30
MM8000	M	NPN	RF		3.5	40	30	30-	50				700
MM8001	M	NPN	RF		3.5	40	30	30-	50				900
MM8002	M	NPN	RF		3.5	40	30	30-	50				1200
MM8006	M	NPN	RF	2N3571	200	15	10	25-	1				1G
MM8007	M	NPN	RF	2N3571	200	15	10	25-	1				1G
MM8009	M	NPN	RF		3.5	55	50			.5	100		100
MMT3823	M	NCH	FE	2N3823	SEE FET INTERCHANGEABILITY LIST								
MPF102	M	NCH	FE	2N3819	SEE FET INTERCHANGEABILITY LIST								
MPF103	M	NCH	FE	2N5953	SEE FET INTERCHANGEABILITY LIST								
MPF104	M	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST								
MPF105	M	NCH	FE	2N5951	SEE FET INTERCHANGEABILITY LIST								
MPF106	M	NCH	FE	2N5952	SEE FET INTERCHANGEABILITY LIST								
MPF107	M	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST								
MPF108	M	NCH	FE	2N3819	SEE FET INTERCHANGEABILITY LIST								
MPF109	M	NCH	FE	2N3819	SEE FET INTERCHANGEABILITY LIST								
MPF111	M	NCH	FE	2N3819	SEE FET INTERCHANGEABILITY LIST								
MPF112	M	NCH	FE	2N3819	SEE FET INTERCHANGEABILITY LIST								
MPF120	M	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
MPF121	M	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
MPF122	M	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
MPF161	M	PCH	FE	2N5462	SEE FET INTERCHANGEABILITY LIST								

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ $^*T_C=25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
MPQ3303	M	NPN	SW		600	25	12	40-200	300	.33	300		400
MPQ3725	M	NPN	SW	Q2T3725	600		40	35-200	100	.45	500		250
MPS404	M	PNP	SW	A8T404	310	25	24	30-400	12	.15	12		
MPS404A	M	PNP	SW	A8T404A	310	40	35	30-400	12	.15	12		
MPS706	M	NPN	SW		310	25	15	20-	10	.6	10		200
MPS706A	M	NPN	SW		310	25	15	20-60	10	.6	10		200
MPS834	M	NPN	SW	2N3903	310	40		25-	10	.25	10		350
MPS918	M	NPN	RF	TIS62	310	30	15	20-	3	.4	10		600
MPS2369	M	NPN	SW		310	40	15	40-120	10	.25	10		500
MPS2711	M	NPN	GP	A8T3709	310	18	18	30-90	2			30	
MPS2712	M	NPN	GP	A8T3710	310	18	18	75-225	2			80	
MPS2713	M	NPN	SW	2N3903	310	18	18	30-90	2			30	
MPS2714	M	NPN	SW	2N3904	310	18	18	75-225	2			80	
MPS2923	M	NPN	GP	A8T3710	200	25	25					90	
MPS2924	M	NPN	GP	A8T3710	200	25	25					150	
MPS2925	M	NPN	GP	A8T3711	200	25	25					235	
MPS2926	M	NPN	GP	A8T3709	310	18	18					35	
MPS3392	M	NPN	GP	A7T3392	310-	25	25	150-300	2			150	
MPS3393	M	NPN	GP	TIS95	310	25	25	90-180	2			90	
MPS3394	M	NPN	GP	TIS96	310	25	25	55-110	2			55	
MPS3395	M	NPN	GP	TIS94	310	25	25	150-500	2			150	
MPS3563	M	NPN	RF	TIS63	310	30	12	20-200	8				600
MPS3638	M	PNP	GP	A5T3638	310	25	25	30-	50	.25	50	25	100
MPS3638A	M	PNP	GP	A5T3638A	310	25	25	100-	50	.25	50	100	150
MPS3639	M	PNP	SW	2N4423	200	6	6	30-120	10	.16	10		500
MPS3640	M	PNP	SW	2N4423	310	12	12	30-120	10	.2	10		500
MPS3646	M	NPN	SW	2N3903	200	40	15	30-120	30	.2	30		350
MPS3693	M	NPN	RF	2N4994	310	45	45	40-160	10				200
MPS3694	M	NPN	RF	2N4995	310	45	45	100-400	10				200
MPS3702	M	PNP	GP	A8T3702	310	40	25	60-300	50	.25	50		100
MPS3703	M	PNP	GP	A8T3703	310	50	30	30-150	50	.25	50		100
MPS3704	M	NPN	GP	A8T3704	310	50	30	100-300	50	.6	100		100
MPS3705	M	NPN	GP	A8T3705	310	50	30	50-150	50	.8	100		100
MPS3706	M	NPN	GP	A8T3706	310	40	20	30-600	50	1	100		100
MPS3707	M	NPN	GP	A8T3707	310	30	30	100-400	.1	1	10	100	
MPS3708	M	NPN	GP	A8T3708	310	30	30	45-660	1	1	10	45	
MPS3709	M	NPN	GP	A8T3709	310	30	30	45-165	1	1	10	45	
MPS3710	M	NPN	GP	A8T3710	310	30	30	90-330	1	1	10	90	
MPS3711	M	NPN	GP	A8T3711	310	30	30	180-660	1	1	10	180	
MPS3721	M	NPN	GP	TIS96	310	18	18					60	

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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS			ELECTRICAL CHARACTERISTICS						
					P_T $T_A=25°C$ *$T_C=25°C$	V_{CBO}	V_{CEO}	h_{FE}			$V_{CE(sat)}$		h_{fe} @ 1 kHz	f_T
								MIN	MAX	@ I_C	MAX	@ I_C	MIN	MIN
					(mW)	(V)	(V)			(mA)	(V)	(mA)		(MHz)
MPS5172	M	NPN	GP	A8T5172	210	25	25	100	500	10	.25	10	100	
MPS6507	M	NPN	RF	TIS86	310	30	20	25		2				440
MPS6511	M	NPN	RF	TIS126	310	30	20	25		10				
MPS6512	M	NPN	GP	A8T3708	310	40	30	50	100	2	.5	50		
MPS6513	M	NPN	GP	A8T3710	310	40	30	90	180	2	.5	50		
MPS6514	M	NPN	GP	A8T3710	310	40	25	150	300	2	.5	50		
MPS6515	M	NPN	GP	A8T3711	310	40	25	250	500	2	.5	50		
MPS6516	M	PNP	GP	A8T4059	310	40	40	50	100	2	.5	50		
MPS6517	M	PNP	GP	A8T4061	310	40	40	90	180	2	.5	50		
MPS6518	M	PNP	GP	A8T4061	310	40	40	150	300	2	.5	50		
MPS6519	M	PNP	GP	A8T4062	310	25	25	250	500	2	.5	50		
MPS6520	M	NPN	GP	A8T3707	310	40	25	200	400	2	.5	50		
MPS6521	M	NPN	GP	A8T3711	310	40	25	300	600	2	.5	50		
MPS6522	M	PNP	GP	A8T4058	310	25	25	200	400	2	.5	50		
MPS6523	M	PNP	GP	A8T4062	310	25	25	300	600	2	.5	50		
MPS6530	M	NPN	GP	A8T3705	310	60	40	40	120	100	.5	100		
MPS6531	M	NPN	GP	A8T3704	310	60	40	90	270	100	.3	100		
MPS6532	M	NPN	GP	A8T3706	310	50	30	30		100	.5	100		
MPS6533	M	PNP	GP	A8T3703	310	40	40	40	120	100	.5	100		
MPS6534	M	PNP	GP	A8T3702	310	40	40	90	270	100	.3	100		
MPS6535	M	PNP	GP	A8T3703	310	30	30	30		100	.5	100		
MPS6539	M	NPN	RF	2N4996	310	20	20	20		4				500
MPS6540	M	NPN	RF	2N4997	310	30	30	25		2				350
MPS6542	M	NPN	RF	TIS86	310	30	20	25		2				700
MPS6543	M	NPN	RF	A5T3571	310	35	25	25		4	.35	10		750
MPS6544	M	NPN	RF	TIS126	310	60	45	20		30	.5	30		
MPS6546	M	NPN	RF	2N4996	310	35	25	20		2	.35	10		600
MPS6547	M	NPN	RF	2N4997	310	35	25	20		2	.35	10		600
MPS6548	M	NPN	RF	A5T3571	310	30	25	25		4	.5	4		650
MPS6560	M	NPN	GP	A5T2192	500	25	25	50	200	500	.5	500		60
MPS6561	M	NPN	GP	A5T2192	500	25	25	50	200	350	.5	350		60
MPS6562	M	PNP	GP	A5T4026	500	20	20	50	200	500	.5	500		60
MPS6563	M	PNP	GP	A5T4026	500	20	20	50	200	350	.5	350		60
MPS6565	M	NPN	GP	TIS96	310	60	45	40	160	10	.4	10		200
MPS6566	M	NPN	GP	TIS95	310	60	45	100	400	10	.4	10		200
MPS6567	M	NPN	RF	2N4994	310		40	25		10	.5	10		
MPS6568	M	NPN	RF	TIS108	310	20	20	20	200	4	3	5		375
MPS6569	M	NPN	RF	TIS84	310	20	20	20	200	4	3	5		300
MPS6570	M	NPN	RF	TIS108	310	20	20	20	200	4	3	5		300
MPS6571	M	NPN	GP	TIS94	310	20	20	250	1K	.1	.5	10		50

TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A=25°C$ *$T_C=25°C$ (mW)	MAXIMUM RATINGS V_{CBO} (V)	MAXIMUM RATINGS V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
MPS-A05	M	NPN	GP	TIS96	500	60	60	50-	10	.25	100		50
MPS-A06	M	NPN	GP	TIS96	500	80	80	50-	10	.25	100		50
MPS-A09	M	NPN	GP	A8T3707	310	50	50	100-600	.1	.9	10		30
MPS-A10	M	NPN	GP	TIS96	300		40	40-400	5				50
MPS-A12	M	NPN	DA	2N5525	500	20		20K-	10	1	10		
MPS-A13	M	NPN	DA	2N5525	500	30		5K-	10	1.5	100		125
MPS-A14	M	NPN	DA	2N5525	500	30		10K-	10	1.5	100		125
MPS-A20	M	NPN	GP	TIS94	300		40	40-400	5	.25	10		125
MPS-A55	M	PNP	GP	A5T2907	500		60	50-	100	.25	100		50
MPS-A56	M	PNP	GP	A5T2907	500		80	50-	100	.25	100		50
MPS-A65	M	PNP	DA		500	30	30	50K-	10				100
MPS-A66	M	PNP	DA		500	30	30	75K-	10				100
MPS-A70	M	PNP	GP	A8T3702	300		40	40-400	5	.25	10		125
MPS-H02	M	NPN	RF	TIS84	500	20	20	20-200	4				375
MPS-H04	M	NPN	RF	TIS94	300	80	80	30-120	1.5	.25	10		80
MPS-H05	M	NPN	RF	TIS94	300	80	80	30-150	1.5	.25	10		80
MPS-H07	M	NPN	RF	TIS125	500	30	30	20-	3				400
MPS-H08	M	NPN	RF	TIS125	500	30	30	20-	3				500
MPS-H10	M	NPN	RF		310	30	25	60-	4	.5	4		650
MPS-H11	M	NPN	RF		310	30	25	60-	4	.5	4		650
MPS-H20	M	NPN	RF	TIS86	310	40	30	25-	4				400
MPS-H24	M	PNP	RF	TIS126	500	40	30	30-	4				400
MPS-H30	M	NPN	RF	TIS108	310	20	20	20-200	4	3	10		300
MPS-H31	M	NPN	RF	TIS108	310	20	20	20-200	4	3	10		300
MPS-H32	M	NPN	RF	TIS84	500	40	30	27-200	4	3	10		300
MPS-H34	M	NPN	RF	TIS126	500	45	45	40-	7	.5	20		500
MPS-H37	M	NPN	RF	2N4994	310		40	25-	5	.5	10		300
MPS-H54	M	PNP	GP	TIS104	300	80	80	30-120	1.5	.25	10		80
MPS-H55	M	PNP	RF	TIS104	300	80	80	30-150	1.5	.25	10		80
MPS-H83	M	PNP	RF		625	30	30	20-	2.5				600
MPS-L01	M	NPN	GP	2N5550	310	140	120	50-300	10	.2	10	30	60
MPS-L07	M	PNP	SW	2N4423	310	12	6	30-120	10	.15	10		500
MPS-L08	M	PNP	SW	2N4423	310	12	6	30-120	10	.15	10		700
MPS-L51	M	PNP	GP	2N5400	310	100	100	40-250	50	.3	50	20	60
MU4891	M	P-N	UJ	2N4891	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
MU4892	M	P-N	UJ	2N4892	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
MU4893	M	P-N	UJ	2N4893	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
MU4894	M	P-N	UJ	2N4894	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
NF500	NA	NCH	FE	2N3823	SEE FET INTERCHANGEABILITY LIST								
NF501	NA	NCH	FE	2N3823	SEE FET INTERCHANGEABILITY LIST								

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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
NF506	NA	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST								
NF510	NA	NCH	FE	2N4861	SEE FET INTERCHANGEABILITY LIST								
NF511	NA	NCH	FE	2N4861	SEE FET INTERCHANGEABILITY LIST								
NF520	NA	NCH	FE	2N3822	SEE FET INTERCHANGEABILITY LIST								
NF521	NA	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
NF522	NA	NCH	FE	2N3822	SEE FET INTERCHANGEABILITY LIST								
NF523	NA	NCH	FE	2N3821	SEE FET INTERCHANGEABILITY LIST								
NF530	NA	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
NF531	NA	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
NF532	NA	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
NF533	NA	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
NF580	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF581	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF582	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF583	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF584	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF585	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF4445	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF4446	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF4447	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF4448	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF5457	NA	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
NF5458	NA	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
NF5459	NA	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
NF5485	NA	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST								
NF5486	NA	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST								
NF5555	NA	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
NF5638	NA	NCH	FE	2N4391	SEE FET INTERCHANGEABILITY LIST								
NF5639	NA	NCH	FE	2N4392	SEE FET INTERCHANGEABILITY LIST								
NF5640	NA	NCH	FE	2N4393	SEE FET INTERCHANGEABILITY LIST								
NF5653	NA	NCH	FE	2N4856	SEE FET INTERCHANGEABILITY LIST								
NF5654	NA	NCH	FE	2N4857	SEE FET INTERCHANGEABILITY LIST								
Q2T2222	TI	NPN	GP	Q2T2222	1.5	60	30	100-300	150	.4	150		250
Q2T2905	TI	PNP	GP	Q2T2905	1.5	60	40	100-300	150	.4	150		200
Q2T3244	TI	PNP	SW	Q2T3244	1.5	40	40	50-150	500	.5	500		175
Q2T3725	TI	NPN	SW	Q2T3725	1.5	60	40	60-200	100	.52	500		250
SE1001	F	NPN	RF	2N4994	200	45	45	40-160	10				200
SE1002	F	NPN	RF	2N4995	200	45	45	100-400	10				200
SE1010	F	NPN	GP	TIS95	200	30	15	20-	2				200
SE1132	F	PNP	GP	2N5448	300	50	35	30-90	150	1.5	150	25	60

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TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
SE2001	F	NPN	GP	2N5450	200	35	20	40-160	10	.7	10		200
SE2002	F	NPN	GP	2N5449	200	35	20	100-400	10	.7	10		200
SE3001	F	NPN	RF	TIS62	200	30	12	20-	8	.6	10		600
SE3002	F	NPN	RF	TIS62	200	30	12	20-	8	.6	10		600
SE3005	F	NPN	RF	A5T3571	200	30	15	45-300	5				800
SE4001	F	NPN	GP	A5T3710	200	30	25	200-1000	1	.35	1		40
SE4002	F	NPN	GP	A5T3711	200	30	25	200-1000	1	.35	1		60
SE4010	F	NPN	GP	A5T3711	200	30	25	200-1000	1	.35	1		60
SE4020	F	NPN	GP	TIS97	200	60	60	150-950	10	.2	10		100
SE4021	F	NPN	GP	TIS97	200	45	45	600-1550	10	.2	10		150
SE4022	F	NPN	GP		200	30	30	1200-2200	10	.2	10		200
SE5001	F	NPN	RF	TIS108	200	40	40	30-	4				400
SE5002	F	NPN	RF	TIS108	200	40	40	30-	4				400
SE5003	F	NPN	RF	TIS84	200	40	40	30-	4				400
SE5006	F	NPN	RF	TIS84	200	40	40	30-	4	2	10		400
SE5025	F	NPN	RF	TIS86	250	30	30	20-	10	.6	20		300
SE6001	F	NPN	GP	TIS99	300	40	30	50-200	10	1	100		40
SE6002	F	NPN	GP	TIS97	300	40	30	150-600	10	1	100		40
SE6020	F	NPN	GP	TIS111	300	60	60	100-300	150	.18	150		250
SE6020A	F	NPN	GP	TIS111	500	60	60	100-300	150	.18	150		250
SE6021	F	NPN	GP		300	80	80	100-300	150	.18	150		250
SE6021A	F	NPN	GP		500	80	80	100-300	150	.18	150		250
SE6022	F	NPN	GP	TIS111	220	60	60	100-300	150	.18	150		250
SE6023	F	NPN	GP		220	80	80	100-300	150	.18	150		250
SE7015	F	NPN	GP	2N5550	450	100	100	50-275	50	2	25	40	50
SE7016	F	NPN	GP	2N5550	450	140	140	50-275	50	2	25	40	50
SE7017	F	NPN	GP	2N5551	450	180	180	20-275	50	2	25	40	50
SE8012	F	NPN	RF		500	100	60	40-	100	.75	500		300
SE8040	F	NPN	GP	A5T2222	500	30	30	40-540	150	.12	150		130
SE8540	F	PNP	GP	A5T2907	500	30	30	40-540	150	.25	150		100
SU2028	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
SU2029	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
SU2031	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
SU2032	IN	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
SU2033	IN	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
SU2034	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
SU2035	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
SU2098	IN	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
SU2098A	IN	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
SU2098B	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								

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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
SU2099	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
SU2099A	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
SX37	TI	PNP	RF	TIS137	360	35	32	45-	1				80
SX38	TI	PNP	RF	TIS138	360	35	32	25-	1				50
SX3391	TI	NPN	GP	A5T3391	625	25	25	250-500	2				
SX3702	TI	PNP	GP	2N5447	360	40	25	60-300	50	.25	50		100
SX3703	TI	PNP	GP	2N5448	360	50	30	30-150	50	.25	50		100
SX3704	TI	NPN	GP	2N5449	360	50	30	100-300	50	.6	100		100
SX3705	TI	NPN	GP	2N5450	360	50	30	50-150	50	.8	100		100
SX3706	TI	NPN	GP	2N5451	360	40	20	30-600	50	1	100		100
SX3707	TI	NPN	GP	A5T3707	360	30	30	100-400	.1	1	10	100	
SX3708	TI	NPN	GP	A5T3708	360	30	30	45-660	1	1	10	45	
SX3709	TI	NPN	GP	A5T3709	360	30	30	45-165	1	1	10	45	
SX3710	TI	NPN	GP	A5T3710	360	30	30	90-330	1	1	10	90	
SX3711	TI	NPN	GP	A5T3711	360	30	30	180-660	1	1	10	180	
SX3819	TI	NCH	FE	2N5949/53	SEE FET INTERCHANGEABILITY LIST								
SX3820	TI	PCH	FE	A5T5460/62	SEE FET INTERCHANGEABILITY LIST								
SX4058	TI	PNP	GP	A5T4058	360	30	30	100-400	.1	.7	10	100	
SX4059	TI	PNP	GP	A5T4059	360	30	30	45-660	1	.7	10	45	
SX4060	TI	PNP	GP	A5T4060	360	30	30	45-165	1	.7	10	45	
SX4061	TI	PNP	GP	A5T4061	360	30	30	90-330	1	.7	10	90	
SX4062	TI	PNP	GP	A5T4062	360	30	30	180-660	1	.7	10	180	
SX4254	TI	NPN	RF	2N4996	250	30	18	50-	2				600
TI407	TI	NPN	RF	TIS62	200	30	12	30-	4				500
TI408	TI	NPN	RF	TIS63	200	30	12	20-	4				400
TI409	TI	NPN	RF	TIS64	200	30	12	20-					300
TI412	TI	NPN	GP	2N3704	360	50	30	100-300	50	.6	100		100
TI413	TI	NPN	GP	2N3705	360	50	30	50-150	50	.8	100		100
TI414	TI	NPN	GP	2N3706	360	40	20	30-600	50	1	100		100
TI415	TI	NPN	GP	2N3707	360	30	30	100-400	.1	1	10	100	
TI416	TI	NPN	GP	2N3708	360	30	30	45-660	1	1	10	45	
TI417	TI	NPN	GP	2N3710	360	30	30	90-330	1	1	10	90	
TI418	TI	NPN	GP	2N3711	360	30	30	180-660	1	1	10	180	
TI480	TI	NPN	GP	2N339	600	50	40					9	
TI481	TI	NPN	GP	2N340	600	80	70					9	
TI482	TI	NPN	GP	2N2217	600	20	20	20-	150	1.5	150		40
TI483	TI	NPN	GP	2N2217	600	40	20	20-60	150	1.5	150		40
TI484	TI	NPN	GP	2N2218	600	40	20	40-120	150	1.5	150		40
TI492	TI	NPN	GP	2N332A	150	40	20					15	
TI493	TI	NPN	GP	2N332A	125	40	20	15-45	10				

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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN MAX	h_{FE} @ I_C (mA)	$V_{CE(sat)}$ MAX (V)	$V_{CE(sat)}$ @ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
TI494	TI	NPN	GP	2N335A	125	40	20	40-125	10				
TI495	TI	NPN	GP	2N2219A	125	40	20	120-250	10				
TI496	TI	NPN	GP	2N340	600	70		10-	3	1.5	3		
TIS03	TI	PNP	GP	2N3702	300	40	25	60-300	50	2.5	50		100
TIS04	TI	PNP	GP	2N3703	300	50	30	30-150	50	2.5	50		100
TIS14	TI	NCH	FE	TIS14	SEE FET INTERCHANGEABILITY LIST								
TIS18	TI	NPN	RF	TIS62	200	25	13	20-	10				600
TIS25	TI	NCH	FE	TIS25	SEE FET INTERCHANGEABILITY LIST								
TIS26	TI	NCH	FE	TIS26	SEE FET INTERCHANGEABILITY LIST								
TIS27	TI	NCH	FE	TIS27	SEE FET INTERCHANGEABILITY LIST								
TIS28	TI	NPN	RF	TIS84	200	40	40	30-	4				630
TIS29	TI	NPN	RF	TIS84	200	40	40	30-	4				500
TIS30	TI	NPN	RF	TIS108	200	40	40	30-	4				500
TIS31	TI	NPN	RF	TIS108	200	40	40	30-	4				500
TIS34	TI	NCH	FE	2N5248	SEE FET INTERCHANGEABILITY LIST								
TIS37	TI	PNP	RF	TIS37	625	35	32	45-	1				80
TIS38	TI	PNP	RF	TIS38	625	35	32	25-	1				50
TIS42	TI	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST								
TIS43	TI	P-N	UJ	TIS43	SEE UNIJUNCTION INTERCHANGEABILITY LIST								
TIS44	TI	NPN	SW		250	25	20	20-	10	.6	10		200
TIS45	TI	NPN	SW		250	40	15	30-120	10	.4	10		300
TIS46	TI	NPN	SW		250	40	15	30-120	10	.25	20		300
TIS47	TI	NPN	SW		250	40	15	20-60	10	.25	10		400
TIS48	TI	NPN	SW		250	40	15	40-120	10	.25	10		500
TIS49	TI	NPN	SW		250	40	15	40-120	10	.25	30		500
TIS50	TI	PNP	SW	2N4423	250	12	12	40-150	30	.2	30		400
TIS51	TI	NPN	SW		250	30	12	30-120	10	.2	10		400
TIS52	TI	NPN	SW		250	40	20	30-120	30	.2	30		350
TIS53	TI	PNP	SW		250	6	6	30-120	10	.16	10		500
TIS54	TI	PNP	SW		250	12	12	30-120	10	.2	10		500
TIS55	TI	NPN	SW		250	40	15	30-120	30	.2	30		350
TIS58	TI	NCH	FE	2N5952/53	SEE FET INTERCHANGEABILITY LIST								
TIS59	TI	NCH	FE	2N5949/51	SEE FET INTERCHANGEABILITY LIST								
TIS60	TI	NPN	GP	TIS60	625	40	25	100-300	50	.6	100		
TIS61	TI	PNP	GP	TIS61	625	40	25	100-300	50	.25	50		
TIS62	TI	NPN	RF	TIS62A	625	30	12	30-	4				500
TIS63	TI	NPN	RF	TIS63A	625	30	12	20-	4				400
TIS64	TI	NPN	RF	TIS64A	625	30	12	20-	4				300
TIS67	TI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
TIS68	TI	NCH	FE	TIS69	SEE FET INTERCHANGEABILITY LIST								

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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
TIS69	TI	NCH	FE	TIS69	SEE FET INTERCHANGEABILITY LIST								
TIS70	TI	NCH	FE	TIS70	SEE FET INTERCHANGEABILITY LIST								
TIS73	TI	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST								
TIS74	TI	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST								
TIS75	TI	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST								
TIS78	TI	NCH	FE	A5T6449	SEE FET INTERCHANGEABILITY LIST								
TIS79	TI	NCH	FE	A5T6450	SEE FET INTERCHANGEABILITY LIST								
TIS83	TI	NPN	RF		250	40	25	30-	5				600
TIS84	TI	NPN	RF	TIS84	625	40	30	30-	4				350
TIS85	TI	NPN	RF	TIS108	250	40	30	25-	4				350
TIS86	TI	NPN	RF	TIS86	625	30	30	40-200	4	.5	15		500
TIS87	TI	NPN	RF	TIS87	625	45	45	30-150	12	.5	15		500
TIS88	TI	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST								
TIS89	TI	NPN	RF	TIS86	400	35	35	30-200	4	.5	15		500
TIS90	TI	NPN	GP	TIS90	625	40	40	100-300	50	.25	50		
TIS91	TI	PNP	GP	TIS91	625	40	40	100-300	50	.25	50		
TIS92	TI	NPN	GP	TIS92	625	40	40	100-300	50	.25	50		
TIS93	TI	PNP	GP	TIS93	625	40	40	100-300	50	.25	50		
TIS94	TI	NPN	GP	TIS94	625	60	40	250-700	.1			250	200
TIS95	TI	NPN	GP	TIS95	625	80	60	100-300	1	.5	100	100	200
TIS96	TI	NPN	GP	TIS96	625	80	65	55-300	100	.5	100	60	200
TIS97	TI	NPN	GP	TIS97	625	60	40	250-700	.1			250	200
TIS98	TI	NPN	GP	TIS98	625	80	60	100-300	1	.5	100	100	200
TIS99	TI	NPN	GP	TIS99	625	80	65	55-300	100	.5	100	60	200
TIS100	TI	NPN	GP	TIS100	625	180	180	30-	25	1	25		80
TIS101	TI	NPN	GP	TIS101	625	150	150	30-	25	1	25		80
TIS102	TI	NPN	GP	2N5059	800	180	180	30-	25	1	25		80
TIS103	TI	NPN	GP	2N5059	800	150	150	30-	25	1	25		80
TIS104	TI	PNP	RF	TIS104	625	60	60	100-500	1	.6	20		90
TIS105	TI	NPN	RF	TIS105	625	45	45	30-150	10	.5	20		300
TIS106	TI	NPN	GP	TIS98	360	80	65	65-300	100	.5	100	100	200
TIS107	TI	NPN	GP	TIS97	360	60	40	35-300	100	.5	100	60	200
TIS108	TI	NPN	RF	TIS108	625	40	30	25-	4				350
TIS109	TI	NPN	GP	TIS109	625	60	30	100-400	150	.4	150		250
TIS110	TI	NPN	GP	TIS110	625	60	40	50-150	150	.4	150		200
TIS111	TI	NPN	GP	TIS111	625	60	40	100-300	150	.4	150		250
TIS112	TI	PNP	GP	TIS112	625	60	40	100-300	150	.4	150		200
TIS113	TI	NPN	SW	TIS133	700	50	30	60-150	100	.3	100		300
TIS114	TI	NPN	SW	TIS134	700	50	30	50-150	100	.4	100		300
TIS115	TI	NPN	SW	TIS135	700	80	50	60-150	100	.3	100		300

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TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS h_{FE} MIN MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
TIS116	TI	NPN	SW	TIS136	700	80	50	50-150	100	.4	100		300
TIS125	TI	NPN	RF	TIS125	625	40	30	30-	4				450
TIS126	TI	NPN	RF	TIS126	625	40	30	25-	10	.5	30		600
TIS128	TI	NPN	RF	TIS128	250	60	45	30-	2				650
TIS129	TI	NPN	RF	TIS129	250	40	25	60-	4	.5	4		800
TIS133	TI	NPN	SW	TIS133	700	50	30	60-150	100	.3	100		250
TIS134	TI	NPN	SW	TIS134	700	50	30	50-150	100	.4	100		250
TIS135	TI	NPN	SW	TIS135	700	80	50	60-150	100	.3	100		250
TIS136	TI	NPN	SW	TIS136	700	80	50	50-150	100	.4	100		250
TIS137	TI	PNP	RF	TIS137	625	35	32	45-	1				80
TIS138	TI	PNP	RF	TIS138	625	35	32	25-	1				50
U110	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
U112	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
U146	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
U147	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
U148	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
U149	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
U133	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST								
U168	SI	PCH	FE	2N2608	SEE FET INTERCHANGEABILITY LIST								
U182	IN	NCH	FE	2N4860	SEE FET INTERCHANGEABILITY LIST								
U183	SI	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
U184	SI	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST								
U197	SI	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST								
U198	SI	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST								
U199	SI	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST								
U200	SI	NCH	FE	2N5549	SEE FET INTERCHANGEABILITY LIST								
U201	SI	NCH	FE	2N4861	SEE FET INTERCHANGEABILITY LIST								
U202	SI	NCH	FE	2N4860	SEE FET INTERCHANGEABILITY LIST								
U221	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
U222	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
U231	IN	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST								
U232	IN	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST								
U233	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
U234	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST								
U235	IN	NCH	FE	2N5045	SEE FET INTERCHANGEABILITY LIST								
U240	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
U241	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
U242	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
U243	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST								
U248	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST								

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					P_T $T_A = 25°C$ *$T_C = 25°C$	V_{CBO}	V_{CEO}	h_{FE}			$V_{CE(sat)}$		h_{fe} @ 1 kHz	f_T
								MIN	MAX	@ I_C	MAX	@ I_C	MIN	MIN
					(mW)	(V)	(V)			(mA)	(V)	(mA)		(MHz)
U248A	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U249	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U249A	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U250	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U250A	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U251	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U251A	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U252	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U253	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U254	IN	NCH	FE	2N4859	SEE FET INTERCHANGEABILITY LIST									
U255	IN	NCH	FE	2N4860	SEE FET INTERCHANGEABILITY LIST									
U256	IN	NCH	FE	2N4861	SEE FET INTERCHANGEABILITY LIST									
U257	IN	NCH	FE	2N5047	SEE FET INTERCHANGEABILITY LIST									
U273	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U273A	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U274	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U274A	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U275	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U275A	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U280	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U281	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U282	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U283	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U284	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U285	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U290	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U291	SI	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U300	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
U301	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
U304	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
U305	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
U306	SI	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
U310	SI	NCH	FE	2N5549	SEE FET INTERCHANGEABILITY LIST									
U312	SI	NCH	FE	2N5397	SEE FET INTERCHANGEABILITY LIST									
U1277	IN	NCH	FE	2N5361	SEE FET INTERCHANGEABILITY LIST									
U1278	IN	NCH	FE	2N5359	SEE FET INTERCHANGEABILITY LIST									
U1279	IN	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST									
U1280	IN	NCH	FE	2N5359	SEE FET INTERCHANGEABILITY LIST									
U1281	IN	NCH	FE	2N5549	SEE FET INTERCHANGEABILITY LIST									
U1282	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									

TRANSISTOR INTERCHANGEABILITY
MASTER LIST OF NONREGISTERED TYPES

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A=25°C$ *$T_C=25°C$ (mW)	MAXIMUM RATINGS: V_{CBO} (V)	MAXIMUM RATINGS: V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
U1283	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
U1284	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
U1285	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U1286	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
U1287	IN	NCH	FE	2N4860	SEE FET INTERCHANGEABILITY LIST									
U1321	IN	NCH	FE	2N3966	SEE FET INTERCHANGEABILITY LIST									
U1322	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
U1323	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
U1324	IN	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST									
U1325	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U1714	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
U1837E	IN	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST									
U1897E	IN	NCH	FE	TIS73	SEE FET INTERCHANGEABILITY LIST									
U1898E	IN	NCH	FE	TIS74	SEE FET INTERCHANGEABILITY LIST									
U1899E	IN	NCH	FE	TIS75	SEE FET INTERCHANGEABILITY LIST									
U1994E	IN	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST									
U3000	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
U3001	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
U3002	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
U3010	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
U3011	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
U3012	IN	NCH	FE	2N3460	SEE FET INTERCHANGEABILITY LIST									
UC20	IN	NCH	FE	2N5358	SEE FET INTERCHANGEABILITY LIST									
UC21	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
UC100	IN	NCH	FE	2N5361	SEE FET INTERCHANGEABILITY LIST									
UC110	IN	NCH	FE	2N5360	SEE FET INTERCHANGEABILITY LIST									
UC115	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
UC130	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
UC155	IN	NCH	FE	2N5364	SEE FET INTERCHANGEABILITY LIST									
UC200	IN	NCH	FE		SEE FET INTERCHANGEABILITY LIST									
UC201	IN	NCH	FE	2N5364	SEE FET INTERCHANGEABILITY LIST									
UC210	IN	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST									
UC220	IN	NCH	FE	2N5360	SEE FET INTERCHANGEABILITY LIST									
UC240	IN	NCH	FE	2N3459	SEE FET INTERCHANGEABILITY LIST									
UC241	IN	NCH	FE	2N5361	SEE FET INTERCHANGEABILITY LIST									
UC250	IN	NCH	FE	2N4391	SEE FET INTERCHANGEABILITY LIST									
UC251	IN	NCH	FE	2N4392	SEE FET INTERCHANGEABILITY LIST									
UC400	IN	PCH	FE	2N3331	SEE FET INTERCHANGEABILITY LIST									
UC401	IN	PCH	FE	2N3994	SEE FET INTERCHANGEABILITY LIST									
UC410	IN	PCH	FE	2N3330	SEE FET INTERCHANGEABILITY LIST									

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE NUMBER	MANUFACTURER	POLARITY	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	MAXIMUM RATINGS: P_T $T_A = 25°C$ *$T_C = 25°C$ (mW)	V_{CBO} (V)	V_{CEO} (V)	ELECTRICAL CHARACTERISTICS: h_{FE} MIN	h_{FE} MAX	@ I_C (mA)	$V_{CE(sat)}$ MAX (V)	@ I_C (mA)	h_{fe} @ 1 kHz MIN	f_T MIN (MHz)
UC420	IN	PCH	FE	2N3329	SEE FET INTERCHANGEABILITY LIST									
UC703	IN	NCH	FE	2N5362	SEE FET INTERCHANGEABILITY LIST									
UC704	IN	NCH	FE	2N5364	SEE FET INTERCHANGEABILITY LIST									
UC705	IN	NCH	FE	2N5364	SEE FET INTERCHANGEABILITY LIST									
UC707	IN	NCH	FE	2N4861	SEE FET INTERCHANGEABILITY LIST									
UC714	IN	NCH	FE	2N3823	SEE FET INTERCHANGEABILITY LIST									
UC714E	IN	NCH	FE	2N5950	SEE FET INTERCHANGEABILITY LIST									
UC734	IN	NCH	FE	2N4416	SEE FET INTERCHANGEABILITY LIST									
UC734E	IN	NCH	FE	2N5245	SEE FET INTERCHANGEABILITY LIST									
UC751	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
UC752	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
UC753	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
UC754	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
UC755	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
UC756	IN	NCH	FE	2N3458	SEE FET INTERCHANGEABILITY LIST									
UC814	IN	PCH	FE	2N3331	SEE FET INTERCHANGEABILITY LIST									
UC851	IN	PCH	FE	2N2608	SEE FET INTERCHANGEABILITY LIST									
UC853	IN	PCH	FE	2N3822	SEE FET INTERCHANGEABILITY LIST									
UC854	IN	PCH	FE	2N2608	SEE FET INTERCHANGEABILITY LIST									
UC855	IN	PCH	FE	2N2609	SEE FET INTERCHANGEABILITY LIST									
UC1700	IN	PCH	FE		SEE FET INTERCHANGEABILITY LIST									
UC1764	IN	PCH	FE	3N163	SEE FET INTERCHANGEABILITY LIST									
UC2130	IN	NCH	FE	2N5545	SEE FET INTERCHANGEABILITY LIST									
UC2132	IN	NCH	FE	2N5546	SEE FET INTERCHANGEABILITY LIST									
UC2134	IN	NCH	FE	2N5547	SEE FET INTERCHANGEABILITY LIST									
UC2136	IN	NCH	FE	2N5045	SEE FET INTERCHANGEABILITY LIST									
UC2138	IN	NCH	FE	2N5046	SEE FET INTERCHANGEABILITY LIST									
UC2139	IN	NCH	FE	2N5047	SEE FET INTERCHANGEABILITY LIST									
UC2147	IN	NCH	FE	2N5047	SEE FET INTERCHANGEABILITY LIST									
UC2148	IN	NCH	FE	2N5047	SEE FET INTERCHANGEABILITY LIST									
UC2149	IN	NCH	FE	2N5047	SEE FET INTERCHANGEABILITY LIST									
UCI766	IN	PCH	FE	2N5047	SEE FET INTERCHANGEABILITY LIST									

TRANSISTOR INTERCHANGEABILITY
REGISTERED FIELD-EFFECT TRANSISTORS

TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} / $^*I_{D(on)}$ MIN MAX (mA) (mA)	$\lvert y_{fs} \rvert$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
2N2386	P	J	FE	2N2386	20	.9-9	1-	50	NF	2 DB	
2N2386A	P	J	FE	2N2386A	20	1-15	2.2-5	10	NF	2 DB	
2N2497	P	J	FE	2N2497	*20	1-3	1-2	32	NF	3 DB	
2N2498	P	J	FE	2N2498	*20	2-6	1.5-3	32	NF	3 DB	
2N2499	P	J	FE	2N2499	*20	5-15	2-4	32	NF	4 DB	
2N2500	P	J	FE	2N2500	20	1-6	1-2.2	32	NF	1 DB	
2N2606	P	J	FE		30	.1-.5	.11-	6	NF	3 DB	10M
2N2607	P	J	FE		30	.3-1.5	.33-	10	NF	3 DB	10M
2N2608	P	J	FE	2N2608	30	.9-4.5	1-	17	NF	3 DB	1M
2N2609	P	J	FE	2N2609	30	2-10	2.5-	30	NF	3 DB	1M
2N2841	P	J	FE		30	.025-.125	.06-	6	NF	3 DB	1K
2N2842	P	J	FE		30	.065-.325	.18-	10	NF	3 DB	1K
2N2843	P	J	FE		30	.2-1	.54-	17	NF	3 DB	1K
2N2844	P	J	FE		30	.44-2.2	1.8-	30	NF	3 DB	1K
2N3066	N	J	FE	2N3459	50	.8-4	.4-1	10	NF	3 DB	1K
2N3067	N	J	FE	2N3460	50	.2-1	.3-1	10	NF	3 DB	1K
2N3068	N	J	FE		50	.05-.25	.2-1	10	NF	3 DB	1K
2N3069	N	J	FE	2N3458	50	2-10	1-2.5	15	NF	3 DB	1K
2N3070	N	J	FE	2N3459	50	.5-2.5	.75-2.5	15	NF	3 DB	1K
2N3071	N	J	FE	2N3460	50	.1-.6	.5-2.5	15	NF	3 DB	1K
2N3084	N	J	FE	2N3459	30	.8-3	.4-1.2				
2N3085	N	J	FE	2N3459	30	.8-3	.4-1.2				
2N3086	N	J	FE	2N3459	40	.8-3	.4-1.2				
2N3087	N	J	FE	2N3459	40	.8-3	.4-1.2				
2N3088	N	J	FE	2N3460	15	.5-2	.3-		NF	3 DB	
2N3088A	N	J	FE	2N3460	15	*.5-2	.9-2	14	NF	.5 DB	1M
2N3089	N	J	FE	2N3460	30	.5-2	.3-2	6	NF	3 DB	10
2N3089A	N	J	FE	2N3460	15	*.5-2	.9-2	14	NF	.5 DB	1M
2N3112	P	J	FE		20	.035-.175	.05-.11	3.5			
2N3113	P	J	FE		20	.035-.175	.05-.11	2			
2N3277	P	J	FE		25	.15-.5	.1-	4.5			
2N3278	P	J	FE		25	.4-.9	.15-	4.5			
2N3328	P	J	FE	2N3328	20	-1	.1-		NF	3 DB	1K
2N3329	P	J	FE	2N3329	20	1-3	1-2		NF	3 DB	1K
2N3330	P	J	FE	2N3330	20	2-6	1.5-3		NF	3 DB	1K
2N3331	P	J	FE	2N3331	20	5-15	2-4		NF	4 DB	1K
2N3332	P	J	FE	2N3332	20	1-6	1-2.2	20	NF	1 DB	
2N3333	P	J	FE	2N3333	20	.3-1	.6-1.8	30			
2N3334	P	J	FE	2N3334	20	.3-1	.6-1.8	30			
2N3335	P	J	FE	2N3335	20	.3-1	.6-1.8	30			

TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} *$I_{D(on)}$ MIN MAX (mA) (mA)	$\lvert y_{fs}\rvert$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
2N3336	P	J	FE	2N3336	20	.3-1	.6-1.8	30			
2N3365	N	J	FE	2N3459	40	.8-4	.4-2	15			
2N3366	N	J	FE	2N3460	40	.2-1	.25-1	15			
2N3367	N	J	FE		40	.05-.25	.1-1	15			
2N3368	N	J	FE	2N3458	40	2-12	1-4	20			
2N3369	N	J	FE	2N3460	40	.5-2.5	.6-2.5	20			
2N3370	N	J	FE	2N3460	40	.1-.6	.3-2.5	20			
2N3376	P	J	FE	2N3329	30	.6-6	.8-2.3				
2N3377	P	J	FE		30	.6-6	.8-2.3				
2N3378	P	J	FE		30	3-6	1.5-2.3				
2N3379	P	J	FE		30	3-6	1.5-2.3				
2N3380	P	J	FE	2N3331	30	3-20	1.5-3				
2N3381	P	J	FE		30	3-20	1.5-3				
2N3382	P	J	FE	2N3994	30	3-30	4.5-12.				
2N3383	P	J	FE		30	3-30	2.5-7				
2N3384	P	J	FE	2N3993	30	15-30	7.5-12.				
2N3385	P	J	FE		30	15-30	5-7				
2N3386	P	J	FE	2N3993	30	15-50	7.5-15				
2N3387	P	J	FE		30	15-50	5-10				
2N3436	N	J	FE	2N3458	50	3-15	2.5-10	18	NF	2 DB	1K
2N3437	N	J	FE	2N3459	50	.8-4	1.5-6	18	NF	2 DB	1K
2N3438	N	J	FE	2N3460	50	.2-1	.8-4.5	18	NF	2 DB	1K
2N3452	N	J	FE	2N3821	50	.8-4	.2-1.2	6	NF	2 DB	
2N3453	N	J	FE	2N3821	50	.2-1	.15-.9	6	NF	2 DB	
2N3454	N	J	FE		50	.05-.25	.1-.6	6	NF	2 DB	
2N3455	N	J	FE	2N3821	50	.8-4	.4-1.2	5	NF	4 DB	
2N3456	N	J	FE	2N3821	50	.2-1	.3-.9	5	NF	4 DB	
2N3457	N	J	FE		50	.05-.25	.15-.6	5	NF	4 DB	
2N3458	N	J	FE	2N3458	50	3-15	2.5-10	18	NF	6 DB	20
2N3459	N	J	FE	2N3459	50	.8-4	1.5-6	18	NF	4 DB	20
2N3460	N	J	FE	2N3460	50	.2-1	.8-4.5	18	NF	4 DB	20
2N3465	N	J	FE		40	1-5	.4-1.2		NF	5 DB	
2N3466	N	J	FE	2N3821	40	1-5	.4-1.2		NF	5 DB	
2N3573	P	J	FE	2N3573	25	.02-.1	.1-.3	6	NF	3 DB	
2N3574	P	J	FE	2N3574	25	.075-.37	.2-.6	6	CRSS	2 PF	
2N3575	P	J	FE	2N3575	25	.2-1	.3-.9	6	CRSS	2 PF	
2N3578	P	J	FE	2N2608	20	.9-4.5	1.2-3.5	65	•		
2N3608	P	IG	FE	3N155	30	*4-7	.8-		CRSS	3 PF	1M
2N3609	P	IG	FE		25	2.25-3.25			CRSS	2 PF	1M
2N3610	P	IG	FE		20	*.4-.6			CRSS	.6 PF	

TRANSISTOR INTERCHANGEABILITY
REGISTERED FIELD-EFFECT TRANSISTORS

TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} *$I_{D(on)}$ MIN MAX (mA) (mA)	$\|Y_{fs}\|$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER: SYMBOL	MAX	@ f (Hz)
2N3631	N	IG	FE		20	2-10	1.4-2.8	7.5	CRSS	1.6 PF	1K
2N3684	N	J	FE	2N3822	50	2.5-7.5	2-3	4	NF	.5 DB	100
2N3684A	N	J	FE	2N3822	50	2.5-7.5	2-3	4	NF	.5 DB	100
2N3685	N	J	FE	2N3821	50	1-3	1.5-2.5	4	NF	.5 DB	100
2N3685A	N	J	FE	2N3821	50	1-3	1.5-2.5	4	NF	.5 DB	100
2N3686	N	J	FE	2N3821	50	.4-1.2	1-2	4	NF	.5 DB	100
2N3686A	N	J	FE	2N3821	50	.4-1.2	1-2	4	NF	.5 DB	100
2N3687	N	J	FE		50	.1-.5	.5-1.5	4	NF	.5 DB	100
2N3687A	N	J	FE		50	.1-.5	.5-1.5	4	NF	.5 DB	100
2N3695	P	J	FE	2N3329	30	1.25-3.75	1-1.75		NF	.5 DB	10M
2N3696	P	J	FE	2N3329	30	*.5-1.5	.75-1.25		NF	.5 DB	10M
2N3697	P	J	FE		30	*.2-.6					
2N3698	P	J	FE		30	.05-.25	.25-.75		NF	.5 DB	10M
2N3796	N	IG	FE		25	.5-3	.9-1.8	7	CRSS	.8 PF	1K
2N3797	N	IG	FE		20	2-6	1.5-3	8	CRSS	.8 PF	1M
2N3819	N	J	AF	2N3819	25	2-20	2-6.5	8	CRSS	4 PF	1M
2N3820	P	J	AF	2N3820	20	.3-15	.8-5	32	CRSS	16 PF	1M
2N3821	N	J	FE	2N3821	50	.5-2.5	1.5-	6	NF	5 DB	10
2N3822	N	J	FE	2N3822	50	2-10	3-	6	NF	5 DB	10
2N3823	N	J	FE	2N3823	30	4-20	3.2-	6	NF	2.5 DB	100M
2N3824	N	J	FE	2N3824	50			6	CRSS	3 PF	1M
2N3882	P	IG	FE		30	*-1	1-2.5		NF	3 DB	10K
2N3909	P	J	FE	2N3909	20	.3-15	1-5	32			
2N3909A	P	J	FE	2N3909A	20	1-15	2.2-5				
2N3921	N	J	FE	2N5545	50	1-10	1.5-7.5	18	NF	2 DB	1K
2N3922	N	J	FE		50	1-10	1.5-7.5	18	NF	2 DB	1K
2N3934	N	J	FE	2N5545	50	.25-1.3	.3-		NF	2 DB	
2N3935	N	J	FE	2N5546	50	.25-1.3	.3-		NF	2 DB	
2N3954	N	J	FE		50	.5-5	1-		NF	.5 DB	
2N3954A	N	J	FE	2N5545	50	.5-5	1-3	4	NF	.5 DB	100
2N3955	N	J	FE	2N5546	50	.5-5	1-		NF	.5 DB	
2N3955A	N	J	FE	2N5546	50	.5-5	1-3	4	NF	.5 DB	100
2N3956	N	J	FE	2N5547	50	.5-5	1-		NF	.5 DB	
2N3957	N	J	FE	2N5547	50	.5-5	1-		NF	.5 DB	
2N3958	N	J	FE	2N5547	50	.5-5	1-		NF	.5 DB	
2N3966	N	J	FE	2N3966	40	2-		6	CRSS	1.5 PF	
2N3967	N	J	FE	2N3822	30	2.5-10	1.6-2.4	5	NF	1.5 DB	
2N3967A	N	J	FE	2N3822	30	2.5-10	1.6-2.4	5	NF	1 DB	1K
2N3968	N	J	FE	2N3822	30	1-5	1.4-2	5	NF	1.5 DB	
2N3968A	N	J	FE	2N3821	30	1-5	1.4-2	5	NF	1 DB	1K

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TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} / $*I_{D(on)}$ MIN - MAX (mA) (mA)	$\lvert y_{fs} \rvert$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER: SYMBOL	MAX	@ f (Hz)
2N3969	N	J	FE	2N3821	30	.4-2	.95-1.4	5	NF	1.5 DB	
2N3969A	N	J	FE	2N3821	30	.4-2	.95-1.4	5	NF	1 DB	1K
2N3970	N	J	FE	2N3970	40	50-150		25	CRSS	6 PF	1M
2N3971	N	J	FE	2N3971	40	25-75		25	CRSS	6 PF	1M
2N3972	N	J	FE	2N3972	40	5-30		25	CRSS	6 PF	1M
2N3993	P	J	FE	2N3993	25	10-		16	CRSS	4.5 PF	
2N3993A	P	J	FE	2N3993A	25	10-		12	CRSS	3 PF	
2N3994	P	J	FE	2N3994	25	2-		16	CRSS	5 PF	
2N3994A	P	J	FE	2N3994A	25	2-		12	CRSS	3.5 PF	
2N4038	N	IG	FE		50	-.1	1.5-2.5				
2N4039	N	IG	FE		50	.1-1.5	1.5-2.5				
2N4065	P	IG	FE	3N174	25	3-6	.4-	4.5	CRSS	.7 PF	
2N4066	P	IG	FE	3N207	30	*10-50	2.5-	7	CRSS	1.5 PF	1M
2N4067	P	IG	FE	3N207	30	*10-50	2.5-	7	CRSS	1.5 PF	1M
2N4082	N	J	FE		50	.25-1.3	.3-		NF	2 DB	
2N4083	N	J	FE		50	.25-1.3	.3-		NF	2 DB	
2N4084	N	J	FE	2N5545	50	1-10	1.5-7.5	18	NF	2 DB	1K
2N4085	N	J	FE	2N5546	50	1-10	1.5-7.5	18	NF	2 DB	1K
2N4088	P	J	FE	2N3331	30	5-15	1-1.6	10	NF	1.5 DB	
2N4089	P	J	FE	2N3330	30	2-8	.8-1.3	10	NF	1.5 DB	
2N4090	P	J	FE	2N3329	30	.4-2.5	.5-.9	10	NF	1.5 DB	
2N4091	N	J	FE	2N4091	40	30-		16	CRSS	5 PF	1M
2N4091A	N	J	FE	2N4091	50	30-		16	CRSS	5 PF	1M
2N4092	N	J	FE	2N4092	40	15-		16	CRSS	5 PF	1M
2N4092A	N	J	FE	2N4092	50	15-		16	CRSS	5 PF	1M
2N4093	N	J	FE	2N4093	40	8-		16	CRSS	5 PF	1M
2N4093A	N	J	FE	2N4093	50	8-		16	CRSS	5 PF	1M
2N4094	N	J	FE	2N4856	40	75-		32	CRSS	7 PF	
2N4095	N	J	FE	2N4857	40	20-		32	CRSS	7 PF	
2N4117	N	J	FE		40	.03-.09	.07-.21	3	CRSS	1.5 PF	1M
2N4117A	N	J	FE		40	.03-.09	.07-.21	3	CRSS	1.5 PF	1M
2N4118	N	J	FE		40	.08-.24	.08-.25	3	CRSS	1.5 PF	1M
2N4118A	N	J	FE		40	.08-.24	.08-.25	3	CRSS	1.5 PF	1M
2N4119	N	J	FE		40	.2-.6	.1-.33	3	CRSS	1.5 PF	1M
2N4119A	N	J	FE		40	.2-.6	.1-.33	3	CRSS	1.5 PF	1M
2N4120	P	IG	FE	3N174	25	5-12	.7-	4.5	CRSS	.7 PF	
2N4139	N	J	FE	2N3458	50	8-11	3.5-7	18	NF	2 DB	
2N4220	N	J	FE	2N4220	30	.5-3	1-4	6	CRSS	2 PF	
2N4220A	N	J	FE	2N4220A	30	.5-3	.75-	6	NF	2.5 DB	100
2N4221	N	J	FE	2N4221	30	.2-6	2-5	6	CRSS	2 PF	1K

TRANSISTOR INTERCHANGEABILITY
REGISTERED FIELD-EFFECT TRANSISTORS

TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	I_{DSS} / *$I_{D(on)}$ MIN-MAX (mA)	$\lvert y_{fs} \rvert$ MIN-MAX (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
2N4221A	N	J	FE	2N4221A	30	2-6	.75-	6	NF	2.5 DB	100
2N4222	N	J	FE	2N4222	30	2-6	2.5-6	6	CRSS	2 PF	1K
2N4222A	N	J	FE	2N4222A	30	5-15	.75-	6	NF	2.5 DB	100
2N4223	N	J	FE	2N4223	30	3-18	3-7	6	NF	5 DB	200M
2N4223A	N	J	FE		30	3-18	2.7-	6	NF	5 DB	200M
2N4224	N	J	FE		30	2-20	1.7-	6	CRSS	2 PF	1M
2N4224A	N	J	FE		30	2-20	1.7-	6	CRSS	2 PF	1M
2N4267	P	IG	FE	3N160	30	*20-100		14	CRSS	3 PF	
2N4268	P	IG	FE	3N160	30	*20-100		14	CRSS	3 PF	
2N4302	N	J	FE	2N5953	30	.5-5	1-	6	NF	2 DB	1K
2N4303	N	J	FE	2N5952	30	4-10	2-	6	NF	2 DB	1K
2N4304	N	J	FE	2N5951	30	.5-15	1-	6	NF	3 DB	1K
2N4338	N	J	FE	2N3460	50	.2-.6	.6-1.8	7	NF	1 DB	1K
2N4339	N	J	FE		50	.5-1.5	.8-2.4	7	NF	1 DB	1K
2N4340	N	J	FE	2N3459	50	1.2-3.6	1.3-3	7	NF	1 DB	1K
2N4341	N	J	FE	2N3458	50	3-9	2-4	7	NF	1 DB	1K
2N4342	P	J	AF	2N3994	25	4-12	2-6	20	NF	1.5 DB	100
2N4343	P	J	AF	2N3993	25	10-30	4-8	20	NF	1.5 DB	100
2N4343	P	J	FE	2N3993	25	10-30	4-8	20	NF	1.5 DB	1M
2N4351	N	IG	FE	3N169	25	*3-		6	CRSS	1.5 PF	
2N4352	P	IG	FE	3N160	25	*30-		5	CRSS	1.3 PF	
2N4353	P	IG	FE	3N161	30		1-4	12	CRSS	4 PF	
2N4360	P	J	AF	A5T5462	20	3-30	2-8	20	NF	5 DB	100
2N4381	P	J	FE		25	10-30	2-	20	CRSS	5 PF	
2N4382	P	J	FE		25	10-30	4-	20	CRSS	5 PF	
2N4391	N	J	FE	2N4391	40	50-150		14	CRSS	3.5 PF	1M
2N4392	N	J	FE	2N4392	40	25-75		14	CRSS	3.5 PF	1M
2N4393	N	J	FE	2N4393	40	5-30		14	CRSS	3.5 PF	1M
2N4416	N	J	FE	2N4416	30	5-15	4.5-7.5	4	NF	2 DB	100M
2N4416A	N	J	FE	2N4416A	35	5-15	4.5-7.5	4	NF	2 DB	100M
2N4417	N	J	FE		30	5-15	4.5-7.5	3.5	NF	2 DB	100M
2N4445	N	J	FE		25	150-		50	CRSS	25 PF	
2N4446	N	J	FE		25	100-		50	CRSS	25 PF	
2N4447	N	J	FE		20	150-		50	CRSS	25 PF	
2N4448	N	J	FE		20	100-		50	CRSS	25 PF	
2N4856	N	J	FE	2N4856	40	50-		18	CRSS	8 PF	1M
2N4856A	N	J	FE	2N4856A	40	50-		10	CRSS	4 PF	1M
2N4857	N	J	FE	2N4857	40	20-100		18	CRSS	8 PF	1M
2N4857A	N	J	FE	2N4857A	40	20-100		10	CRSS	3.5 PF	1M
2N4858	N	J	FE	2N4858	40	8-80		18	CRSS	8 PF	1M

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TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE	ELECTRICAL CHARACTERISTICS: I_{DSS} / *$I_{D(on)}$ MIN MAX	ELECTRICAL CHARACTERISTICS: $\|y_{fs}\|$ MIN MAX	C_{iss} MAX	OTHER PARAMETER: SYMBOL	MAX	@ f
					(V)	(mA) (mA)	(mmho) (mmho)	(pF)			(Hz)
2N4858A	N	J	FE	2N4858A	40	8-80		10	CRSS	3.5 PF	1M
2N4859	N	J	FE	2N4859	30	50-		18	CRSS	8 PF	1M
2N4859A	N	J	FE	2N4859A	30	50-		10	CRSS	4 PF	1M
2N4860	N	J	FE	2N4860	30	20-100		18	CRSS	8 PF	1M
2N4860A	N	J	FE	2N4860A	30	20-100		10	CRSS	3.5 PF	1M
2N4861	N	J	FE	2N4861	30	8-80		18	CRSS	8 PF	1M
2N4861A	N	J	FE	2N4861A	30	8-80		10	CRSS	3.5 PF	1M
2N4867	N	J	FE		40	.4-1.2	.7-2	25	NF	1 DB	1K
2N4867A	N	J	FE		40	.4-1.2	.7-2	25	NF	1 DB	1K
2N4868	N	J	FE		40	1-3	1-3	25	NF	1 DB	1K
2N4868A	N	J	FE		40	1-3	1-3	25	NF	1 DB	1K
2N4869	N	J	FE		40	2.5-7.5	1.3-4	25	NF	1 DB	1K
2N4869A	N	J	FE	2N5361	40	2.5-7.5	1.3-4	25	NF	1 DB	1K
2N4881	N	J	FE	2N6449	300	.4-2	.35-1	15	NF	3 DB	
2N4882	N	J	FE	2N6449	300	1.5-7.5	.6-1.5	15	NF	3 DB	
2N4883	N	J	FE	2N6450	200	.4-2	.35-1	15	NF	3 DB	
2N4884	N	J	FE	2N6450	-200	1.5-7.5	.6-1.5	15	NF	3 DB	
2N4885	N	J	FE	2N6450	125	.4-2	.35-1	15	NF	3 DB	
2N4886	N	J	FE	2N6450	125	1.5-7.5	.6-1.5	15	NF	3 DB	
2N4977	N	J	FE		30	50-		35	CRSS	8 PF	
2N4978	N	J	FE		30	15-		35	CRSS	8 PF	
2N4979	N	J	FE		30	7.5-		35	CRSS	8 PF	
2N5018	P	J	FE		30	10-		45	CRSS	10 PF	
2N5019	P	J	FE	2N3993	30	5-		45	CRSS	10 PF	
2N5020	P	J	FE		25	.3-1.2	1-3.5	25	NF	3 DB	
2N5021	P	J	FE		25	1-3.5	1.5-5	25	CRSS	7 PF	
2N5033	P	J	GP	A5T5460	20	.3-3.5	1-	25	NF	2 DB	1K
2N5045	N	J	FE	2N5045	50	.5-8	1.5-6	8	NF	5 DB	10
2N5046	N	J	FE	2N5046	50	.5-8	1.5-6	8	NF	5 DB	10
2N5047	N	J	FE	2N5047	50	.5-8	1.5-6	8			
2N5078	N	J	FE	2N4416	30	4-25	4-	6	NF	4 DB	
2N5103	N	J	FE		25	1-8	2-8	5	NF	1.5 DB	100
2N5104	N	J	FE		25	2-6	3.5-7.5	5	NF	1.5 DB	100
2N5105	N	J	FE	2N4416	25	5-15	5-10	5	NF	1.5 DB	100
2N5114	P	J	FE		30	30-90		25	CRSS	7 PF	
2N5115	P	J	FE		30	15-60		25	CRSS	7 PF	
2N5116	P	J	FE		30	5-25		25	CRSS	7 PF	
2N5158	N	J	FE		40	100-		50	CRSS	25 PF	
2N5159	N	J	FE		40	200-		50	CRSS	25 PF	
2N5163	N	J	RF	2N5246	25	1-40	2-9	20	CRSS	5 PF	1M

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TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} / $*I_{D(on)}$ MIN MAX (mA) (mA)	$\|y_{fs}\|$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
2N5196	N	J	FE		50	.7-7	1-4	6	NF	.5 DB	100
2N5197	N	J	FE	2N5545	50	.7-7	1-4	6	NF	.5 DB	100
2N5198	N	J	FE	2N5546	50	.7-7	1-4	6	NF	.5 DB	100
2N5199	N	J	FE	2N5547	50	.7-7	1-4	6	NF	.5 DB	100
2N5245	N	J	RF	2N5245	30	5-15	4.5-7.5	4.5	NF	2 DB	100M
2N5246	N	J	RF	2N5246	30	1.5-7	3-6	4.5	NF	2 DB	100M
2N5247	N	J	RF	2N5247	30	8-24	4.5-8	4.5	NF	2 DB	100M
2N5248	N	J	RF	2N5248	30	4-20	3.5-6.5	6	CRSS	2 PF	1M
2N5257	N	J	AF	2N5953	25	1-5	1-5	7	CRSS	3 PF	1M
2N5258	N	J	AF	2N5952	25	2-9	1.5-5.5	7	CRSS	3 PF	1M
2N5259	N	J	AF	2N5951	25	4-16	2-6	7	CRSS	3 PF	1M
2N5260	P	J	AF	2N5460	40	1-5	1-4	7	NF	2.5 DB	100
2N5265	P	J	FE		60	.5-1	.9-2.7	7	CRSS	2 PF	
2N5266	P	J	FE		60	.8-1.6	1-3	7	CRSS	2 PF	
2N5267	P	J	FE		60	1.5-3	1.5-3.5	7	CRSS	2 PF	
2N5268	P	J	FE		60	2.5-5	2-4	7	CRSS	2 PF	
2N5269	P	J	FE		60	4-8	2.2-4.5	7	CRSS	2 PF	
2N5270	P	J	FE		60	7-14	2.5-5	7	CRSS	2 PF	
2N5277	N	J	FE		150	1-40	2-5	25	NF	3 DB	1K
2N5278	N	J	FE		150	2.5-12.	3-6	25	NF	3 DB	1K
2N5358	N	J	FE	2N5358	40	.5-1	1-3	6	NF	2.5 DB	1M
2N5359	N	J	FE	2N5359	40	.8-1.6	1.2-3.6	6	NF	2.5 DB	1M
2N5360	N	J	FE	2N5360	40	1.5-3	1.4-4.2	6	NF	2.5 DB	1M
2N5361	N	J	FE	2N5361	40	2.5-5	1.5-4.5	6	NF	2.5 DB	1M
2N5362	N	J	FE	2N5362	40	4-8	2-5.5	6	NF	2.5 DB	1M
2N5363	N	J	FE	2N5363	40	7-14	2.5-6	6	NF	2.5 DB	1M
2N5364	N	J	FE	2N5364	40	9-18	2.7-6.5	6	CRSS	2 PF	
2N5391	N	J	FE	2N5359	70	.5-1.5	1.5-4.5	18	NF	1 DB	100
2N5392	N	J	FE	2N5361	70	1-3	2-6	18	NF	1 DB	100
2N5393	N	J	FE	2N5362	70	2.5-4.5	3-6.5	18	NF	1 DB	100
2N5394	N	J	FE	2N5362	70	4-6	4-7	18	NF	1 DB	100
2N5395	N	J	FE	2N5362	70	5.5-8	4.5-7	18	NF	1 DB	100
2N5396	N	J	FE	2N5363	70	7.5-10	4.5-7.5	18	NF	1 DB	100
2N5397	N	J	FE	2N5397	25	10-30	6-10	5	NF	3.5 DB	450M
2N5398	N	J	FE	2N5398	25	5-40	5.5-10	5.5	NF	3.5 DB	450M
2N5432	N	J	FE		25	150-		30	CRSS	15 PF	
2N5433	N	J	FE		25	100-		30	CRSS	15 PF	1M
2N5434	N	J	FE		25	30-		30	CRSS	15 PF	1M
2N5452	N	J	FE	2N5545	50	.5-5	1-3	4	NF	.5 DB	
2N5453	N	J	FE	2N5545	50	.5-5	1-3	4	NF	.5 DB	

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TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	I_{DSS} / *$I_{D(on)}$ MIN MAX (mA) (mA)	$\lvert y_{fs} \rvert$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
2N5454	N	J	FE	2N5546	50	.5-5	1-3	4	NF	.5 DB	
2N5457	N	J	FE	2N5953	25	1-5	1-5	7	CRSS	3 PF	1M
2N5458	N	J	FE	2N5952	25	2-9	1.5-5.5	7	CRSS	3 PF	1M
2N5459	N	J	FE	2N5951	25	4-16	2-6	7	CRSS	3 PF	1M
2N5460	P	J	FE	2N5460	40	1-5	1-4	7	NF	2.5 DB	100
2N5461	P	J	AF	2N5461	40	2-9	1.5-5	7	NF	2.5 DB	100
2N5462	P	J	AF	2N5462	40	4-16	2-6	7	NF	2.5 DB	100
2N5463	P	J	AF		60	1-5	1-4	7	NF	2.5 DB	100
2N5464	P	J	AF		60	2-9	1.5-5	7	NF	2.5 DB	100
2N5465	P	J	AF		60	4-16	2-6	7	NF	2.5 DB	100
2N5471	P	J	FE		40	.02-.06	.06-.18	5	NF	2.5 DB	1K
2N5472	P	J	FE		40	.05-.12	.09-.225	5	NF	2.5 DB	1K
2N5473	P	J	FE		40	.1-.25	.12-.3	5	NF	2.5 DB	1K
2N5474	P	J	FE		40	.2-.5	.16-.4	5	CRSS	1 PF	
2N5475	P	J	FE		40	.4-1	.2-.5	5	CRSS	1 PF	
2N5476	P	J	FE		40	.8-2	.26-.65	5	CRSS	1 PF	
2N5484	N	J	RF	2N5246	25	1-5	3-6	5	NF	2.5 DB	1K
2N5485	N	J	RF	2N5245	25	4-10	3.5-7	5	NF	2.5 DB	1K
2N5486	N	J	RF	2N5247	25	8-20	4-8	5	NF	2.5 DB	1K
2N5505	P	J	FE		30	*.8-7	1-3.5	16	NF	2 DB	1K
2N5506	P	J	FE		30	*.8-7	1-3.5	16	NF	2 DB	1K
2N5507	P	J	FE		30	*.8-7	1-3.5	16	NF	2 DB	1K
2N5508	P	J	FE		30	*.8-7	1-3.5	16	NF	2 DB	1K
2N5509	P	J	FE		30	*.8-7	1-3.5	16	NF	2 DB	1K
2N5514	P	J	FE		30	30-90		25	CRSS	7 PF	
2N5515	P	J	FE		40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5516	N	J	FE	2N5545	40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5517	N	J	FE	2N5546	40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5518	N	J	FE	2N5547	40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5519	N	J	FE	2N5045	40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5520	N	J	FE		40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5521	N	J	FE	2N5545	40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5522	N	J	FE	2N5546	40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5523	N	J	FE	2N5547	40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5524	N	J	FE	2N5045	40	.5-7.5	1-4	25	CRSS	5 PF	1M
2N5543	N	J	FE	2N6449	75	2-10	.75-3	10	CRSS	2 PF	1M
2N5544	N	J	FE	2N6450	50	2-10	.75-3	10	CRSS	2 PF	1M
2N5545	N	J	FE	2N5545	50	.5-8	1.5-6	6	NF	3.5 DB	10
2N5546	N	J	FE	2N5546	50	.5-8	1.5-6	6	NF	5 DB	10
2N5547	N	J	FE	2N5547	50	.5-8	1.5-6	6	CRSS	2 PF	10

TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE	ELECTRICAL CHARACTERISTICS: I_{DSS} / *$I_{D(on)}$ MIN MAX	$\lvert y_{fs}\rvert$ MIN MAX	C_{iss} MAX	OTHER PARAMETER: SYMBOL	MAX	@ f
					(V)	(mA) (mA)	(mmho) (mmho)	(pF)			(Hz)
2N5548	P	IG	SW		25	*40-120	3.5-6.5	10	CRSS	4 PF	1M
2N5549	N	J	FE	2N5549	40	10-60	6-15	8	CRSS	2 PF	1M
2N5555	N	J	SW	2N5949	25	15-		5	CRSS	1.2 PF	1M
2N5556	N	J	FE	2N3821	30	.5-2.5	1.5-6.5	6	CRSS	3 PF	
2N5557	N	J	FE	2N5361	30	2-5	1.5-6.5	6	CRSS	3 PF	
2N5558	N	J	FE	2N5362	30	4-10	1.5-6.5	6	CRSS	3 PF	
2N5561	N	J	FE		50	1-10	1.5-	7	NF	1 DB	10
2N5562	N	J	FE	2N5545	50	1-10	2-3	7	NF	1 DB	10
2N5563	N	J	FE	2N5547	50	1-10	2-3	7	NF	1 DB	10
2N5564	N	J	FE		40	5-30	7.5-12.5	12	NF	1 DB	10
2N5565	N	J	FE		40	5-30	7.5-12.5	12	NF	1 DB	10
2N5566	N	J	FE		40	5-30	7.5-12.5				
2N5592	N	J	FE		50	1-10	2-7	20	NF	2.6 DB	
2N5593	N	J	FE		50	1-10	2-7	20	NF	1 DB	
2N5594	N	J	FE		50	1-10	2-7	20	NF	10 DB	
2N5638	N	J	SW	TIS73	30	50-		10	CRSS	4 PF	1M
2N5639	N	J	SW	TIS74	30	25-		10	CRSS	4 PF	1M
2N5640	N	J	SW	TIS75	30	5-		10	CRSS	4 PF	1M
2N5647	N	J	FE		50	.3-.6	.3-.65	3	NF	1 DB	1K
2N5648	N	J	FE		50	.5-1	.4-.8	3	NF	1 DB	1K
2N5649	N	J	FE		50	.8-1.6	.45-.9	3	NF	1 DB	1K
2N5653	N	J	SW	TIS74	30	40-		10	CRSS	3.5 PF	1M
2N5654	N	J	SW	TIS75	30	15-		10	CRSS	3.5 PF	1M
2N5668	N	J	RF	2N5953	25	1-5	1.5-6.5	7	NF	2.5 DB	100M
2N5669	N	J	RF	2N5952	25	4-10	2-6.5	7	NF	2.5 DB	100M
2N5670	N	J	RF	2N5950	25	8-20	3-7.5	7	NF	2.5 DB	100M
2N5716	N	J	AF		40	.05-.2	.2-1	5	CRSS	1.5 PF	1M
2N5717	N	J	AF		40	.2-1	.4-1.6	5	CRSS	1.5 PF	1M
2N5718	N	J	AF	2N5953	40	.8-4	.5-2	5	CRSS	1.5 PF	1M
2N5797	P	J	FE		40	.02-.10	.06-.22	5	CRSS	1 PF	
2N5798	P	J	FE		40	.08-.40	.1-.4	5	CRSS	1 PF	
2N5799	P	J	FE		40	.25-1	.16-.5	5	CRSS	1 PF	
2N5800	P	J	FE		40	.70-2	.25-.7	5	CRSS	1 PF	
2N5801	N	J	FE	2N4858	40	2-15	4.5-12	15	NF	1 DB	
2N5802	N	J	FE	2N5549	40	10-40	6.5-14	15	NF	1 DB	
2N5803	N	J	FE	2N5549	40	30-80	8-17	15	NF	1 DB	
2N5902	N	J	FE		40	.03-.5	.07-.25	3	NF	3 DB	100
2N5903	N	J	FE		40	.03-.5	.07-.25	3	NF	3 DB	100
2N5904	N	J	FE		40	.03-.5	.07-.25	3	NF	3 DB	100
2N5905	N	J	FE		40	.03-.5	.07-.25	3	NF	3 DB	100

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TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} / $*I_{D(on)}$ MIN MAX (mA) (mA)	$\|y_{fs}\|$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
2N5906	N	J	FE		40	.03-.5	.07-.25	3	NF	1 DB	100
2N5907	N	J	FE		40	.03-.5	.07-.25	3	NF	1 DB	100
2N5908	N	J	FE		40	.03-.5	.07-.25	3	NF	1 DB	100
2N5909	N	J	FE		40	.03-.5	.07-.25	3	NF	1 DB	100
2N5911	N	J	FE		25	7-40	5-10	5	NF	1 DB	10K
2N5912	N	J	FE		25	7-40	5-10	5	NF	1 DB	10K
2N5949	N	J	GP	2N5949	30	12-18	3.5-7.5	6	NF	2 DB	1K
2N5950	N	J	GP	2N5950	30	10-15	3.5-7.5	6	NF	2 DB	1K
2N5951	N	J	GP	2N5951	30	7-13	3.5-6.5	6	NF	2 DB	1K
2N5952	N	J	GP	2N5952	30	4-8	2-6.5	6	NF	2 DB	1K
2N5953	N	J	GP	2N5953	30	2.5-5	2-6.5	6	NF	2 DB	1K
2N6449	N	J	FE	2N6449	300	2-10	.5-3	10	CRSS	5 PF	
2N6450	N	J	FE	2N6450	200	2-10	.5-3	10	CRSS	5 PF	
2N6451	N	J	FE	2N6451	20	5-20	15-30	25	VN	5 NV	
2N6452	N	J	FE	2N6452	20	5-20	15-30	25	VN	10 NV	
2N6453	N	J	FE	2N6453	20	15-50	15-30	25	VN	5 NV	
2N6454	N	J	FE	2N6454	25	15-50	20-40	25	VN	10 NV	
3N89	P	J	FE		30	.5-2.5	.45-1.3				
3N96	P	J	FE		30	.5-2.5	.45-1.3	4	NF	4 DB	1K
3N97	P	J	FE		30	.5-2.5	.45-1.3	4	NF	4 DB	1K
3N98	N	IG	FE		32	3.5-7.7	1-3	7	CRSS	.5 PF	
3N99	N	IG	FE	3N128	32	5-10.	1-4	7	CRSS	.5 PF	
3N124	N	J	FE		50	.2-2	.25-1	14	NF	4 DB	1K
3N125	N	J	FE		50	1.5-4.5	.4-1.6	14	NF	4 DB	1K
3N126	N	J	FE		50	3-9	.6-2.7	14	NF	4 DB	1K
3N128	N	IG	FE	3N128	20	5-25	5-12	7	NF	5 DB	200M
3N138	N	IG	FE		45			5	CRSS	.25 PF	1M
3N139	N	IG	FE	3N203	45	5-25	3-7.5	7			
3N140	N	IG	FE	3N201	20	5-30			NF	4.5 DB	200M
3N141	N	IG	FE	3N201	20	5-30	6-1.8				
3N142	N	IG	FE	3N201	20	5-25	5-		NF	5 DB	100M
3N143	N	IG	FE	3N128	20	5-30	5-12				
3N145	P	IG	FE	3N174	30	*3-					
3N146	P	IG	FE	3N174	30	*3-					
3N147	P	IG	FE	3N208	30	*8-					
3N148	P	IG	FE	3N208	30	*8-					
3N149	P	IG	FE	3N161	30	*16-					
3N150	P	IG	FE	3N161	30	*16-					
3N151	P	IG	FE		30	*3-	.5-3	12	NF	10 DB	100
3N152	N	IG	FE	3N128	20	5-30	5-12		NF	3.5 DB	200M

TRANSISTOR INTERCHANGEABILITY
REGISTERED FIELD-EFFECT TRANSISTORS

TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} / $*I_{D(on)}$ MIN–MAX (mA)	$\lvert y_{fs} \rvert$ MIN–MAX (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER: SYMBOL	MAX	@ f (Hz)
3N153	N	IG	FE	3N153	20	*5-		8	CRSS	.6 PF	1M
3N154	N	IG	FE	3N128	20	10-25	5-12		NF	5 DB	200M
3N155	P	IG	FE	3N155	50	*5-		5	CRSS	1.3 PF	140K
3N155A	P	IG	FE	3N155A	50	*5-		5	CRSS	1.3 PF	140K
3N156	P	IG	FE	3N156	50	*5-		5	CRSS	1.3 PF	140K
3N156A	P	IG	FE	3N156A	50	*5-		5	CRSS	1.3 PF	140K
3N157	P	IG	FE	3N157	50	*5-	1-4	5	CRSS	1.3 PF	140K
3N157A	P	IG	FE	3N157A	50	*5-	1-4	5	CRSS	1.3 PF	140K
3N158	P	IG	FE	3N158	50	*5-	1-4	5	CRSS	1.3 PF	140K
3N158A	P	IG	FE	3N158A	50	*5-	1-4	5	CRSS	1.3 PF	140K
3N159	N	IG	FE		20	5-30	7-18	7	NF	3.5 DB	200M
3N160	P	IG	FE	3N160	25	*40-120	3.5-6.5	10	CRSS	4 PF	1M
3N161	P	IG	FE	3N161	25	*40-120	3.5-6.5	10	CRSS	4 PF	1M
3N162	P	IG	FE	3N162	25	*25-		20	CRSS	10 PF	1M
3N163	P	IG	FE	3N163	40	*5-30	2-4	2.5	CRSS	.7 PF	1M
3N164	P	IG	FE	3N164	30	*3-30	1-4	2.5	CRSS	.7 PF	1M
3N165	P	IG	FE		40	*5-30	1.5-3	3	CRSS	.7 PF	1M
3N166	P	IG	FE		40	*5-30	1.5-3	3	CRSS	.7 PF	1M
3N167	P	IG	FE		30	200-		35	CRSS	.3 PF	1M
3N168	P	IG	FE	3N160	25	100-		35	CRSS	.3 PF	1M
3N169	N	IG	FE	3N169	35	*10-		5	CRSS	1.3 PF	1M
3N170	N	IG	FE	3N170	35	*10-		5	CRSS	1.3 PF	1M
3N171	N	IG	FE	3N171	35	*10-		5	CRSS	1.3 PF	1M
3N172	P	IG	FE	3N161	40	*5-30	1.5-4	3.5	CRSS	1 PF	1M
3N173	P	IG	FE	3N161	40	*5-30	1-4	3.5	CRSS	1 PF	1M
3N174	P	IG	FE	3N174	30	*3-12	.4-	4	CRSS	.7 PF	1M
3N175	N	IG	FE	3N170	30	*20-		5	CRSS	.5 PF	1M
3N176	N	IG	FE	3N170	25	*15-		5	CRSS	.5 PF	1M
3N177	N	IG	FE	3N171	20	*10-		7	CRSS	.75 PF	1M
3N178	P	IG	FE		75	*3-		3.5	CRSS	.25 PF	1M
3N179	P	IG	FE		60	*3-		4.5	CRSS	.35 PF	1M
3N180	P	IG	FE	3N174	40	*3-		5	CRSS	.5 PF	1M
3N181	P	IG	FE		30	*40-		25	CRSS	8 PF	1M
3N182	P	IG	FE		30	*40-		25	CRSS	10 PF	1M
3N183	P	IG	FE		25	*25-		30	CRSS	12 PF	1M
3N184	P	IG	FE		35	*20-		9	CRSS	3.5 PF	1M
3N185	P	IG	FE		30	*15-		10	CRSS	4.5 PF	1M
3N186	P	IG	FE		25	*10-		11	CRSS	5.5 PF	1M
3N188	P	IG	FE		40	*5-30	1.5-4	4.5	CRSS	1.5 PF	1M
3N189	P	IG	FE		40	*5-30	1.5-4	4.5	CRSS	1.5 PF	1M

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE NUMBER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE	ELECTRICAL CHARACTERISTICS					
						I_{DSS} / $^{\bullet}I_{D(on)}$	$\|y_{fs}\|$	C_{iss}	OTHER PARAMETER		
						MIN MAX	MIN MAX	MAX	SYMBOL	MAX	@ f
					(V)	(mA) (mA)	(mmho) (mmho)	(pF)			(Hz)
3N190	P	IG	FE		40	•5-30	1.5-4	4.5	CRSS	1 PF	1M
3N191	P	IG	FE		40	•5-30	1.5-4	4.5	CRSS	1 PF	1M
3N192	N	IG	FE		20	3-30	8-24	6	CRSS	.6 PF	44M
3N193	N	IG	FE		20	1-20	6-22	7	CRSS	.6 PF	44M
3N200	N	IG	FE		20	.5-12	10-20		CRSS	.03 PF	1M
3N201	N	IG	FE	3N201	30	6-30	8-20		CRSS	.03 PF	1M
3N202	N	IG	FE	3N202	30	6-30	8-20		CRSS	.03 PF	1M
3N203	N	IG	FE	3N203	30	3-15	7-15		CRSS	.03 PF	1M
3N204	N	IG	FE	3N204	30	6-30	10-22		NF	3.5 DB	
3N205	N	IG	FE	3N205	30	6-30	10-22		CRSS	.03 PF	1M
3N206	N	IG	FE	3N206	30	3-15	7-17		NF	4 DB	45M
3N207	P	IG	FE	3N207	25	1.5-		4	CRSS	2.5 PF	1M
3N208	P	IG	FE	3N208	25	1.5-		4	CRSS	2.5 PF	1M
3N211	N	IG	FE	3N211	35	6-40	17-40		NF	3.5 DB	200M
3N212	N	IG	FE	3N212	35	6-40	17-40		CRSS	.05 PF	1M
3N213	N	IG	FE	3N213	40	6-40	15-35		CRSS	.05 PF	1M
3N214	N	IG	FE	3N214	20	•50-		6	CRSS	2 PF	1M
3N215	N	IG	FE	3N215	20	•50-		6	CRSS	2 PF	1M
3N216	N	IG	FE	3N216	20	•50-		6	CRSS	2 PF	1M
3N217	N	IG	FE	3N217	20	•50-		6	CRSS	2 PF	1M

TRANSISTOR INTERCHANGEABILITY
NONREGISTERED FIELD-EFFECT TRANSISTORS

TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	I_{DSS} *$I_{D(on)}$ MIN (mA)	I_{DSS} *$I_{D(on)}$ MAX (mA)	$\|Y_{fs}\|$ MIN (mmho)	$\|Y_{fs}\|$ MAX (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
40467A	RC	N	IG	FE		20	10-50		4-7.5			CRSS	.2 PF	1M
40468	RC	N	IG	FE		20	5-50				10	CRSS	.2 PF	1M
40468A	RC	N	IG	FE		20	5-25				10	CRSS	.2 PF	1M
40559	RC	N	IG	FE		20	5-50					CRSS	.2 PF	1M
40559A	RC	N	IG	FE		20	5-25					CRSS	.3 PF	1M
40600	RC	N	IG	FE	3N211	20						CRSS	.03 PF	1M
40601	RC	N	IG	FE	3N211	20						CRSS	.03 PF	1M
40602	RC	N	IG	FE	3N211	20						CRSS	.03 PF	1M
40603	RC	N	IG	FE	3N211	20						CRSS	.03 PF	1M
40604	RC	N	IG	FE	3N211	20						CRSS	.03 PF	1M
40673	RC	N	IG	FE	3N211	20	5-35				6	CRSS	.03 PF	1M
4360TP	TI	P	J	FE	A5T5462	20	3-30		2-8		20	NF	5 DB	100
5033TP	TI	P	J	GP	A5T5460	20	.3-3.5		1-		25	NF	2 DB	1K
A5T3821	TI	N	J	GP	A5T3821	50	.5-2.5		1.5-4.5		6	NF	5 DB	10
A5T3822	TI	N	J	GP	A5T3822	50	2-10		3-6.5		6	NF	5 DB	10
A5T3823	TI	N	J	GP	A5T3823	30	4-20		3.5-6.5		6	NF	2.5 DB	100M
A5T3824	TI	N	J	GP	A5T384	50	12-24		-		6	CRSS	3 PF	1M
A5T5460	TI	P	J	GP	A5T5460	40	1-5		1-4		7	NF	2.5 DB	100
A5T5461	TI	P	J	GP	A5T5461	40	2-9		1.5-5		7	NF	2.5 DB	100
A5T5462	TI	P	J	GP	A5T5462	40	4-16		2-6		7	NF	2.5 DB	100
A5T6449	TI	N	J	HV	A5T6449	300	2-10		.5- 3		10	CRSS	5 PF	1M
A5T5450	TI	N	J	HV	A5T6450	200	2-10		.5- 3		10	CRSS	5 PF	1M
C413N	CR	N	J		2N6451	15	10-		25-40		80	CRSS	30 PF	1M
C680	CR	N	J			15	.08-.4		.2-.5					
C681	CR	N	J			15	.08-.4		.2-.5					
C682	CR	N	J		2N3460	15	.4-1.6		.4-1					
C683	CR	N	J		2N3460	15	.4-1.6		.4-1					
C684	CR	N	J		2N3459	15	1.5-6		.6-1.5					
C685	CR	N	J		2N3459	15	1.5-6		.6-1.5					
C6690	CR	N	J		2N3458	45						CRSS	5 PF	1M
C6691	CR	N	J		2N3458	25						CRSS	5 PF	1M
C6692	CR	N	J		2N3459	25						CRSS	5 PF	1M
CM600	CR	N	J		2N4857	10						CRSS	6.5 PF	1M
CM601	CR	N	J		2N4856	15						CRSS	6.5 PF	1M
CM602	CR	N	J		2N4856	30						CRSS	6.5 PF	1M
CM603	CR	N	J		2N4856	15						CRSS	6.5 PF	1M
CM640	CR	N	J			20	.5-					CRSS	5 PF	1M
CM641	CR	N	J		2N4858	20	3-					CRSS	5 PF	1M
CM642	CR	N	J		2N4858	20	10-					CRSS	5 PF	1M
CM643	CR	N	J		2N4857	20	15-					CRSS	5 PF	1M

TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} *$I_{D(on)}$ MIN MAX (mA) (mA)	$\|y_{fs}\|$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
CM644	CR	N	J		2N4858	30	10-			CRSS	5 PF	1M
CM645	CR	N	J		2N4857	30	15-			CRSS	5 PF	1M
CM646	CR	N	J		2N4856	30	30-			CRSS	5 PF	1M
CM647	CR	N	J		2N4856	30	50-			CRSS	5 PF	1M
CM697	CR	N	J			25	30-			CRSS	20 PF	1M
CMX740	CR	N	J			30	500-			CRSS	60 PF	1M
DU4339	IN	N	J			50	.5-1.5	.8-2.4	7	CRSS	3 PF	1M
DU4340	IN	N	J		2N5047	50	1.2-3.6	1.3-3	7	CRSS	3 PF	1M
E100	IN	N	J		2N5950	30	.2-20	.5-	8	CRSS	3 PF	1M
E101	IN	N	J		A5T3821	30	.2-1	.5-	8	CRSS	3 PF	1M
E102	IN	N	J		2N5953	30	.9-4.5	1-	8	CRSS	3 PF	1M
E103	IN	N	J		2N5950	30	4-20	1.5-	8	CRSS	3 PF	1M
E108	IN	N	J			20	80-		85	CRSS	15 PF	1M
E109	IN	N	J			20	40-		85	CRSS	15 PF	1M
E110	IN	N	J			20	10-		85	CRSS	15 PF	1M
E111	IN	N	J		TIS73	25	20-		28	CRSS	5 PF	1M
E112	IN	N	J		TIS74	25	5-		28	CRSS	5 PF	1M
E113	IN	N	J		TIS75	25	2-		28	CRSS	5 PF	1M
E300	IN	N	J		2N5245	25	6-30	4.5-	5.5	CRSS	1.7 PF	1M
FE0654A	F	N	J		2N5950	25	10-40	4.5-9	20	CRSS	5 PF	1M
FE0654B	F	N	J		2N5951	25	3-12	3.5-8	20	CRSS	5 PF	1M
FE3819	F	N	J		2N5953	25	2-20	2-6.5	8	CRSS	4 PF	1M
FE5245	F	N	J		2N5245	30	5-15	4-	4.5	CRSS	1.2 PF	1M
FE5246	F	N	J		2N5246	30	1.5-7	2.5-	4.5	CRSS	1.2 PF	1M
FE5247	F	N	J		2N5247	30	8-24	4-	4.5	CRSS	1.2 PF	1M
FE5457	F	N	J		2N5953	25	1-5	1-5	7	CRSS	3 PF	1M
FE5458	F	N	J		2N5952	25	2-9	1.5-5.5	7	CRSS	3 PF	1M
FE5459	F	N	J		2N5950	25	4-16	2-6	7	CRSS	3 PF	1M
FE5484	F	N	J		2N5953	25	1-5	2.5-	5	CRSS	1.2 PF	1M
FE5485	F	N	J		2N5952	25	1-5	2.5-	5	CRSS	1.2 PF	1M
FE5486	F	N	J		2N5949	25	4-10	3-	5	CRSS	1.2 PF	1M
FT0654A	F	N	J			50	10-40	4.5-9	20	CRSS	5 PF	1M
FT0654B	F	N	J			50	10-40	4.5-9	20	CRSS	5 PF	1M
FT0654C	F	N	J			50	3-12	3.5-8	20	CRSS	5 PF	1M
FT0654D	F	N	J			50	3-12	3.5-8	20	CRSS	5 PF	1M
FT701	F	P	IG		3N207	30		1.2-				
FT703	F	P	IG		3N160	30		2.5-	15	CRSS	3 PF	1M
FT704	F	P	IG		3N163	30		.3-	4.5	CRSS	.7 PF	1M
FT3820	F	P	J		A5T5460	20	.3-15	.8-5	32	CRSS	16 PF	1M
IMF3954	IN	N	J		2N5545	40	.5-5	1-				

TRANSISTOR INTERCHANGEABILITY
NONREGISTERED FIELD-EFFECT TRANSISTORS

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IMF3954A	IN	N	J		2N5545	40	.5-5	1-				
IMF3955	IN	N	J		2N5547	40	.5-5	1-				
IMF3955A	IN	N	J		2N5546	40	.5-5	1-				
IMF3956	IN	N	J		2N5547	40	.5-5	1-				
IMF3957	IN	N	J		2N5547	40	.5-5	1-				
IMF3958	IN	N	J		2N5045	40	.5-5	1-				
IT108	IN	N	J		2N5245	25	5-25	4-	5	CRSS	1.2 PF	1M
IT109	IN	N	J			20	15-40	7.5-	6	CRSS	1.8 PF	1M
IT1700	IN	P	IG		3N163	40		2-4	5	CRSS	1.2 PF	1M
IT1701	IN	P	IG		3N163	40		2-4	5	CRSS	1.2 PF	1M
IT1702	IN	P	IG		3N163	30		1-	5	CRSS	1.2 PF	1M
IT1750	IN	N	IG			25	*10-		6	CRSS	1.6 PF	1M
IT2700	IN	P	IG			40		2-4				
IT2701	IN	P	IG			40		2-4				
ITE3066	IN	N	J		2N5953	45	.8-4	.3-	10	CRSS	1.5 PF	1M
ITE3067	IN	N	J		2N3460	45	.2-1	.25-	10	CRSS	1.5 PF	1M
ITE3068	IN	N	J			45	.05-.25	.15-	10	CRSS	1.5 PF	1M
ITE4117	IN	N	J			40	.02-.09	.06-	3	CRSS	1.5 PF	1M
ITE4118	IN	N	J			40	.08-.24	.07-	3	CRSS	1.5 PF	1M
ITE4119	IN	N	J			40	.2-1	.09-	3	CRSS	1.5 PF	1M
ITE4338	IN	N	J		2N3460	40	.2-.6	.5-	7	CRSS	3 PF	1M
ITE4339	IN	N	J		2N3460	40	.5-1.5	.7-	7	CRSS	3 PF	1M
ITE4340	IN	N	J		2N5953	40	1.2-3.6	1-	7	CRSS	3 PF	1M
ITE4341	IN	N	J		2N5953	40	3-9	1.5-	7	CRSS	3 PF	1M
ITE4391	IN	N	J		TIS73	30	50-150		16	CRSS	5 PF	1M
ITE4392	IN	N	J		TIS74	30	25-75		16	CRSS	5 PF	1M
ITE4393	IN	N	J		TIS75	30	5-30		16	CRSS	5 PF	1M
ITE4416	IN	N	J		2N5245	25	4-20	3-	5	CRSS	1.2 PF	1M
ITE4867	IN	N	J		2N3460	35	.4-1.2	.7-	25	CRSS	5 PF	1M
ITE4868	IN	N	J		2N3459	35	1-3	1-	25	CRSS	5 PF	1M
ITE4869	IN	N	J		2N5953	35	2.5-7.5	1.3-	25	CRSS	5 PF	1M
KE3684	IN	N	J		2N5953	50	2.5-7.5	2-3	5	CRSS	1.5 PF	1M
KE3685	IN	N	J		A5T3821	50	1-3	1.5-2.5	5	CRSS	1.5 PF	1M
KE3686	IN	N	J			50	.4-1.2	1-2	5	CRSS	1.5 PF	1M
KE3687	IN	N	J			50	.1-.5	.5-1.5	5	CRSS	1.5 PF	1M
KE3823	IN	N	J		A5T3823	30	4-20	3.2-	6	CRSS	2 PF	1M
KE3970	IN	N	J		TIS73	40	50-150		25	CRSS	6 PF	1M
KE3971	IN	N	J		TIS74	40	25-75		25	CRSS	6 PF	1M
KE3972	IN	N	J		TIS75	40	5-30		25	CRSS	6 PF	1M
KE4091	IN	N	J		TIS73	40	30-		16	CRSS	5 PF	1M

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TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	I_{DSS} *$I_{D(on)}$ MIN (mA)	I_{DSS} *$I_{D(on)}$ MAX (mA)	$\|y_{fs}\|$ MIN (mmho)	$\|y_{fs}\|$ MAX (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	OTHER PARAMETER MAX	@ f (Hz)
KE4092	IN	N	J		TIS74	40	15-				16	CRSS	5 PF	1M
KE4093	IN	N	J		TIS75	40	8-				16	CRSS	5 PF	1M
KE4220	IN	N	J		A5T3821	30	.5-3		1-4		6	CRSS	2 PF	1M
KE4221	IN	N	J		A5T3822	30	2-6		2-5		6	CRSS	2 PF	1M
KE4222	IN	N	J		A5T3822	30	5-15		2.5-6		6	CRSS	2 PF	1M
KE4223	IN	N	J		2N5950	30	3-18		2.7-		6	CRSS	2 PF	1M
KE4224	IN	N	J		2N5949	30	2-20		1.7-		6	CRSS	2 PF	1M
KE4391	IN	N	J		TIS73	40	50-150				14	CRSS	3.5 PF	1M
KE4392	IN	N	J		TIS74	40	25-75				14	CRSS	3.5 PF	1M
KE4393	IN	N	J		TIS75	40	5-30				14	CRSS	3.5 PF	1M
KE4416	IN	N	J		2N5245	30	5-15		4-		4	CRSS	1.2 PF	1M
KE4856	IN	N	J		TIS73	40	50-				18	CRSS	8 PF	1M
KE4857	IN	N	J		TIS74	40	20-100				18	CRSS	8 PF	1M
KE4858	IN	N	J		TIS75	40	8-80				18	CRSS	8 PF	1M
KE4859	IN	N	J		TIS73	30	50-				18	CRSS	8 PF	1M
KE4860	IN	N	J		TIS74	30	20-100				18	CRSS	8 PF	1M
KE4861	IN	N	J		TIS75	30	8-80				18	CRSS	8 PF	1M
KE5103	IN	N	J		2N5952	25	1-8		2-8		5	CRSS	1.2 PF	1M
KE5104	IN	N	J		2N5953	25	2-6		3.5-7.5		5	CRSS	1.2 PF	1M
KE5105	IN	N	J		2N5245	25	5-15		5-10		5	CRSS	1.2 PF	1M
M100	SI	N	IG			20	1.5-4.5		1-2.2		7.5			
M101	SI	N	IG			20	4-12		1.5-3.3		7.5			
M103	SI	P	IG		3N161	30						CRSS	4 PF	1M
M104	SI	P	IG		3N161	30						CRSS	.5 PF	1M
M106	SI	P	IG		3N208	30	*10-		2-			CRSS	4 PF	1M
M107	SI	P	IG		3N208	30	*10-		2-			CRSS	4 PF	1M
M108	SI	P	IG		3N207	30	*10-		2-			CRSS	4 PF	1M
M113	SI	P	IG		3N156	30						CRSS	4 PF	1M
M114	SI	P	IG		3N160	40	* 8-200		2-4			CRSS	4 PF	1M
M116	SI	N	IG		3N161	30					2.5	CRSS	10 PF	1M
M117	SI	N	IG		3N160	50					2.5	CRSS	8 PF	1M
M119	SI	P	IG		3N161	80						CRSS	8 PF	1M
M511	SI	P	IG		3N161	30	-.01		1-			CRSS	4 PF	1M
M511A	SI	P	IG		3N161	30	-.01		1-			CRSS	2.5 PF	1M
M517	SI	P	IG		3N161	30						CRSS	7 PF	1M
MEM511	GI	P	IG		3N174	30	*3-		1-			CRSS	2.5 PF	1M
MEM511C	GI	P	IG		3N174	25	*3-		1-			CRSS	4 PF	1M
MEM517	GI	P	IG			25	*25-		1.2-			CRSS	10 PF	1M
MEM517A	GI	P	IG			25	*25-		1.2-			CRSS	10 PF	1M
MEM517C	GI	P	IG			25	*20-		1.2-			CRSS	15 PF	1M

TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE	ELECTRICAL CHARACTERISTICS I_{DSS} *$I_{D(on)}$ MIN	MAX	$\lvert y_{fs} \rvert$ MIN	MAX	C_{iss} MAX	OTHER PARAMETER SYMBOL	MAX	@ f
						(V)	(mA)	(mA)	(mmho)	(mmho)	(pF)			(Hz)
MEM520	GI	P	IG		3N174	40	*3-		1-			CRSS	2.5 PF	1M
MEM520C	GI	P	IG		3N174	25	*3-		1-			CRSS	4 PF	1M
MEM550	GI	P	IG		3N208	30	*1.5-		.5-			CRSS	1.1 PF	1M
MEM550C	GI	P	IG		3N207	25	*1.5-					CRSS	4 PF	1M
MEM551	GI	P	IG		3N208	30	*1.5-		.5-			CRSS	1.1 PF	1M
MEM551C	GI	P	IG		3N207	25	*1.5-		.5-			CRSS	4 PF	1M
MEM554	GI	N	IG		3N201	20	3-30		10-13					
MEM554C	GI	N	IG		3N201	20	3-30		8-11					
MEM556	GI	P	IG		3N174	50	*3-		.8-			CRSS	.5 PF	1M
MEM556C	GI	P	IG		3N174	45	*3-		.7-			CRSS	.7 PF	1M
MEM557	GI	N	IG			20	3-		8-		5			
MEM557C	GI	N	IG			20	3-		6-		5			
MEM560	GI	P	IG		3N161	35	*15-		2-		9	CRSS	3.5 PF	1M
MEM560C	GI	P	IG		3N161	30	*10-		2-		11	CRSS	4.5 PF	1M
MEM562	GI	N	IG			30	*5-		1-		4	CRSS	.5 PF	1M
MEM562C	GI	N	IG			30	*5-		1-		5	CRSS	.6 PF	1M
MEM563	GI	N	IG			30	*15-		2-		5	CRSS	.6 PF	1M
MEM564C	GI	N	IG			20	3-		8-		8	CRSS		1M
MEM571C	GI	N	IG			30	3-		8-		6	CRSS	.5 PF	1M
MEM575	GI	P	IG			25	*50-		10-		50	CRSS	20 PF	1M
MEM614	GI	N	IG		3N203	20	1-20		6-10		8			
MEM655	GI	N	IG			20	1-20		6-		7			
MEM660	GI	N	IG		3N214	20	-10				7		1 PF	1M
MFE2000	M	N	J		2N4416	25	4-10		2.5-6		5	CRSS	1 PF	1M
MFE2001	M	N	J		2N5247	25	8-20		4-8		5	CRSS	1 PF	1M
MFE2004	M	N	J		2N4860	30	8-				16	CRSS	5 PF	1M
MFE2005	M	N	J		2N4859	30	15-				16	CRSS	5 PF	1M
MFE2006	M	N	J		2N4859	30	30-				16	CRSS	5 PF	1M
MFE2007	M	N	J		2N4860	25	8-				30	CRSS	15 PF	1M
MFE2008	M	N	J		2N4859	25	20-				30	CRSS	15 PF	1M
MFE2009	M	N	J		2N4859	25	50-				30	CRSS	15 PF	1M
MFE2010	M	N	J		2N4859	25	15-				50	CRSS	20 PF	1M
MFE2011	M	N	J			25	40-				50	CRSS	20 PF	1M
MFE2012	M	N	J			25	100-				50	CRSS	20 PF	1M
MFE2093	M	N	J		2N5358	50	.1-.7		.25-.5		6	CRSS	2 PF	1M
MFE2094	M	N	J		2N5359	50	.4-1.4		.35-.7		6	CRSS	2 PF	1M
MFE2095	M	N	J		2N5360	50	1-3		.4-.8		6	CRSS	2 PF	1M
MFE2133	M	N	J		2N4860	30	25-		12-		20	CRSS	5 PF	1M
MFE3001	M	N	IG		3N128	30	.5-6		.7-3.5		5	CRSS	1.5 PF	1M
MFE3002	M	N	IG		3N169	20					5	CRSS	1 PF	1M

TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS I_{DSS} *$I_{D(on)}$ MIN MAX (mA) (mA)	$\|y_{fs}\|$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
MFE3003	M	P	IG		3N156	20			5	CRSS	1 PF	1M
MFE3004	M	N	IG			20	2-10	2-	4.5	CRSS	.2 PF	1M
MFE3005	M	N	IG			20	2-10	2-	4.5	CRSS	.2 PF	1M
MFE3006	M	N	IG		3N203	35	2-18	8-18	6			
MFE3007	M	N	IG		3N201	35	5-20	10-18	5.5			
MFE3008	M	N	IG		3N203	35	2-20	8-18	6			
MFE3020	M	P	IG		3N207	25	*10-75	.5-	7	CRSS	1.5 PF	1M
MFE3021	M	P	IG			25	*10-75	.5-	7	CRSS	1.5 PF	1M
MFE4007	M	P	J			40	.5-1	.9-2.7	7	CRSS	2 PF	1M
MFE4008	M	P	J			40	.8-1.6	1-3	7	CRSS	2 PF	1M
MFE4009	M	P	J			40	1.5-3	1.5-3.5	7	CRSS	2 PF	1M
MFE4010	M	P	J			40	2.5-5	2-4	7	CRSS	2 PF	1M
MFE4011	M	P	J			40	4-8	2.2-4.5	7	CRSS	2 PF	1M
MPF102	M	N	J		2N3819	25	2-20	2-7.5	7	CRSS	3 PF	1M
MPF108	M	N	J		2N3819	25	1.5-24	2-7.5	6.5	CRSS	2.5 PF	1M
MFE4012	M	P	J			40	7-14	2.5-5	7	CRSS	2 PF	1M
MMT3823	M	N	J		2N3823	30	5-20	3-8	7	CRSS	3 PF	1M
MPF102	M	N	J	RF	2N3819	25	2-20	2-7.5	7	CRSS	3 PF	1M
MPF103	M	N	J		2N5953	25	1-5	1-5	7	CRSS	3 PF	1M
MPF104	M	N	J		2N5952	25	2-9	1.5-5.5	7	CRSS	3 PF	1M
MPF105	M	N	J		2N5951	25	4-16	2-6	7	CRSS	3 PF	1M
MPF106	M	N	J		2N5952	25	4-10	2.5-	5	CRSS	1.2 PF	1M
MPF107	M	N	J		2N5950	25	8-20	4-	5	CRSS	1.2 PF	1M
MPF108	M	N	J	RF	2N3819	25	1.5-24	2-7.5	6.5	NF	2.5 DB	1K
MPF109	M	N	J	GP	2N3819	25	.5-24	.8-6	7	NF	2.5 DB	1K
MPF111	M	N	J	GP	2N3819	20	.5-20	.5-3	4.5	CRSS	1.5 PF	1M
MPF112	M	N	J	RF	2N3819	25	1-25	1-7.5				
MPF120	M	N	IG			25	2-18	8-18	4.5	CRSS	7 PF	1M
MPF121	M	N	IG			25	5-30	10-20	4.5	CRSS	6 PF	1M
MPF122	M	N	IG			25	2-20	8-18	4.5	CRSS	7 PF	1M
MPF161	M	P	J	GP	2N5462	40	.5-14	.8-6	7	NF	2.5 DB	1K
NF500	NA	N	J		2N3823	25	1-30	2-	5	CRSS	1.2 PF	1M
NF501	NA	N	J		2N3823	15	1-30	2-	5	CRSS	1.2 PF	1M
NF506	NA	N	J		2N4416	25	4-15	2.5-	4	CRSS	1 PF	1M
NF510	NA	N	J		2N4861	30	5-		20			
NF511	NA	N	J		2N4861	20	5-		20			
NF520	NA	N	J		2N3822	30	1-10	.5-				
NF521	NA	N	J		2N3821	30	.1-2	.4-				
NF522	NA	N	J		2N3822	20	1-10	.5-				
NF523	NA	N	J		2N3821	20	.1-2	.4-				

TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE	ELECTRICAL CHARACTERISTICS							
							I_{DSS} *$I_{D(on)}$		$\|y_{fs}\|$		C_{iss}	OTHER PARAMETER		
							MIN	MAX	MIN	MAX	MAX	SYMBOL	MAX	@ f
						(V)	(mA)	(mA)	(mmho)	(mmho)	(pF)			(Hz)
NF530	NA	N	J		2N3459	30	1-10		.5-					
NF531	NA	N	J		2N3460	30	.1-2		.4-					
NF532	NA	N	J		2N3459	20	1-10		.5-					
NF533	NA	N	J		2N3460	20	.1-2		.4-					
NF580	NA	N	J			25					25	CRSS	13 PF	1M
NF581	NA	N	J			25					25	CRSS	13 PF	1M
NF582	NA	N	J			25					25	CRSS	13 PF	1M
NF583	NA	N	J			25					25	CRSS	13 PF	1M
NF584	NA	N	J			15					25	CRSS	13 PF	1M
NF585	NA	N	J			15					25	CRSS	13 PF	1M
NF4445	NA	N	J			25	150-				50	CRSS	25 PF	1M
NF4446	NA	N	J			25	100-				50	CRSS	25 PF	1M
NF4447	NA	N	J			20	150-				50	CRSS	25 PF	1M
NF4448	NA	N	J			20	100-				50	CRSS	25 PF	1M
NF5457	NA	N	J		2N3459	25	1-5		1-5		7	CRSS	3 PF	1M
NF5458	NA	N	J		2N3459	25	2-9		1.5-5.5		7	CRSS	3 PF	1M
NF5459	NA	N	J		2N3458	25	4-16		2-6		7	CRSS	3 PF	1M
NF5485	NA	N	J		2N4416	25	4-10		3-		5	CRSS	1 PF	1M
NF5486	NA	N	J		2N4416	25	8-20		3.5-		5	CRSS	1 PF	1M
NF5555	NA	N	J			25	15-				5	CRSS	1.2 PF	1M
NF5638	NA	N	J		2N4391	30	50-				10	CRSS	4 PF	1M
NF5639	NA	N	J		2N4392	30	25-				10	CRSS	4 PF	1M
NF5640	NA	N	J		2N4393	30	5-				10	CRSS	4 PF	1M
NF5653	NA	N	J		2N4856	30	40-				10	CRSS	3.5 PF	1M
NF5654	NA	N	J		2N4857	30	15-				10	CRSS	3.5 PF	1M
SU2028	IN	N	J			50	.25-1.3		.3-					
SU2029	IN	N	J			50	.8-3		.4-					
SU2031	IN	N	J			50	.8-3		.4-					
SU2032	IN	N	J		2N5545	50	1-10		1.5-					
SU2033	IN	N	J		2N5545	50	5-20		2.5-					
SU2034	IN	N	J		2N5547	50	1-10		1.5-					
SU2035	IN	N	J		2N5547	50	5-20		2.5-					
SU2098	IN	N	J		2N5545	30	1-8		1-					
SU2098A	IN	N	J		2N5545	50	1-8		1.5-					
SU2098B	IN	N	J			50	1-8		1.5-					
SU2099	IN	N	J		2N5547	30	1-8		1-					
SU2099A	IN	N	J		2N5547	50	1-8		1.5-					
SX3819	TI	N	J	AF	2N5949/53	25	2-20		2-6.5		8	CRSS	4 PF	1M
SX3820	TI	P	J	AF	A5T5460/62	20	.3-15		.8-5		32	CRSS	16 PF	1M
TIS14	TI	N	J		TIS14	30	.5-15		1-7.5		8	CRSS	4 PF	1M

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TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS I_{DSS} *$I_{D(on)}$ MIN MAX (mA) (mA)	$\|y_{fs}\|$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
TIS25	TI	N	J		TIS25	30	.5-8	2-6.5	6	CRSS	2 PF	1M
TIS26	TI	N	J		TIS26	30	.5-8	2-6.5	6	CRSS	2 PF	1M
TIS27	TI	N	J		TIS27	30	.5-8	2-6.5	6	CRSS	2 PF	1M
TIS34	TI	N	J	RF	2N5248	30	4-20	3.5-6.5	6	CRSS	2 PF	1M
TIS42	TI	N	J	SW	TIS75	25	10-		18	CRSS	9 PF	1M
TIS58	TI	N	J	GP	2N5952/53	25	2.5-8	1.3-4	6	CRSS	3 PF	1M
TIS59	TI	N	J	GP	2N5949/51	25	6-25	2.5-5	6	CRSS	3 PF	1M
TIS67	TI	P	J	GP		25	*40-120	3.5-6.5	10	CRSS	4 PF	1M
TIS68	TI	N	J	GP	TIS69	25	.5-8	1-6	8	CRSS	4 PF	1M
TIS69	TI	N	J	GP	TIS69	25	.5-8	1-6	8	CRSS	4 PF	1M
TIS70	TI	N	J	GP	TIS70	25	.5-8	1-6	8	CRSS	4 PF	1M
TIS73	TI	N	J	SW	TIS73	30	50-		18	CRSS	8 PF	1M
TIS74	TI	N	J	SW	TIS74	30	20-100		18	CRSS	8 PF	1M
TIS75	TI	N	J		TIS75	30	8-80		18	CRSS	8 PF	1M
TIS78	TI	N	J	HV	A5T6449	300	2-10	.75-3	15	CRSS	3 PF	1M
TIS79	TI	N	J	HV	A5T6450	200	2-10	.75-3	15	CRSS	3 PF	1M
TIS88	TI	N	J	RF	TIS88	30	5-15	4.5-7.5	4.5	NF	2 DB	100M
U110	SI	P	J			20	.1-1	.11-	6			
U112	SI	P	J			20	.9-9	1-	17			
U146	SI	P	J			20	025-	.06-	6			
U147	SI	P	J			20	065-	.18-	10			
U148	SI	P	J			20	.2-	.54-	17			
U149	SI	P	J			20	.44-	1.4-	30			
U133	SI	P	J			50	.3-1.5	.33-	10			
U168	SI	P	J		2N2608	20	.6-6	.8-	65			
U182	IN	N	J		2N4860	40	40-120		20	CRSS	6 PF	1M
U183	SI	N	J		2N3458	25	2-20	1.6-	8	CRSS	4 PF	1M
U184	SI	N	J		2N4416	25	3-30	3-8.5	4	CRSS	1 PF	1M
U197	SI	N	J		2N3460	30	.1-1	.2-	7			
U198	SI	N	J		2N3459	30	.6-6	.6-	7			
U199	SI	N	J		2N3458	30	.3-20	1.5-	7			
U200	SI	N	J		2N5549	30	3-25		30	CRSS	8 PF	1M
U201	SI	N	J		2N4861	30	15-75		30	CRSS	8 PF	1M
U202	SI	N	J		2N4860	30	30-150		30	CRSS	8 PF	1M
U221	SI	N	J			50	50-110	15-40	28	CRSS	7 PF	1M
U222	SI	N	J			50	100-250	20-50	28	CRSS	7 PF	1M
U231	IN	N	J		2N5545	50	.5-5	1-				
U232	IN	N	J		2N5546	50	.5-5	1-				
U233	IN	N	J		2N5547	50	.5-5	1-				
U234	IN	N	J		2N5547	50	.5-5	1-				

TRANSISTOR INTERCHANGEABILITY
NONREGISTERED FIELD-EFFECT TRANSISTORS

TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} *$I_{D(on)}$ MIN MAX (mA) (mA)	$\lvert y_{fs} \rvert$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
U235	IN	N	J		2N5045	50	.5-5	1-				
U240	SI	N	J			25	150-		70	CRSS	35 PF	1M
U241	SI	N	J			25	10-		70	CRSS	35 PF	1M
U242	SI	N	J			20	150-		70	CRSS	35 PF	1M
U243	SI	N	J			20	100-		70	CRSS	35 PF	1M
U248	IN	N	J			40	.03-.5					
U248A	IN	N	J			40	.03-.5					
U249	IN	N	J			40	.03-.5					
U249A	IN	N	J			40	.03-.5					
U250	IN	N	J			40	.03-.5					
U250A	IN	N	J			40	.03-.5					
U251	IN	N	J			40	.03-.5					
U251A	IN	N	J			40	.03-.5					
U252	IN	N	J			25	7-40	5-10		CRSS	1.2 PF	1M
U253	IN	N	J			25	7-40	5-10		CRSS	1.2 PF	1M
U254	IN	N	J		2N4859	30	50-		18	CRSS	8 PF	1M
U255	IN	N	J		2N4860	30	20-100		18	CRSS	8 PF	1M
U256	IN	N	J		2N4861	30	8-80		18	CRSS	8 PF	1M
U257	IN	N	J		2N5047	25	5-40	5-10		CRSS	1.2 PF	1M
U273	SI	N	J			30	.5-2	.5-	2	CRSS	.5 PF	1M
U273A	SI	N	J			30	.5-2	.5-	2	CRSS	.5 PF	1M
U274	SI	N	J			30	1-4	.6-	2	CRSS	.5 PF	1M
U274A	SI	N	J			30	1-4	.6-	2	CRSS	.5 PF	1M
U275	SI	N	J			30	3-6.5	.8-	2	CRSS	.5 PF	1M
U275A	SI	N	J			30	3-6.5	.8-	2	CRSS	.5 PF	1M
U280	SI	N	J			50	.5-6	1-3	6	CRSS	1.7 PF	1M
U281	SI	N	J			50	.5-6	1-3	6	CRSS	1.7 PF	1M
U282	SI	N	J			50	.5-6	1-3	6	CRSS	1.7 PF	1M
U283	SI	N	J			50	.5-6	1-3	6	CRSS	1.7 PF	1M
U284	SI	N	J			50	.5-6	1-3	6	CRSS	1.7 PF	1M
U285	SI	N	J			50	.5-6	1-3	6	CRSS	1.7 PF	1M
U290	SI	N	J			30	500-			CRSS	30 PF	1M
U291	SI	N	J			30	200-			CRSS	30 PF	1M
U300	SI	P	J			40	30-90	8-12	20	CRSS	5.5 PF	1M
U301	SI	P	J			40	15-60	8-12	20	CRSS	5.5 PF	1M
U304	SI	P	J			30	30-90		27	CRSS	7 PF	1M
U305	SI	P	J			30	15-60		27	CRSS	7 PF	1M
U306	SI	P	J			30	5-25		27	CRSS	7 PF	1M
U310	SI	N	J		2N5549	25	20-60	10-20		CRSS	2.5 PF	1M
U312	SI	N	J		2N5397	25	10-30	6-10		CRSS	1.2 PF	1M

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TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} *$I_{D(on)}$ MIN MAX (mA) (mA)	$\lvert y_{fs}\rvert$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	f (Hz)
U1277	IN	N	J		2N5361	50	1.5-8	.45-	6	CRSS	1.2 PF	1M
U1278	IN	N	J		2N5359	50	.5-3	.35-	6	CRSS	1.2 PF	1M
U1279	IN	N	J		2N5362	50	.2-1.5	.25-	6	CRSS	1.2 PF	1M
U1280	IN	N	J		2N5359	50	.1-10	.25-	6	CRSS	1.2 PF	1M
U1281	IN	N	J		2N5549	50	8-		18	CRSS	5 PF	1M
U1282	IN	N	J		2N3458	50	4-20	2.5-	18	CRSS	5 PF	1M
U1283	IN	N	J		2N3459	50	1-10	1.5-	18	CRSS	5 PF	1M
U1284	IN	N	J		2N3458	50	.2-40	1-	18	CRSS	5 PF	1M
U1285	IN	N	J			30	.1-	.2-1.2		CRSS	2 PF	1M
U1286	IN	N	J		2N3459	30	.2-	1-10		CRSS	8 PF	1M
U1287	IN	N	J		2N4860	30				CRSS	20 PF	1M
U1321	IN	N	J		2N3966	30				CRSS	1.3 PF	1M
U1322	IN	N	J		2N3459	30	2.5-10		6	CRSS	1.3 PF	1M
U1323	IN	N	J		2N3459	30	1-5		6	CRSS	1.3 PF	1M
U1324	IN	N	J		2N5362	30	.4-2	1.2-	6	CRSS	1.3 PF	1M
U1325	IN	N	J			30	.1-.5	.5-	6	CRSS	1.3 PF	1M
U1714	IN	N	J		2N3459	25	.5-5	.4-	3	CRSS	1.2 PF	1M
U1837E	IN	N	J		2N5245	30	4-25	4-	6	CRSS	2 PF	1M
U1897E	IN	N	J		TIS73	40	30-		16	CRSS	5 PF	1M
U1898E	IN	N	J		TIS74	40	15-		16	CRSS	5 PF	1M
U1899E	IN	N	J		TIS75	40	8-		16	CRSS	5 PF	1M
U1994E	IN	N	J		2N5245	30	5-15	4-	4	CRSS	1 PF	1M
U3000	IN	N	J		2N3459	30	1.5-7.5	.3-		CRSS	2 PF	1M
U3001	IN	N	J		2N3459	30	.4-2	.25-		CRSS	2 PF	1M
U3002	IN	N	J			30	.1-.5	.2-		CRSS	2 PF	1M
U3010	IN	N	J		2N3458	30	3-15	.75-		CRSS	3 PF	1M
U3011	IN	N	J		2N3459	30	.8-4	.6-		CRSS	3 PF	1M
U3012	IN	N	J		2N3460	30	.2-1	.5-		CRSS	3 PF	1M
UC20	IN	N	J		2N5358	30	.4-2	.3-	2	CRSS	.8 PF	1M
UC21	IN	N	J			30	.12-.6	.2-	2	CRSS	.8 PF	1M
UC100	IN	N	J		2N5361	30	2.5-7.5	2-	5	CRSS	1.5 PF	1M
UC110	IN	N	J		2N5360	30	1-3	1.5-	5	CRSS	1.5 PF	1M
UC115	IN	N	J		2N3459	30	1-3	1.5-	5	CRSS	1.5 PF	1M
UC130	IN	N	J			30	.1-.5	.5-	5	CRSS	1.5 PF	1M
UC155	IN	N	J		2N5364	30	10-		4	CRSS	1 PF	1M
UC200	IN	N	J			50	10-30	6-	7	CRSS	2 PF	1M
UC201	IN	N	J		2N5364	50	15-		7	CRSS	4 PF	1M
UC210	IN	N	J		2N5362	50	4-12	4.5-	7	CRSS	2 PF	1M
UC220	IN	N	J		2N5360	50	1-5	3-	7	CRSS	2 PF	1M
UC240	IN	N	J		2N3459	50	1-10	1.2-	18	CRSS	5 PF	1M

TRANSISTOR INTERCHANGEABILITY
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TYPE NUMBER	MANUFACTURER	POLARITY	GATE TYPE	CLASSIFICATION	TI REPLACEMENT OR NEAREST EQUIVALENT	RATED DRAIN-GATE VOLTAGE (V)	ELECTRICAL CHARACTERISTICS: I_{DSS} / $*I_{D(on)}$ MIN MAX (mA) (mA)	$\|y_{fs}\|$ MIN MAX (mmho) (mmho)	C_{iss} MAX (pF)	OTHER PARAMETER SYMBOL	MAX	@ f (Hz)
UC241	IN	N	J		2N5361	50	1-10	2-	20	CRSS	5 PF	1M
UC250	IN	N	J		2N4391	30	50-150		25	CRSS	7 PF	1M
UC251	IN	N	J		2N4392	30	7.5-75		25	CRSS	7 PF	1M
UC400	IN	P	J		2N3331	30	5-15	3-	8	CRSS	2.5 PF	1M
UC401	IN	P	J		2N3994	30	8-		8	CRSS	4 PF	1M
UC410	IN	P	J		2N3330	30	2-6	2.25-	8	CRSS	2.5 PF	1M
UC420	IN	P	J		2N3329	30	.5-2.3	1.5-	8	CRSS	2.5 PF	1M
UC703	IN	N	J		2N5362	40	.1-10	.5-5	6			
UC704	IN	N	J		2N5364	40	.2-24	1-10	8			
UC705	IN	N	J		2N5364	40	.5-50	2-20	12			
UC707	IN	N	J		2N4861	20	2.5-250	5-50	30			
UC714	IN	N	J		2N3823	30	2-20	2-6.5	8	CRSS	4 PF	1M
UC714E	IN	N	J		2N5950	30	2-20	2-6.5	8	CRSS	4 PF	1M
UC734	IN	N	J		2N4416	30	4-20	3-	4	CRSS	.8 PF	1M
UC734E	IN	N	J		2N5245	30	4-20	3-	4.5	CRSS	1 PF	1M
UC751	IN	N	J		2N3458	30	.1-	.35-	10			
UC752	IN	N	J		2N3458	30	.3-	1-	17			
UC753	IN	N	J		2N3458	30	.9-	2.5-	25			
UC754	IN	N	J		2N3458	30	.5-	1-	6	CRSS	3 PF	1M
UC755	IN	N	J		2N3458	30	4-10	2-	6	CRSS	3 PF	1M
UC756	IN	N	J		2N3458	30	.5-15	1-	6	CRSS	3 PF	1M
UC814	IN	P	J		2N3331	25	.3-15	.8-5	16	CRSS	8 PF	1M
UC851	IN	P	J		2N2608	20	.9-9	1-	17			
UC853	IN	P	J		2N3822	25	.065-	.18-	10			
UC854	IN	P	J		2N2608	25	.2-	.54-	17			
UC855	IN	P	J		2N2609	25	.44-	1.4-	25			
UC1700	IN	P	IG			40		2-4	5	CRSS	1.2 PF	1M
UC1764	IN	P	IG		3N163	30	*3-30		3	CRSS	1 PF	1M
UC2130	IN	N	J		2N5545	50	.5-4.5	1-				
UC2132	IN	N	J		2N5546	50	.5-4.5	1-				
UC2134	IN	N	J		2N5547	50	.5-4.5	1-				
UC2136	IN	N	J		2N5045	50	.5-4.5	1-				
UC2138	IN	N	J		2N5046	50	.5-4.5	1-				
UC2139	IN	N	J		2N5047	30	.2-6	.75-				
UC2147	IN	N	J		2N5047	30	.5-	1-				
UC2148	IN	N	J		2N5047	50	.2-	2-				
UC2149	IN	N	J		2N5047	30	.5-15	1-				
UCI766	IN	P	IG		2N5047	30	*5-30		3.5	CRSS	1 PF	1M

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TYPE NUMBER	CLASSIFICATION	POLARITY	TI REPLACEMENT	P_D (mW)	CHARACTERISTICS r_{BB} (kΩ)	η	I_V (mA)	I_P (µA)	I_{EB20} (µA)
2N489	UJT	P-N	2N489	600	4.7-6.8	.51-.62	8	12	2
2N489A	UJT	P-N	2N489A	600	4.7-6.8	.51-.62	8	12	2
2N489B	UJT	P-N	2N489B	600	4.7-6.8	.51-.62	8	6	2
2N490	UJT	P-N	2N490	600	6.2-9.1	.51-.62	8	12	2
2N490A	UJT	P-N	2N490A	600	6.2-9.1	.51-.62	8	12	2
2N490B	UJT	P-N	2N490B	600	6.2-9.1	.51-.62	8	6	2
2N491	UJT	P-N	2N491	600	4.7-6.8	.56-.68	8	12	2
2N491A	UJT	P-N	2N491A	600	4.7-6.8	.56-.68	8	12	2
2N491B	UJT	P-N	2N491B	600	4.7-6.8	.56-.68	8	6	2
2N492	UJT	P-N	2N492	600	6.2-9.1	.56-.68	8	12	2
2N492A	UJT	P-N	2N492A	600	6.2-9.1	.56-.68	8	12	2
2N492B	UJT	P-N	2N492B	600	6.2-9.1	.56-.68	8	6	2
2N493	UJT	P-N	2N493	600	4.7-6.8	.62-.75	8	12	2
2N493A	UJT	P-N	2N493A	600	4.7-6.8	.62-.75	8	12	2
2N493B	UJT	P-N	2N493B	600	4.7-6.8	.62-.75	8	6	2
2N494	UJT	P-N		600	6.2-9.1	.62-.75	8	12	2
2N494A	UJT	P-N		600	6.1-9.1	.62-.75	8	12	2
2N494B	UJT	P-N		600	6.2-9.1	.62-.75	8	6	2
2N494C	UJT	P-N		600	6.2-9.1	.62-.75	8	2	.02
2N1671	UJT	P-N	2N1671	450	4.7-9.1	.47-.62	8	5	12
2N1671A	UJT	P-N	2N1671A	450	4.7-9.1	.47-.62	8	25	12
2N1671B	UJT	P-N	2N1671B	450	4.7-9.1	.47-.62	8	6	.2
2N2160	UJT	P-N	2N2160	450	4-12	.47-.80	8	25	12
2N2307	UJT	P-N		250	4.5-9.1	.45-.70			10
2N2417	UJT	P-N	2N489	350	4.7-6.8	.51-.62	5	20	12
2N2417A	UJT	P-N	2N489A	350	4.7-6.8	.51-.62	5	20	12
2N2417B	UJT	P-N	2N489B	350	4.7-6.8	.51-.62	8	6	12
2N2418	UJT	P-N	2N490	350	6.2-9.1	.51-.62	5	20	12
2N2418A	UJT	P-N	2N490A	350	6.2-9.1	.51-.62	5	20	12
2N2418B	UJT	P-N	2N490B	350	6.2-9.1	.51-.62	8	6	12
2N2419	UJT	P-N	2N491	350	4.7-6.8	.56-.68	5	20	12
2N2419A	UJT	P-N	2N491A	350	4.7-6.8	.56-.68	5	20	12
2N2419B	UJT	P-N	2N491B	350	4.7-6.8	.56-.68	8	6	12
2N2420	UJT	P-N	2N492	350	6.2-9.1	.56-.68	5	20	12
2N2420A	UJT	P-N	2N492A	350	6.2-9.1	.56-.68	5	20	12
2N2420B	UJT	P-N	2N492B	350	6.2-9.1	.56-.68	8	6	12
2N2421	UJT	P-N	2N493	350	4.7-6.8	.62-.75	5	20	12
2N2421A	UJT	P-N	2N493A	350	4.7-6.8	.62-.75	5	20	12
2N2421B	UJT	P-N	2N493B	350	4.7-6.8	.62-.75	8	6	12
2N2422	UJT	P-N		350	6.2-9.1	.62-.75	5	20	12
2N2422A	UJT	P-N		350	6.2-9.1	.62-.75	5	20	12
2N2422B	UJT	P-N		350	6.2-9.1	.62-.75	8	6	12

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TYPE NUMBER	CLASSIFICATION	POLARITY	TI REPLACEMENT	P_D (mW)	r_{BB} (kΩ)	η	I_V (mA)	I_P (µA)	I_{EB20} (µA)
				CHARACTERISTICS					
2N2646	UJT	P-N	2N2646	300	4.7-9.1	.56-.75	4	5	12
2N2647	UJT	P-N	2N2647	300	4.7-9.1	.68-.82	8	2	.2
2N2840	UJT	P-N	2N3980	300	4.7-9.1	.40-.85	.2	10	1
2N3406	UJT	P-N		450	6.2-9.1	.53-.59	8	20	12
2N3479	UJT	P-N	2N1671A	400	4.7-9.1	.47-.62	6	20	12
2N3480	UJT	P-N	2N2646	400	4.7-9.1	.56-.75	4	20	12
2N3481	UJT	P-N	2N4853	400	4.7-9.1	.70-.85	6	20	12
2N3482	UJT	P-N		400	4.7-6.8	.51-.62	8	2	.02
2N3483	UJT	P-N		400	4.7-9.1	.60-.72	8	5	1
2N3484	UJT	P-N		400	6.2-9.1	.70-.85	8	5	.2
2N3679	UJT	P-N		250	4.7-9.1	.66-.80	4.2		12
2N3980	UJT	P-N	2N3980	360	4-8	.68-.82	1	2	.01
2N4851	UJT	P-N	2N4851	300	4.7-9.1	.56-.75	2	2	.5
2N4852	UJT	P-N	2N4852	300	4.7-9.1	.70-.85	4	2	.1
2N4853	UJT	P-N	2N4853	300	4.7-9.1	.70-.85	6	.4	.05
2N4870	UJT	P-N	2N4891	300	4-9.1	.56-.75	2	5	1
2N4871	UJT	P-N	2N4891	300	4-9.1	.70-.85	4	5	1
2N4891	UJT	P-N	2N4891	360	4-9.1	.55-.82	2	5	.01
2N4892	UJT	P-N	2N4891	360	4-9.1	.51-.69	4	2	.01
2N4893	UJT	P-N	2N4893	360	4-12	.55-.82	2	2	.01
2N4894	UJT	P-N	2N4893	360	4-12	.74-.86	2	1	.01
2N4947	UJT	P-N	2N4947	360	4-9.1	.51-.69	4	2	.01
2N4948	UJT	P-N	2N4948	360	4-12	.55-.82	2	2	.01
2N4949	UJT	P-N		360	4-12	.74-.86	2	1	.01
2N5431	UJT	P-N		300	6-8.5	.72-.80	2	4	.01
2N6027	PUT	PNPN	A7T6027	See Data Sheet On A7T6027					
2N6028	PUT	PNPN	A7T6028	See Data Sheet On A7T6028					
2N6114	UJT	P-N		300	5.5-8.2	.58-.62	1	5	.01
2N6115	UJT	P-N		300	5-25	.58-.62	1	15	.1
2N6116	PUT	PNPN	2N6116	See 2N6116 Data Sheet					
2N6117	PUT	PNPN	2N6117	See 2N6117 Data Sheet					
2N6118	PUT	PNPN	2N6118	See 2N6118 Data Sheet					
2N6119	PUT	PNPN							
2N6120	PUT	PNPN							
2N6137	PUT	PNPN							
2N6138	PUT	PNPN							

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TYPE NUMBER	MANUFACTURER	CLASSIFICATION	POLARITY	TI REPLACEMENT	CHARACTERISTICS					
					P_D (mW)	r_{BB} (kΩ)	η	I_V (mA)	I_P (μA)	I_{EB2O} (μA)
A5T6116	TI	PUT	PNPN	A5T6116	See Data Sheet On A5T6116					
A5T6117	TI	PUT	PNPN	A5T6117	See Data Sheet On A5T6117					
A5T6118	TI	PUT	PNPN	A5T6118	See Data Sheet On A5T6118					
A7T6027	TI	PUT	PNPN	A7T6027	See Data Sheet On A7T6027					
A7T6028	TI	PUT	PNPN	A7T6028	See Data Sheet On A7T6028					
MU4891	M	UJT	P-N	2N4891	300	4-9.1	.55-.82	2	5	.01
MU4892	M	UJT	P-N	2N4892	300	4-9.1	.51-.69	2	2	.01
MU4893	M	UJT	P-N	2N4893	300	4-12	.55-.82	2	2	.01
MU4894	M	UJT	P-N	2N4894	300	4-12	.74-.86	2	1	.01
TIS43	TI	UJT	P-N	TIS43	300	4-9.1	.55-.82	2	5	.01
TIS43	TI	UJT	P-N	2N4891	300	4-9.1	.55-.82	2	5	.01

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Transistor Data Sheets

TRANSISTOR DATA SHEETS

CONTENTS

In this section are data sheets for most of the Texas Instruments line of standard, low-power silicon transistors. (For reference to TI's line of silicon power transistors, see either Section 0, Type Number Index, or *The Power Semiconductor Data Book.*

Excluded from this volume are data sheets for certain obsolescent types listed and so indicated in Section 0, Type Number Index. Loose-leaf data sheets for these devices may be available upon request.

DERIVED TYPES

Many of the JEDEC-registered types are available in repackaged form. The designations of these repackaged devices are derived from the original JEDEC type numbers by replacing the 2N or 3N prefix with a prefix explained in the table below.

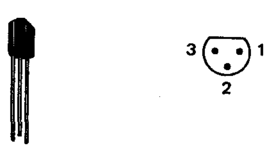
"Repackaging" may mean providing a plastic-encapsulated (*Silect*†) equivalent for a metal-cased type (for example, the A5T2222 is a *Silect* 100-mil pin-circle equivalent for the metal-cased 2N2222) or perhaps different basing (lead locations) from the registered type (for example, the A5T3904 is a *Silect* 100-mil pin-circle equivalent of the plastic-encapsulated, 2N3904 which is registered with the in-line-lead TO-92 package.) In the case of the A4T prefix for unmounted transistor chips, "repackaging" means no package at all.

In any case, the specifications for the prefixed devices are as close to the registered devices as packaging will permit.

PREFIXES FOR REPACKAGED TRANSISTORS

A3T	*Microsilect*† (obsolescent, not covered in this book)
A4T	Unencapsulated transistor chips (not covered in this book)

A5T, A6T



Silect† Package

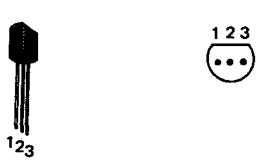
A5T

TRANSISTOR	LEAD 1	LEAD 2	LEAD 3
Multijunction	Emitter	Base	Collector
Field-Effect	Source	Drain	Gate
Programmable Unijunction	Cathode	Gate	Anode

A6T

TRANSISTOR	LEAD 1	LEAD 2	LEAD 3
Multijunction	Base	Emitter	Collector

A7T, A8T



TO-92 *Silect*† Package

A7T

TRANSISTOR	LEAD 1	LEAD 2	LEAD 3
Multijunction	Emitter	Collector	Base
Programmable Unijunction	Anode	Cathode	Gate

A8T

TRANSISTOR	LEAD 1	LEAD 2	LEAD 3
Multijunction	Emitter	Base	Collector

†Trademark of Texas Instruments Incorporated

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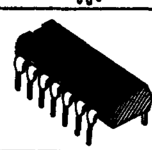
B2T	Unencapsulated beam-lead transistor chips (not covered in this book)	
B3T		Beam-lead transistors, 100-mil pin circle (not covered in this book)
B4T		Beam-Lead transistors, 200-mil pin circle (not covered in this book)
B5T		Beam-lead transistors, plastic high-frequency package (not covered in this book)
D2T		Dual transistors, short-can version of TO-78 package
Q2T		Quad transistors, TO-116 plastic dual-in-line package

ORGANIZATION

Data Sheets are organized in alphanumeric order with numbers taking precedence over letters. The exception to this is that derived types are placed immediately after the registered types from which they were derived.

CHIP-CHARACTERIZATION REFERENCE

Transistor chip families are characterized in Section 5. Reference to the related chip family is made on the lower right-hand corner of each data sheet, if appropriate.

Exceptions:

- Grown-junction bars are not characterized.
- Bar-type unijunction transistors are not characterized.
- When the observed values of the characteristics of the basic chips are not applicable to specific devices because of highly selective screening or special diffusions, chip-family references are omitted.
- Transistor types containing two darlington-connected chips do have the chip-family reference but it should be noted that while the characterization data does apply to the individual chips, it does not apply directly to the darlington-connected pairs.

N-P-N GROWN-JUNCTION SILICON TRANSISTOR

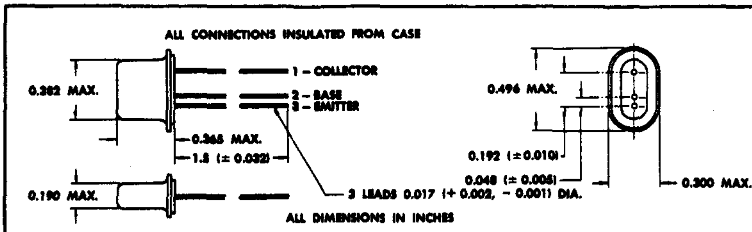
BULLETIN NO. DL-S 58896, MARCH 1958

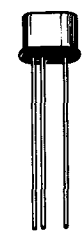
9 to 20 beta spread

Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Approximate weight is 1.7 grams.





absolute maximum ratings at 25°C ambient (except where advanced temperatures are indicated)

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	– 25 mA
Collector Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range	–65°C to +175°C

common base design characteristics at Tj = 25°C (except where advanced temperatures are indicated)

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	42	80	Ohm
h_{ob}	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.4	1.2	μmho
h_{rb}	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	25	120	500	$X10^{-6}$
h_{fb}	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	–0.9	–0.925	–0.953	
PG_e	Power Gain*†	$V_{CE} = 20V$	$I_E = -2mA$		35		db
NF	Noise Figure*‡	$V_{CE} = 5V$	$I_E = -1mA$		20		db
$f_{\alpha b}$	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$		4		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		7		μμf
R_{cs}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		100	200	Ohm

*Common Emitter †R_g = 1k; R_L = 20k ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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TYPE 2N118

N-P-N GROWN-JUNCTION SILICON TRANSISTOR

BULLETIN NO. DL-S 58897, MARCH 1958

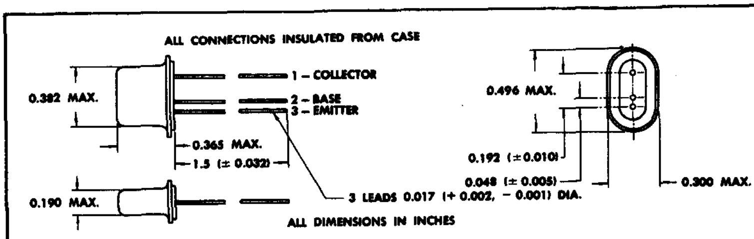
18 to 40 beta spread

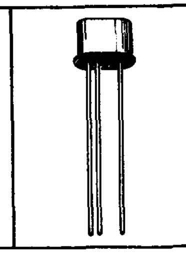
Specifically designed for high gain at high temperatures

4

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Approximate weight is 1.7 grams.





absolute maximum ratings at 25°C ambient [except where advanced temperatures are indicated]

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	– 25 mA
Collector Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range	–65°C to +175°C

common base design characteristics at T_J = 25°C [except where advanced temperatures are indicated]

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	42	80	Ohm
h_{ob}	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.4	1.2	μmho
h_{rb}	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	25	250	1000	$X10^{-6}$
h_{fb}	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	–0.948	–0.96	–0.976	
PG_e	Power Gain*†	$V_{CE} = 20V$	$I_E = -2mA$		39		db
NF	Noise Figure*‡	$V_{CE} = 5V$	$I_E = -1mA$		20		db
f_{ab}	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$		5		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		7		$\mu\mu$f
R_{cs}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		100	200	Ohm

*Common Emitter †R_g = 1k; R_L = 20k ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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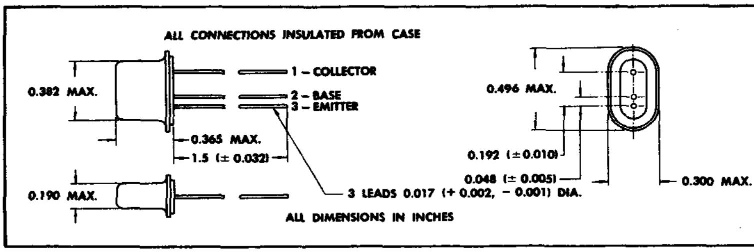
N-P-N GROWN-JUNCTION SILICON TRANSISTOR

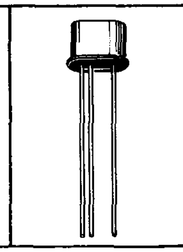
BULLETIN NO. DL-S 73898, MARCH 1968—REVISED MARCH 1973

18 to 86 beta spread
Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Approximate weight is 1.7 grams.





absolute maximum ratings at 25°C ambient (except where advanced temperatures are indicated)

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	– 25 mA
Collector Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range	–65°C to +175°C

common base design characteristics at $T_j = 25°C$ (except where advanced temperatures are indicated)

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	42	80	Ohm
h_{ob}	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.4	1.2	μmho
h_{rb}	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	50	400	1000	$X10^{-6}$
h_{fb}	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	–0.948	–0.975	–0.989	
PG_e	Power Gain*†	$V_{CE} = 20V$	$I_E = -2mA$		39		db
NF	Noise Figure*‡	$V_{CE} = 5V$	$I_E = -1mA$		20		db
$f_{\alpha b}$	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$	8			mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		7	20	$\mu\mu f$
R_{cs}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		100	200	Ohm

*Common Emitter †$R_g = 1k$; $R_L = 20k$ ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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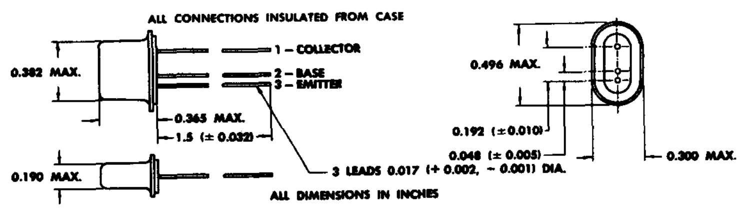
TYPE 2N119
N-P-N GROWN-JUNCTION SILICON TRANSISTOR

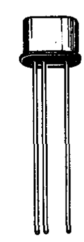
BULLETIN NO. DL-S 58899, MARCH 1958

36 to 86 beta spread
Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Approximate weight is 1.7 grams.





4

absolute maximum ratings at 25°C ambient (except where advanced temperatures are indicated)

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	– 25 mA
Collector Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range . . . . –65°C to +175°C

common base design characteristics at Tj = 25°C (except where advanced temperatures are indicated)

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	42	80	Ohm
h_{ob}	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.4	1.2	μmho
h_{rb}	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	50	400	1000	$X10^{-6}$
h_{fb}	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	–0.9735	–0.98	–0.989	
PG_e	Power Gain*†	$V_{CE} = 20V$	$I_E = -2mA$		42		db
NF	Noise Figure*‡	$V_{CE} = 5V$	$I_E = -1mA$		20		db
$f_{\alpha b}$	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$		6		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		7		$\mu\mu$f
R_{cs}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		100	200	Ohm

*Common Emitter †$R_g = 1k$; $R_L = 20k$ ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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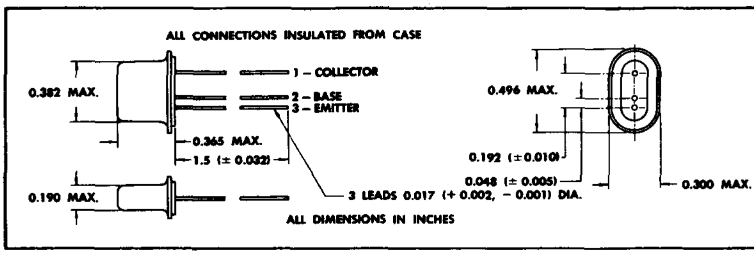
N-P-N GROWN-JUNCTION SILICON TRANSISTOR

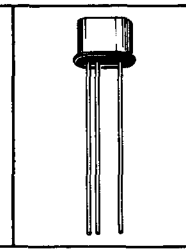
BULLETIN NO. DL-S 58900, MARCH 1958

76 to 333 beta spread
Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Approximate weight is 1.7 grams.





absolute maximum ratings at 25°C ambient (except where advanced temperatures are indicated)

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	– 25 mA
Collector Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range	–65°C to +175°C

common base design characteristics at T_j = 25°C (except where advanced temperatures are indicated)

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current}	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C}	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C}	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	42	80	Ohm
h_{ob}	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.4	1.2	μmho
h_{rb}	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	50	400	1000	$X10^{-6}$
h_{fb}	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	–0.987	–0.99	–0.997	
PG_e	Power Gain*†	$V_{CE} = 20V$	$I_E = -2mA$		42.5		db
NF	Noise Figure*‡	$V_{CE} = 5V$	$I_E = -1mA$		20		db
f_{ab}	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$		7		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		7		μμf
R_{CS}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		100	200	Ohm

*Common Emitter †R_g = 1k; R_L = 20k ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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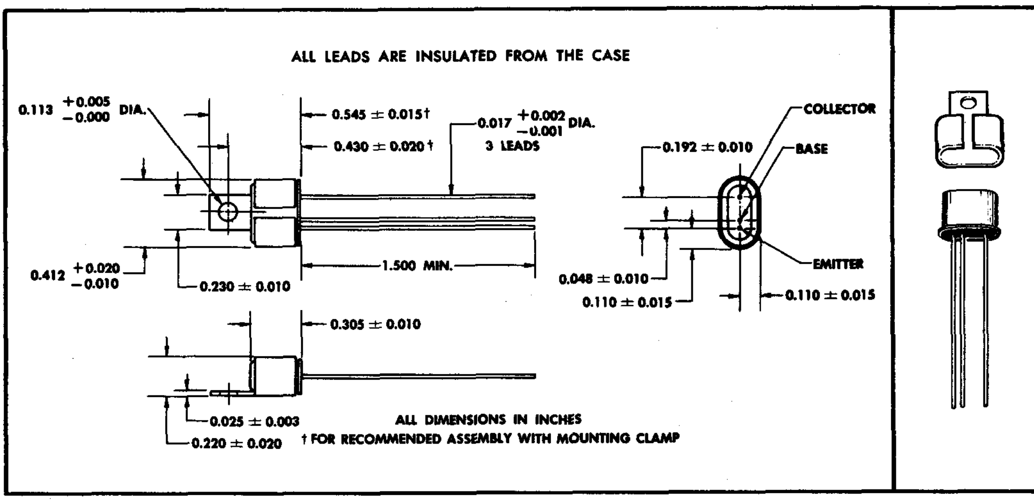
BULLETIN NO. DL-S 612238, DECEMBER 1961

Oval Welded Package

mechanical data

The transistor is in an oval welded package with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. The mounting clip is hardware supplied with the transistor.



*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

Collector-Base Voltage	60 v
Collector Current	60 ma
Total Device Dissipation (see note 1)	750 mw
Collector Junction Operating Temperature	+150°C
Storage Temperature Range	−55° to +150°C

NOTE: 1. Derate linearly to 150°C case temperature at the rate of 6 mw/°C.

*JEDEC registered data

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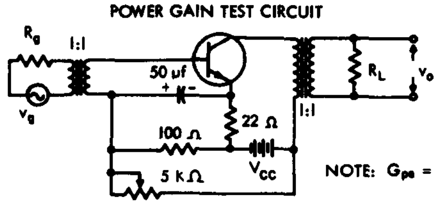
electrical characteristics at 25°C case temperature (unless otherwise noted)

parameter		test conditions		types	min*	typ	max*	unit
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v,	$I_E = 0$	All			1	μa
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $T_C = 150°C$	$I_E = 0$	All		15		μa
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 50\ \mu a$,	$I_E = 0$	All	60			v
BV_{CEO}	Collector-Emitter Breakdown Voltage	$I_C = 100\ \mu a$,	$I_B = 0$	All		60		v
V_{BE}	Base-Emitter Voltage	$I_B = 3$ ma,	$I_C = 20$ ma	All			1	v
$r_{CE(sat)}$	DC Collector-Emitter Saturation Resistance	$I_B = 3$ ma,	$I_C = 20$ ma	All			350	ohm
h_{fb}	AC Common-Base Forward Current Transfer Ratio	$V_{CB} = 10$ v, f = 1 kc	$I_E = -5$ ma	2N243 2N244	−0.9 −0.961	−0.94 −0.97	−0.968 −0.989	
h_{ib}	AC Common-Base Input Impedance	$V_{CB} = 10$ v, f = 1 kc	$I_E = -5$ ma	All		12	30	ohm
h_{rb}	AC Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 10$ v, f = 1 kc	$I_E = -5$ ma	All		60×10^{-6}	300×10^{-6}	

functional tests at 25°C case temperature

G_{pe}	Common-Emitter Power Gain (See Circuit Below)	$V_{CB} = 28$ v $R_g = 100\ \Omega$, f = 1 kc,	$I_C = 20$ ma $R_L = 1\ k\Omega$ $V_g = 0.2$ v	All	30			db

POWER GAIN TEST CIRCUIT



NOTE: $G_{pe} = 10 \log \frac{4 R_g}{R_L} \left(\frac{V_o}{V_g}\right)^2$

* JEDEC registered data

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TYPE 2N332
N-P-N GROWN-JUNCTION SILICON TRANSISTOR

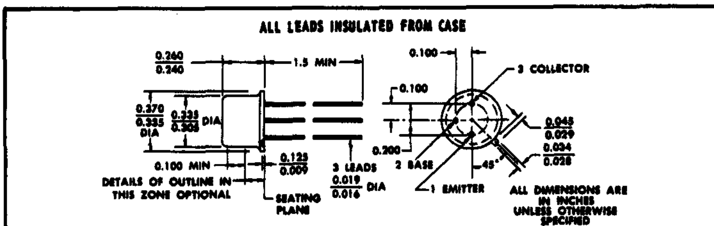
BULLETIN NO. DL-S 591035, MARCH 1959

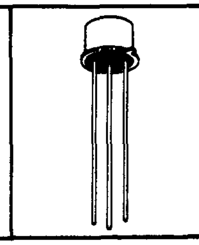
Beta From 9 to 20

Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. All JEDEC TO-5 dimensions and notes are applicable.





absolute maximum ratings at 25°C ambient [except where advanced temperatures are indicated]

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	−25 mA
Device Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range	−65°C to +175°C

common base design characteristics at $T_j = 25°C$ [except where advanced temperatures are indicated]

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib} †	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	55	80	Ohm
h_{ob} †	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.5	1.2	μmho
h_{rb} †	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	0	195	500	$X10^{-6}$
h_{fb} †	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	−0.9	−0.925	−0.953	
NF	Noise Figure*‡	$V_{CB} = 5V$	$I_E = -1mA$		20	30	db
$f_{\alpha b}$	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$	1	6		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		10	30	$\mu\mu f$
R_{CS}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		70	200	Ohm

*Common Emitter † f=1 kc ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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TYPE 2N333
N-P-N GROWN-JUNCTION SILICON TRANSISTOR

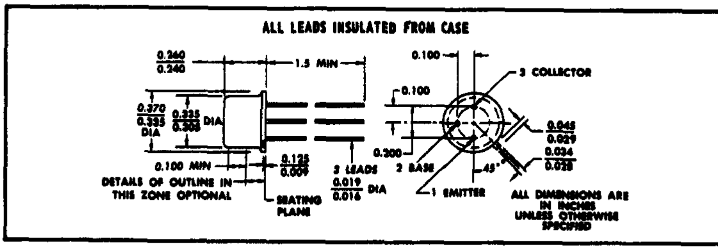
BULLETIN NO. DL-S 591036, MARCH 1959

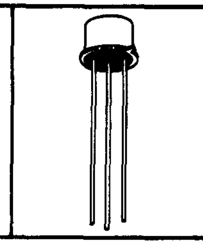
Beta From 18 to 40

Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. All JEDEC TO-5 dimensions and notes are applicable.





absolute maximum ratings at 25°C ambient [except where advanced temperatures are indicated]

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	−25 mA
Device Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range . . . . −65°C to +175°C

common base design characteristics at $T_j = 25°C$ [except where advanced temperatures are indicated]

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50 \mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}†	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	55	80	Ohm
h_{ob}†	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.5	1.2	μmho
h_{rb}†	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	0	370	1000	$X10^{-6}$
h_{fb}†	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	−0.948	−0.96	−0.976	
NF	Noise Figure*‡	$V_{CB} = 5V$	$I_E = -1mA$		20	30	db
$f_{\alpha b}$	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$	2	8		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		10	30	μμf
R_{CS}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		70	200	Ohm

*Common Emitter †f=1 kc ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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TYPE 2N334

N-P-N GROWN-JUNCTION SILICON TRANSISTOR

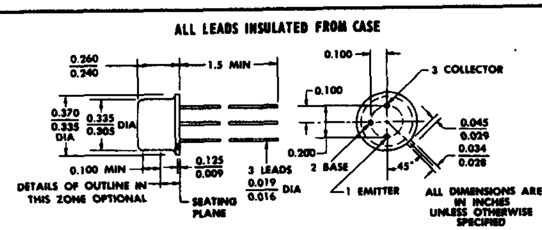
BULLETIN NO. DL-S 591037, MARCH 1959

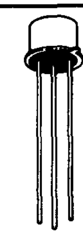
Beta From 18 to 90

Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. All JEDEC TO-5 dimensions and notes are applicable.





absolute maximum ratings at 25°C ambient [except where advanced temperatures are indicated]

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	−25 mA
Device Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range . . . . −65°C to +175°C

common base design characteristics at $T_j = 25°C$ [except where advanced temperatures are indicated]

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}†	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	55	80	Ohm
h_{ob}†	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.5	1.2	μmho
h_{rb}†	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	0	350	1000	$X10^{-6}$
h_{fb}†	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	−0.948	−0.975	−0.989	
NF	Noise Figure*‡	$V_{CB} = 5V$	$I_E = -1mA$		20	30	db
$f_{\alpha b}$	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$	8	10		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		10	30	μμf
R_{CS}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		70	200	Ohm

*Common Emitter † f=1 kc ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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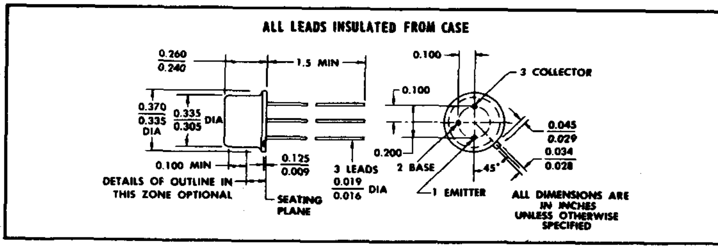
TYPE 2N335
N-P-N GROWN-JUNCTION SILICON TRANSISTOR

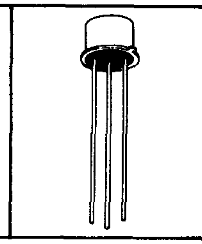
BULLETIN NO. DL-S 591038, MARCH 1959

Beta From 36 to 90
Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. All JEDEC TO-5 dimensions and notes are applicable.





absolute maximum ratings at 25°C ambient (except where advanced temperatures are indicated)

Collector Voltage Referred to Base	15 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	−25 mA
Device Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range	−65°C to +175°C

common base design characteristics at $T_j = 25°C$ (except where advanced temperatures are indicated)

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}†	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	55	80	Ohm
h_{ob}†	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.3	1.2	μmho
h_{rb}†	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	0	600	1000	$X10^{-6}$
h_{fb}†	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	−0.9735	−0.98	−0.989	
NF	Noise Figure*‡	$V_{CE} = 5V$	$I_E = -1mA$		20	30	db
$f_{\alpha b}$	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$	2	11		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		10	30	$\mu\mu f$
R_{CS}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		70	200	Ohm

* Common Emitter † f=1 kc ‡ Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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N-P-N GROWN-JUNCTION SILICON TRANSISTOR

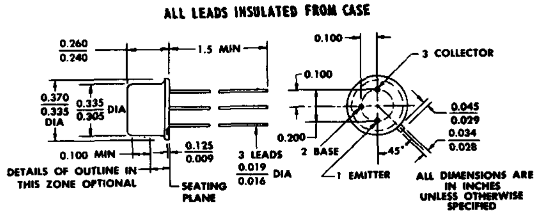
BULLETIN NO. DL-S 591039, MARCH 1959

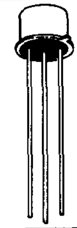
Beta From 76 to 333

Specifically designed for high gain at high temperatures

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. All JEDEC TO-5 dimensions and notes are applicable.





absolute maximum ratings at 25°C ambient [except where advanced temperatures are indicated]

Collector Voltage Referred to Base	45 V
Emitter Voltage Referred to Base	1 V
Collector Current	25 mA
Emitter Current	−25 mA
Device Dissipation	150 mW
at 100°C	100 mW
at 150°C	50 mW

junction temperature

Maximum Range . . . . −65°C to +175°C

common base design characteristics at $T_j = 25°C$ [except where advanced temperatures are indicated]

		test conditions		min.	design center	max.	unit
BV_{CBO}	Collector Breakdown Voltage	$I_C = 50\mu A$	$I_E = 0$	45			Volt
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30V$	$I_E = 0$			2	μA
	at 100° C	$V_{CB} = 5V$	$I_E = 0$			10	μA
	at 150° C	$V_{CB} = 5V$	$I_E = 0$			50	μA
h_{ib}†	Input Impedance	$V_{CB} = 5V$	$I_E = -1mA$	30	55	80	Ohm
h_{ob}†	Output Admittance	$V_{CB} = 5V$	$I_E = -1mA$	0	0.25	1.2	μmho
h_{rb}†	Feedback Voltage Ratio	$V_{CB} = 5V$	$I_E = -1mA$	0	700	1000	$X10^{-6}$
h_{fb}†	Current Transfer Ratio	$V_{CB} = 5V$	$I_E = -1mA$	−0.987	−0.99	−0.997	
NF	Noise Figure*‡	$V_{CE} = 5V$	$I_E = -1mA$		20	30	db
$f_{\alpha b}$	Frequency Cutoff	$V_{CB} = 5V$	$I_E = -1mA$	2	13		mc
C_{ob}	Output Capacitance (1mc)	$V_{CB} = 5V$	$I_E = -1mA$		10	30	$\mu\mu f$
R_{CS}	Saturation Resistance*	$I_B = 2.2mA$	$I_C = 5mA$		70	200	Ohm

*Common Emitter † f=1 kc ‡Conventional Noise—Compared to 1000 ohm resistor, 1000 cps and 1 cycle band width

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N-P-N GROWN-JUNCTION SILICON TRANSISTOR

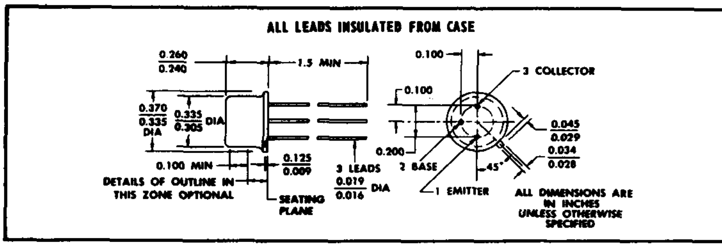
BULLETIN NO DL-S 69355, MAY 1960—REVISED APRIL 1969

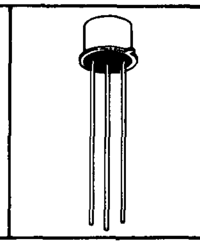
FOR SWITCHING AND GENERAL PURPOSE APPLICATIONS

- Guaranteed 20-55 DC Beta
- 10 mc min Alpha-Cutoff
- Low Collector Capacity
- High Gain at Low Levels

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. All JEDEC TO-5 dimensions and notes are applicable.





absolute maximum ratings at 25°C ambient temperature (unless otherwise noted)

Collector-Base Voltage	45 v
Collector-Emitter Voltage	30 v
Collector Current	20 ma
Emitter Current	20 ma
Total Device Dissipation (Derate 1mw/°C for Advanced Temperatures)	125 mw
Storage Temperature Range	−65°C to +150°C

electrical characteristics at 25°C ambient temperature (unless otherwise noted)

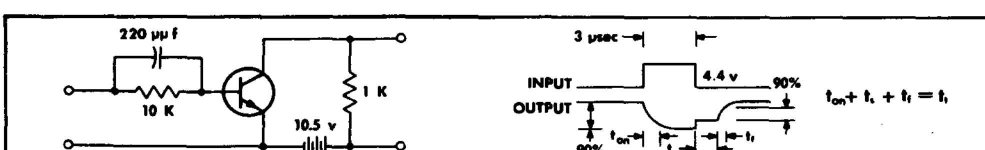
	parameters	test conditions	min	typ	max	unit
I_{CBO}	Collector Reverse Current	V_{CB} = 20 v, I_E = 0			1	μa
I_{CBO}	Collector Reverse Current	V_{CB} = 20 v, I_E = 0, T_A = 150° C			100	μa
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 50 μa, I_E = 0	45			v
BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 100 μa, I_B = 0	30			v
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 50 μa, I_C = 0	1			v
h_{ib}	A-C Common-Base Input Impedance	V_{CB} = 20 v, I_E = −1 ma, f = 1 kc	30	50	80	ohm
h_{ob}	A-C Common-Base Output Admittance	V_{CB} = 20 v, I_E = −1 ma, f = 1 kc		0.2	1	μmho
h_{rb}	A-C Common-Base Reverse-Voltage Transfer Ratio	V_{CB} = 20 v, I_E = −1 ma, f = 1 kc		200	2000	$x10^{-6}$
h_{fb}	A-C Common-Base Forward-Current Transfer Ratio	V_{CB} = 20 v, I_E = −1 ma, f = 1 kc	−0.95	−0.985		
h_{FE}*	D-C Forward-Current Transfer Ratio	V_{CE} = 5 v, I_C = 10 ma	20		55	
$\|h_{fe}\|$	A-C Common-Emitter Forward Current Transfer Ratio	V_{CB} = 20 v, I_E = −1 ma, f = 2.5 mc	14	22		db
$f_{\alpha b}$	Common-Base Alpha-Cutoff Frequency	V_{CB} = 20 v, I_E = −1 ma	10	20		mc
C_{ob}	Common-Base Output Capacitance	V_{CB} = 20 v, I_E = 0, f = 1 mc		2	3	μμf
$r_{CE(Sat)}$*	D-C Common-Emitter Saturation Resistance	I_B = 1 ma, I_C = 10 ma		80	150	ohm

switching characteristics

	parameters	test conditions	min	typ	max	unit
t_{on}	Turn-on Time [Includes delay time (t_d)]	See Test Circuit		0.05		μsec
t_s	Storage Time	See Test Circuit		0.02		μsec
t_f	Fall Time	See Test Circuit		0.08		μsec

* These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

test circuit



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TYPE 2N338
N-P-N GROWN-JUNCTION SILICON TRANSISTOR

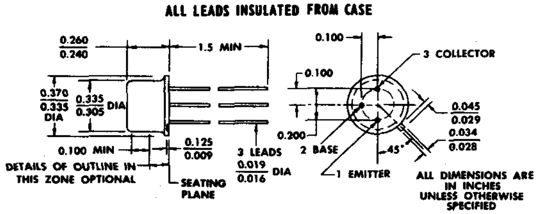
BULLETIN NO. DL-S 73356, JUNE 1960—REVISED MARCH 1973

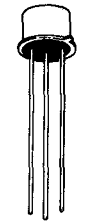
FOR SWITCHING AND GENERAL PURPOSE APPLICATIONS

- Guaranteed 45-150 DC Beta
- 20 mc min Alpha-Cutoff
- Low Collector Capacity
- High Gain at Low Levels

mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. All JEDEC TO-5 dimensions and notes are applicable.





absolute maximum ratings at 25°C ambient temperature (unless otherwise noted)

Collector-Base Voltage	45 v
Collector-Emitter Voltage	30 v
Collector Current	20 ma
Emitter Current	20 ma
Total Device Dissipation (Derate 1mw/°C for Advanced Temperatures)	125 mw
Storage Temperature Range	−65°C to +150°C

electrical characteristics at 25°C ambient temperature (unless otherwise noted)

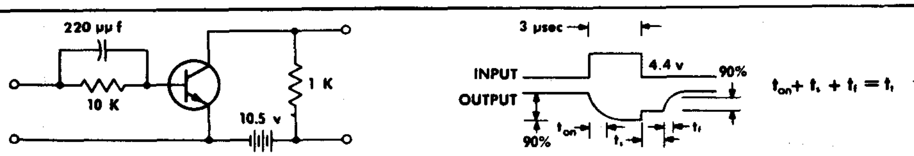
	parameters	test conditions	min	typ	max	unit
I_{CBO}	Collector Reverse Current	V_{CB} = 20 v I_E = 0			1	μa
I_{CBO}	Collector Reverse Current	V_{CB} = 20 v I_E = 0 T_A = 150° C			100	μa
BV_{CBO}	Collector-Base Breakdown Voltage	I_C = 50 μa I_E = 0	45			v
BV_{CEO}	Collector-Emitter Breakdown Voltage	I_C = 100 μa I_B = 0	30			v
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E = 50 μa I_C = 0	1			v
h_{ib}	A-C Common-Base Input Impedance	V_{CB} = 20 v I_E = −1 ma f = 1 kc	30	50	80	ohm
h_{ob}	A-C Common-Base Output Admittance	V_{CB} = 20 v I_E = −1 ma f = 1 kc		0.2	1	μmho
h_{rb}	A-C Common-Base Reverse-Voltage Transfer Ratio	V_{CB} = 20 v I_E = −1 ma f = 1 kc		300	2000	x10⁻⁶
h_{fb}	A-C Common-Base Forward-Current Transfer Ratio	V_{CB} = 20 v I_E = −1 ma f = 1 kc	−0.975	−0.99		
h_{FE}*	D-C Forward-Current Transfer Ratio	V_{CE} = 5 v I_C = 10 ma	45	80	150	
$\|h_{fe}\|$	A-C Common-Emitter Forward-Current Transfer Ratio	V_{CB} = 20 v I_E = −1 ma f = 2.5 mc	20	24		db
f_{ab}	Common-Base Alpha-Cutoff Frequency	V_{CB} = 20 v I_E = −1 ma	20	30		mc
C_{ob}	Common-Base Output Capacitance	V_{CB} = 20 v I_E = 0 f = 1 mc		2	3	μμf
$r_{CE(Sat)}$*	D-C Common-Emitter Saturation Resistance	I_B = 1 ma I_C = 10 ma		80	150	ohm

switching characteristics

t_{on}	Turn-on Time [Includes delay time (t_d)]	See Test Circuit		0.05		μsec
t_s	Storage Time			0.02		μsec
t_f	Fall Time			0.08		μsec

* These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

test circuit



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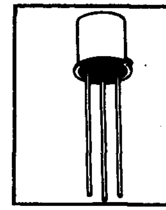
BULLETIN NO. DL-S 733955, JUNE 1963—REVISED MARCH 1973



1 Watt at 25°C Case Temperature

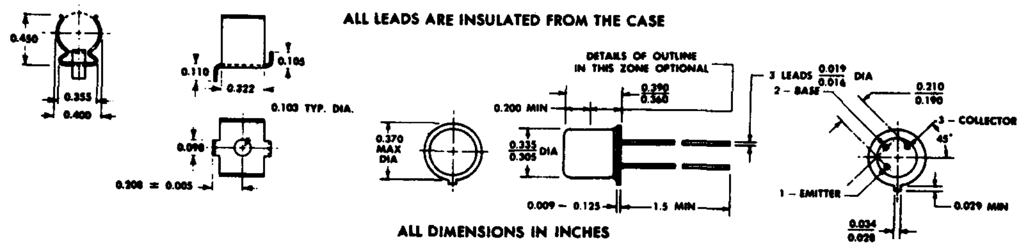
Designed for

Audio and Servo Amplifier Applications

mechanical data

The transistor is in an welded package with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1.5 grams. *JEDEC TO-11.

A non-insulated mounting clip (TI P/N 10-31-052-006) is provided with each transistor. Material is beryllium copper, cadmium plated — gold iridited.



absolute maximum ratings at 25°C case temperature (unless otherwise noted)

*Collector Current . . . . 60 ma
*Total Device Dissipation (see note 1) . . . . 1000 mw
*Total Device Dissipation at 100°C Case Temperature (see note 1) . . . . 400 mw
*Total Device Dissipation at 125°C Case Temperature (see note 1) . . . . 200 mw
*Storage and Operating Collector Junction Temperature Range . . . . −65° to +150°C
Storage and Operating Collector Junction Temperature Range (TI Guarantee) . . . . −65° to +175°C

*electrical characteristics at 25°C case temperature (unless otherwise noted)

parameter		test conditions		2N339		2N340		2N341		2N342		2N343		unit
				min	max	min	max	min	max	min	max	min	max	
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v	$I_E = 0$		1		1		1		1		1	μa
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $T_C = +150°C$	$I_E = 0$		250		250		250		250		250	μa
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 50$ μa	$I_E = 0$	55		85		125		60		60		v
BV_{CEO}	Collector-Emitter Breakdown Voltage	$I_C = 100$ μa	$I_B = 0$	55		85		85		60		60		v
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_E = 100$ μa	$I_C = 0$	1		1		1		1		1		v
$r_{CE(sat)}$	DC Collector-Emitter Saturation Resistance	$I_B = 3$ ma	$I_C = 20$ ma		300		350		400		350		350	ohm
h_{fb}	AC Common-Base Forward Current Transfer Ratio	$V_{CB} = 10$ v, f = 1 kc	$I_E = -5$ ma	−0.9	−0.989	−0.9	−0.989	−0.9	−0.989	−0.9	−0.97	−0.966	−0.989	
h_{ib}	AC Common-Base Input Impedance	$V_{CB} = 10$ v, f = 1 kc	$I_E = -5$ ma		30		30		30		30		30	ohm
h_{ob}	AC Common-Base Output Admittance	$V_{CB} = 10$ v, f = 1 kc	$I_E = -5$ ma		2		2		2		2		2	μmho
h_{rb}	AC Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 10$ v, f = 1 kc	$I_E = -5$ ma		300 x10⁻⁶		300 x10⁻⁶		300 x10⁻⁶		300 x10⁻⁶		300 x10⁻⁶	

NOTE 1: For increased dissipation capability (at elevated temperature) guaranteed by Texas Instruments, see Dissipation Derating Curve on page 2.
*Indicates JEDEC registered data

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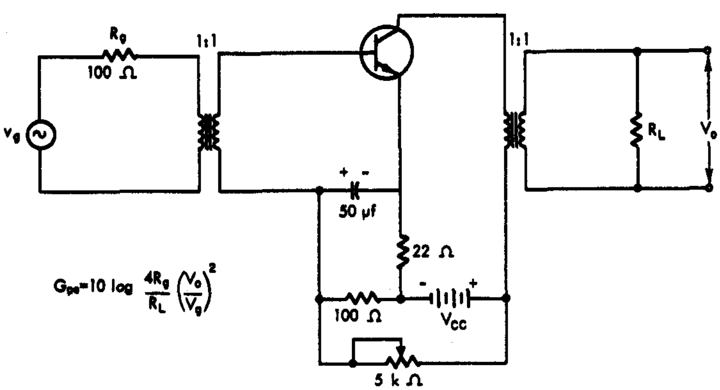
*functional tests at 25°C case temperature

parameter	test conditions	type	min	typ	max	unit
G_{pe} Common-Emitter Power Gain	$V_{CE} = 28$ v; $I_C = 20$ ma; $R_L = 1\ k\ \Omega$; f = 1 kc; $V_g = 0.2$ v	2N339 2N342 2N343	30			db
	$V_{CE} = 45$ v; $I_C = 15$ ma; $R_L = 2\ k\ \Omega$; f = 1 kc; $V_g = 0.2$ v	2N340	30			db
	$V_{CE} = 67.5$ v; $I_C = 10$ ma; $R_L = 4\ k\ \Omega$; f = 1 kc; $V_g = 0.2$ v	2N341	30			db

POWER GAIN TEST CIRCUIT

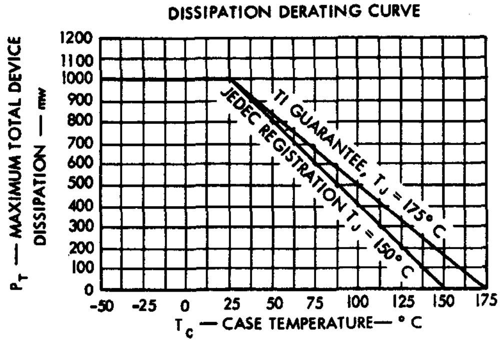


$$G_{pe} = 10 \log \frac{4R_g}{R_L} \left(\frac{V_o}{V_g}\right)^2$$

*Indicates JEDEC registered data

THERMAL CHARACTERISTICS

DISSIPATION DERATING CURVE



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BULLETIN NO. DL-S 7311979, MARCH 1973

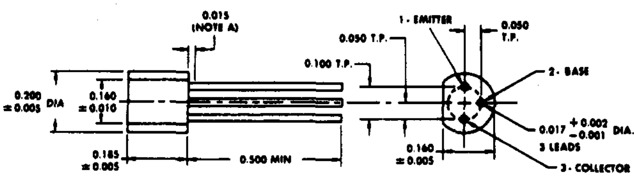
SILECT† TRANSISTORS‡
FOR LOW-COST REPLACEMENT OF GERMANIUM 2N404, 2N404A

- **A5T404, A5T404A Have Standard TO-18 100-mil Pin-Circle Configuration**
- **A8T404, A8T404A Have Same Outline and Basing as Motorola MPS404, MPS404A**

mechanical data

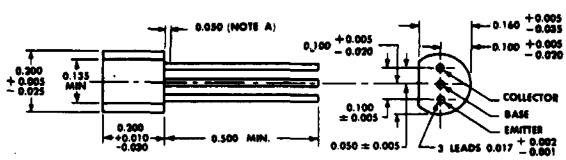
These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

A5T404, A5T404A



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

A8T404, A8T404A



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T404 A8T404	A5T404A A8T404A
Collector-Base Voltage	−25 V	−40 V
Collector-Emitter Voltage (See Note 1)	−24 V	−35 V
Emitter-Base Voltage	−12 V	−25 V
Continuous Collector Current	−150 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	1.25 W	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP P14

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		A5T404 A8T404 MIN	A5T404 A8T404 MAX	A5T404A A8T404A MIN	A5T404A A8T404A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−25		−40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 4	−24		−35		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−12		−25		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -12$ V, $I_E = 0$			−100		−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -10$ V, $I_C = 0$			−100		−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.15$ V, $I_C = -12$ mA		30	400	30	400	
		$V_{CE} = -0.2$ V, $I_C = -24$ mA		24		24		
V_{BE}	Base-Emitter Voltage (See Note 5)	$I_B = -0.4$ mA, $I_C = -12$ mA	See Note 4		−0.85		−0.85	V
		$I_B = -1$ mA, $I_C = -24$ mA			−1		−1	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.4$ mA, $I_C = -12$ mA	See Note 4		−0.15		−0.15	V
		$I_B = -1$ mA, $I_C = -24$ mA			−0.2		−0.2	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -6$ V, $I_E = 0$,	f = 1 MHz		20		20	pF
f_{hfb}	Small-Signal Common-Base Forward Current Transfer Ratio Cutoff Frequency	$V_{CB} = -6$ V, $I_E = 1$ mA		4		4		MHz

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
5. The base-emitter voltage is the principal characteristic difference between these devices and their germanium counterparts. The V_{BE} maximum limits for the 2N404 and 2N404A are −0.35 V at $I_C = -12$ mA, and −0.4 V at $I_C = -24$ mA.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	A5T404 A8T404 MIN	A5T404 A8T404 TYP	A5T404 A8T404 MAX	A5T404A A8T404A MIN	A5T404A A8T404A TYP	A5T404A A8T404A MAX	UNIT
t_d	Delay Time	$V_{CC} = -10$ V, $I_C = -10$ mA, $I_{B(1)} = -1$ mA, $V_{BE(off)} = 5$ V, See Figure 1		65			80		ns
t_r	Rise Time			55			100		ns
t_s	Storage Time	$V_{CC} = -10$ V, $I_C = -10$ mA, $I_{B(1)} = -1$ mA, $I_{B(2)} = 1$ mA, See Figure 1		400			400		ns
t_f	Fall Time			70			100		ns
Q_T	Total Control Charge	See Figure 2			1.8			1.8	nC

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

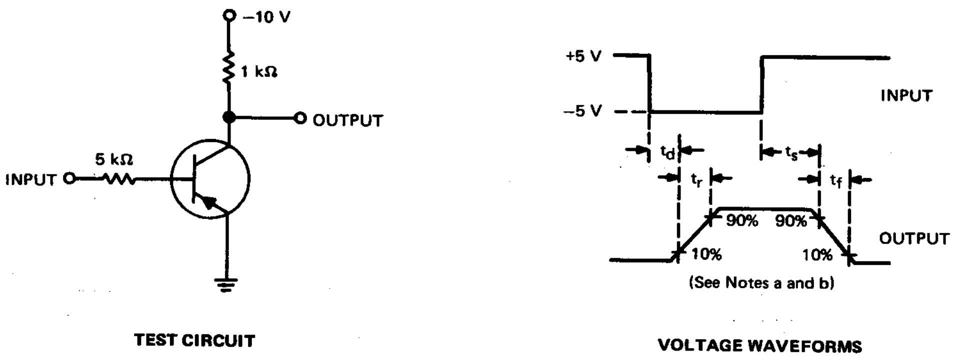


FIGURE 1—SWITCHING TIMES

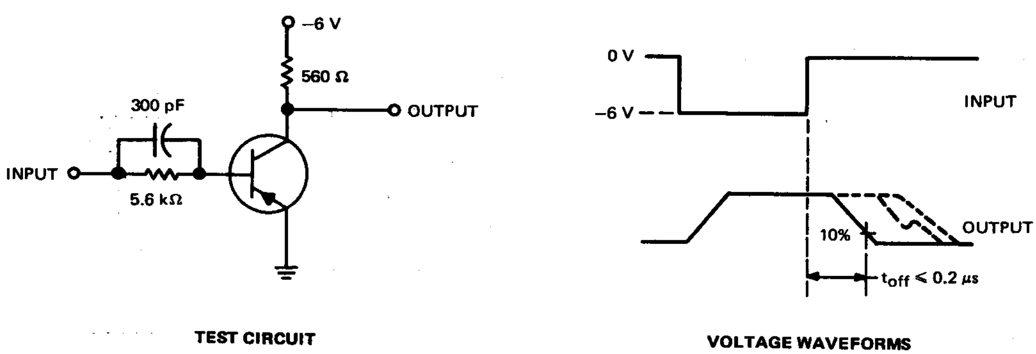


FIGURE 2—TOTAL CONTROL CHARGE

NOTES: a. The input waveform has the following characteristics: $t_r \leq 1$ ns, $t_f \leq 1$ ns, $t_w \geq 5\ \mu s$, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 4$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 12$ pF.
c. $Q_T \leq 1.8$ nC when the transistor turns off monotonically as shown by the solid line.

BULLETIN NO. DL-S 733190, OCTOBER 1962—REVISED MARCH 1973

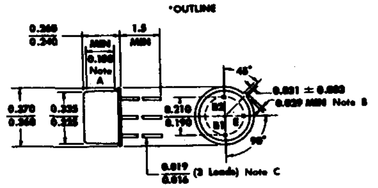
Designed for Medium-Power Switching, Oscillator and Pulse Timing Circuits

- **Highly Stable Negative Resistance and Firing Voltage**
- **Low Firing Current**
- **High Pulse Current Capabilities**
- **Simplified Circuit Design**

*mechanical data

Package outline is similar to JEDEC TO-5 except for lead position. Approximate weight is one gram.

ALL LEADS INSULATED FROM CASE.

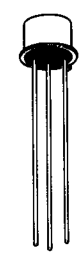


NOTES A. This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.010.

B. Measured from max. diameter of the actual device.

C. The specified lead diameter applies in the zone between 0.050 and 0.250 from the base seat. Between 0.250 and 1.5 maximum of 0.021 diameter is held. Outside of these zones the lead diameter is not controlled.

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED.



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Emitter-Base Reverse Voltage below 150°C Junction Temperature	−60 v
Interbase Voltage	See Note 1
RMS Emitter Current	70 ma
Peak Emitter Current below 150°C Junction Temperature	2 a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	450 mw
Total Device Dissipation at (or below) 25°C Free-Air Temperature, Stabilized (See Notes 3, 4)	600 mw
Operating Temperature Range	−65°C to 140°C
Operating Temperature Range, Stabilized (See Note 4)	−65°C to 175°C
Storage Temperature Range	−65°C to 175°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES 1. For maximum interbase voltage see Figure 1
2. Derate linearly to 140°C free-air temperature at the rate of 3.9 mw/°C.
3. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/°C.
4. Total interbase power dissipation must be limited by external circuit.

* Indicates JEDEC registered data.

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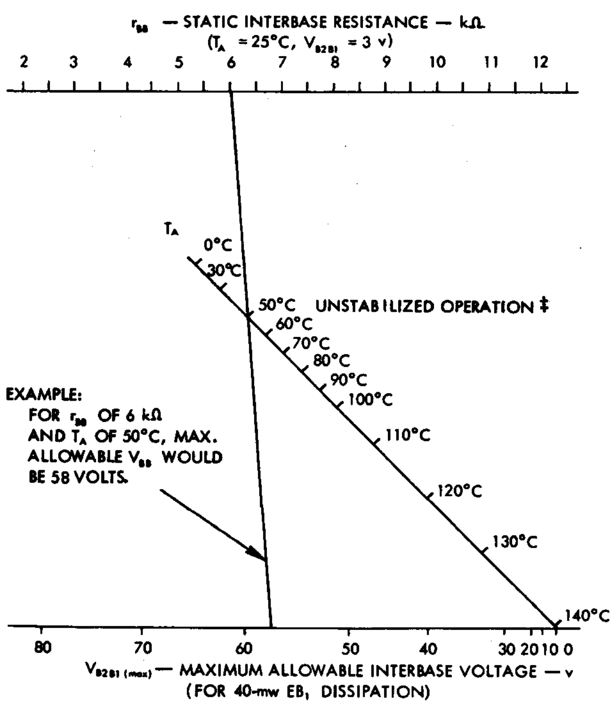
***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	TYPE	PARENT SERIES MIN	PARENT SERIES MAX	A SERIES MIN	A SERIES MAX	B SERIES MIN	B SERIES MAX	UNIT
r_{BB}	Static Interbase Resistance	$V_{B2B1} = 3$ v, $I_E = 0$	2N489, 2N491, 2N493	4.7	6.8	4.7	6.8	4.7	6.8	kΩ
			2N490, 2N492	6.2	9.1	6.2	9.1	6.2	9.1	kΩ
η	Intrinsic Standoff Ratio	$V_{B2B1} = 10$ v See Figure 5	2N489, 2N490	0.51	0.62	0.51	0.62	0.51	0.62	
			2N491, 2N492	0.56	0.68	0.56	0.68	0.56	0.68	
			2N493	0.62	0.75	0.62	0.75	0.62	0.75	
$I_{B2(mod)}$	Modulated Interbase Current	$V_{B2B1} = 10$ v, $I_E = 50$ ma	All Types	6.8	22	6.8	22	6.8	22	ma
I_{EB2O}	Emitter Reverse Current	$V_{B2E} = 60$ v, $I_{B1} = 0$	All Types		−2		−2		−2	μa
		$V_{B2E} = 30$ v, $I_{B1} = 0$	All Types						−0.2	μa
		$V_{B2E} = 10$ v, $I_{B1} = 0$ $T_J = 150°C$	All Types		−20		−20		−20	μa
I_P	Peak-Point Emitter Current	$V_{B2B1} = 25$ v	All Types		12		12		6	μa
$V_{EB1(sat)}$	Emitter Base-One Saturation Voltage	$V_{B2B1} = 10$ v, $I_E = 50$ ma	2N489, 2N490		5.0		4.0		4.0	v
			2N491, 2N492		5.0		4.3		4.3	v
			2N493		5.0		4.6		4.6	v
I_V	Valley-Point Emitter Current	$V_{B2B1} = 20$ v, $R_{B2} = 100\ \Omega$	All Types	8		8		8		ma
V_{OB1}	Base-One Peak Pulse Voltage	$V_1 = 20$ v $R_{B1} = 20\ \Omega$ See Figure 4	All Types			3.0		3.0		v

FIGURE 1—INTERBASE VOLTAGE RATING CURVE



‡For stabilized operation multiply temperature shown by 1.25 (i.e., 175/140)

*Indicates JEDEC registered data

4

PARAMETER MEASUREMENT INFORMATION

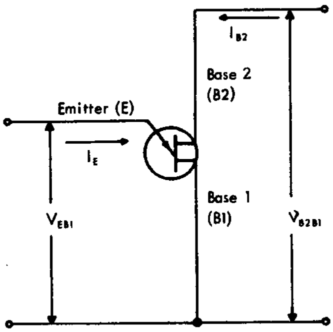


FIGURE 2 — UNIJUNCTION TRANSISTOR NOMENCLATURE

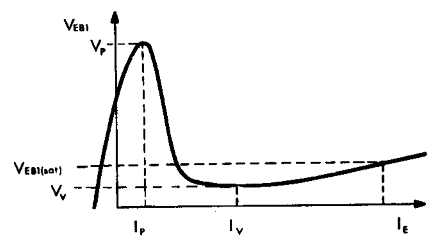


FIGURE 3 — GENERAL STATIC EMITTER CHARACTERISTIC CURVE

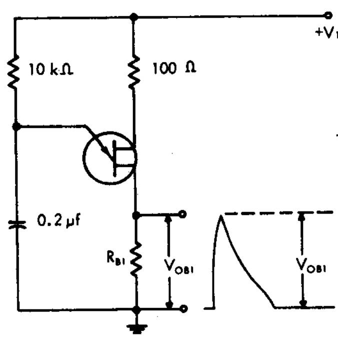


FIGURE 4 — V_{OB1} TEST CIRCUIT

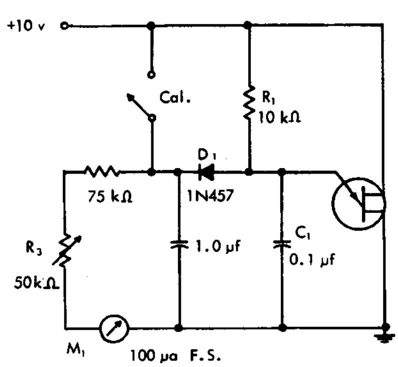


FIGURE 5 — TEST CIRCUIT FOR INTRINSIC STANDOFF RATIO (η)

η — Intrinsic Standoff Ratio — This parameter is defined in terms of the peak-point voltage, V_p, by means of the equation: $V_p = \eta V_{B2B1} + V_F$, where V_F is about 0.56 volt at 25°C and decreases with temperature at about 2 millivolts/deg.

The circuit used to measure η is shown in the figure. In this circuit, R_1, C_1 and the unijunction transistor form a relaxation oscillator, and the remainder of the circuit serves as a peak-voltage detector with the diode D_1 automatically subtracting the voltage V_F. To use the circuit, the "cal" button is pushed, and R_3 is adjusted to make the current meter M_1 read full scale. The "cal" button then is released and the value of η is read directly from the meter, with $\eta = 1$ corresponding to full-scale deflection of 100 μA.

D_1: 1N457, or equivalent, with the following characteristics:
$V_F = 0.565$ V at $I_F = 50$ μA,
$I_R \leq 2$ μA at $V_R = 20$ V

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TYPES 2N696, 2N697, 2N717, 2N718, 2N718A, 2N730, 2N731, 2N956, 2N1420, 2N1507, 2N1613, 2N1711
N-P-N SILICON TRANSISTORS

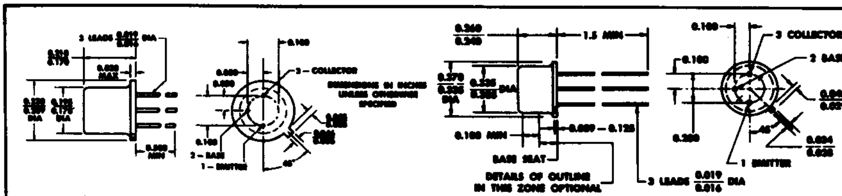
BULLETIN NO. DL-S 693471, MAY 1963—REVISED AUGUST 1969

Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

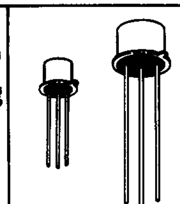
- **High Voltage** • **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

*mechanical data

Device types 2N717, 2N718, 2N718A, 2N730, 2N731, and 2N956 are in JEDEC TO-18 packages.
Device types 2N696, 2N697, 2N1420, 2N1507, 2N1613, and 2N1711 are in JEDEC TO-5 packages.



TO-18 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-5



TO-18 TO-5

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N696 2N697	2N717 2N718	2N718A	2N730 2N731	2N956	2N1420 2N1507	2N1613	2N1711	UNIT
Collector-Base Voltage	60	60	75	60	75	60	75	75	v
Collector-Emitter Voltage (See Note 1)	40	40	50	40	50	30	50	50	v
Collector-Emitter Voltage (See Note 2)			32						v
Emitter-Base Voltage	5	5	7	5	7	5	7	7	v
Collector Current				1.0		1.0		1.0	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses)→	0.6 † (3)	0.4 †† (5)	0.5 (7)	0.5 †† (9)	0.5 (7)	0.6 † (3)	0.8 (10)	0.8 (10)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses)→	2.0 † (4)	1.5 †† (6)	1.8 (8)	1.5 †† (6)	1.8 (8)	2.0 † (4)	3.0 (11)	3.0 (11)	w
Total Device Dissipation at 100°C Case Temperature	1.0 †	0.75 ††	1.0	0.75 ††	1.0	1.0 †	1.7	1.7	w
Operating Collector Junction Temperature	175†	175††	200	175††	200	175†	200	200	°C
Storage Temperature Range	—65°C to 200°C								

NOTES: 1. This value applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/C°.
4. Derate linearly to 175°C case temperature at the rate of 13.3 mw/C°.
5. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/C°.
6. Derate linearly to 175°C case temperature at the rate of 10.0 mw/C°.
7. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/C°.
8. Derate linearly to 200°C case temperature at the rate of 10.3 mw/C°.
9. Derate linearly to 175°C free-air temperature at the rate of 3.33 mw/C°.
10. Derate linearly to 200°C free-air temperature at the rate of 4.56 mw/C°.
11. Derate linearly to 200°C case temperature at the rate of 17.2 mw/C°.

†Texas Instruments guarantees its types 2N696, 2N697, 2N1420, and 2N1507 to be capable of the same dissipation as registered and shown for types 2N1613 and 2N1711 with appropriate derating factors shown in Notes 10 and 11.

††Texas Instruments guarantees its types 2N717, 2N718, 2N730, and 2N731 to be capable of the same dissipation as registered and shown for types 2N718A and 2N956 with appropriate derating factors shown in Notes 7 and 8.

*Indicates JEDEC registered data.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TO-18→ / TO-5→ 2N696 MIN	2N696 MAX	2N697 MIN	2N697 MAX	2N717 / 2N730 MIN	2N717 / 2N730 MAX	2N718 / 2N731 MIN	2N718 / 2N731 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	60		60		60		60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 12									v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 12	40		40		40		40		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$ Except 2N717, 2N718: $I_E = 1$ ma	5		5		5		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$		1.0		1.0		1.0		1.0	μa
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$		100		100		100		100	μa
		$V_{CB} = 60$ v, $I_E = 0$									μa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$									μa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100\ k\Omega$									μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$									μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$									
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$									
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 12									
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$ See Note 12									
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 12	20	60	40	120	20	60	40	120	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 12									
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.5		1.5		1.5		1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									μmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.0		2.5		2.0		2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		35		35		35		35	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc						80		80	pf

NOTE 12: These parameters must be measured using pulse techniques. PW ≤ 300 μsec, Duty Cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data

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TYPES 2N698, 2N699, 2N719, 2N719A, 2N720, 2N720A, 2N870, 2N871, 2N1889, 2N1890, 2N1893 N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 733442, MAY 1963—REVISED MARCH 1973

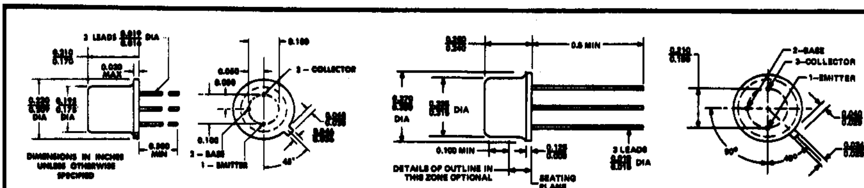
Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

- **High Voltage** • **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

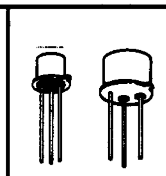
4

mechanical data

Device types 2N719, 2N719A, 2N720, 2N720A, 2N870 and 2N871 are in JEDEC TO-18 packages*.
Device types 2N698, 2N699, 2N1889, 2N1890, and 2N1893 are in JEDEC TO-39 packages♦.



TO-18* THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-39♦



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N698	2N699	2N719 2N720	2N719A	2N720A	2N870 2N871	2N1889 2N1890	2N1893	UNIT
Collector-Base Voltage	120	120	120	120	120	100	100	120	v
Collector-Emitter Voltage (See Note 1)	80	80	80	80	100	80	80	100	v
Collector-Emitter Voltage (See Note 2)	60			60	80	60	60	80	v
Emitter-Base Voltage	7	5	5	7	7	7	7	7	v
Collector Current				1.0				0.5	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) ⟶	0.8 (3)	0.6 † (5)	0.4 ‡ (7)	0.5 (9)	0.5 (9)	0.5 (9)	0.8 (3)	0.8 (3)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) ⟶	3.0 † (4)	2.0 † (6)	1.5 ‡ (8)	1.8 (10)	1.8 (10)	1.8 (10)	3.0 † (4)	3.0 † (4)	w
Storage Temperature Range	—65°C to 200°C								

NOTES: 1. This values applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This values applies when the base-emitter diode is open-circuited.
3. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
4. Derate linearly to 200°C case temperature at the rate of 17.2 mw/°C.
5. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/°C.
6. Derate linearly to 175°C case temperature at the rate of 13.3 mw/°C.
7. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/°C.
8. Derate linearly to 175°C case temperature at the rate of 10.0 mw/°C.
9. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/°C.
10. Derate linearly to 200°C case temperature at the rate of 10.3 mw/°C.

†Texas Instruments guarantees these devices in TO-39 packages date-coded 7326 or higher to be capable of increased dissipation as follows: 0.8 W at T_A < 25°C derated linearly to T_A = 200°C at the rate of 4.57 mW/°C, or 10 W at T_C < 25°C (5.71 W at T_C = 100°C) derated linearly to T_C = 200°C at the rate of 57.1 mW/°C.

‡Texas Instruments guarantees its types 2N719 and 2N720 to be capable of the same dissipation as registered and shown for types 2N719A, 2N720A, 2N870, and 2N871 with appropriate derating factors shown in Notes 9 and 10.

*JEDEC registered data.
♦The JEDEC registered outline for these devices is TO-5.
TO-39 falls within TO-5 with the exception of lead length.

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS (TO-18 → / TO-39 →)	2N698 MIN	2N698 MAX	2N699 MIN	2N699 MAX	2N719 MIN	2N719 MAX	2N719A MIN	2N719A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	120				120		120		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 11	60						60		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 11	80		80		80		80		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	7						7		v
		$I_E = 1$ ma, $I_C = 0$					5				v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$				2		2			μa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$						200			μa
		$V_{CB} = 75$ v, $I_E = 0$		0.005						0.010	μa
		$V_{CB} = 75$ v, $I_E = 0$, $T_A = 150°C$		15						15	μa
		$V_{CB} = 90$ v, $I_E = 0$									μa
		$V_{CB} = 90$ v, $I_E = 0$, $T_A = 150°C$									μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 2$ v, $I_C = 0$				100					μa
		$V_{EB} = 5$ v, $I_C = 0$		0.010						0.010	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$									
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 11									
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 11									
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 11	20	60	40	120	20	60	20	60	
V_{BE}	Base-Emitter Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11		0.9						0.9	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11		1.2						1.2	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		5		5		5		5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	20	35	20	30	20	35	20	35	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		10		10		10		10	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		2.5×10^{-4}		2.5×10^{-4}		2.5×10^{-4}		2.5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		5×10^{-4}		3×10^{-4}		5×10^{-4}		5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		0.5	0.1	0.5	0.1	0.5	0.1	0.5	μmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		1.0		1.0		1.0		1.0	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	15		35	100	15		15		
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	25		45		25		25		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.0		2.5		2.0		2.0		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc; Except 2N719: $f = 140$ kc		15		20		20		15	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc; Except 2N719: $f = 140$ kc		85				85		85	pf

NOTE 11 These parameters must be measured using pulse techniques. PW $\leq 300\ \mu$sec., Duty cycle $\leq 2\%$. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data.

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TYPES 2N696, 2N697, 2N717, 2N718, 2N718A, 2N730, 2N731, 2N956, 2N1420, 2N1507, 2N1613, 2N1711
N-P-N SILICON TRANSISTORS

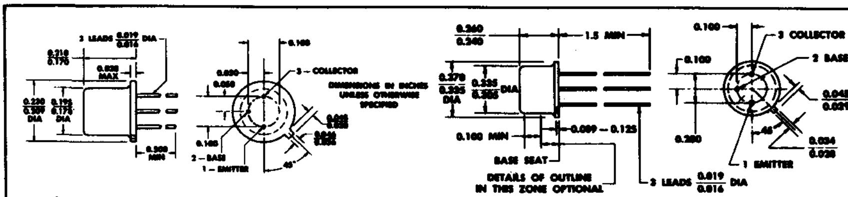
BULLETIN NO. DL-S 693471, MAY 1963—REVISED AUGUST 1969

Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

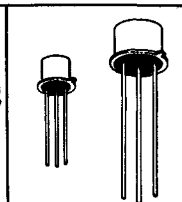
- **High Voltage**
- **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

*mechanical data

Device types 2N717, 2N718, 2N718A, 2N730, 2N731, and 2N956 are in JEDEC TO-18 packages.
Device types 2N696, 2N697, 2N1420, 2N1507, 2N1613, and 2N1711 are in JEDEC TO-5 packages.



TO-18 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-5



TO-18 TO-5

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*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N696 2N697	2N717 2N718	2N718A	2N730 2N731	2N956	2N1420 2N1507	2N1613	2N1711	UNIT
Collector-Base Voltage	60	60	75	60	75	60	75	75	v
Collector-Emitter Voltage (See Note 1)	40	40	50	40	50	30	50	50	v
Collector-Emitter Voltage (See Note 2)			32						v
Emitter-Base Voltage	5	5	7	5	7	5	7	7	v
Collector Current				1.0		1.0		1.0	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) →	0.6 † (3)	0.4 †† (5)	0.5 (7)	0.5 †† (9)	0.5 (7)	0.6 † (3)	0.8 (10)	0.8 (10)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) →	2.0 † (4)	1.5 †† (6)	1.8 (8)	1.5 †† (6)	1.8 (8)	2.0 † (4)	3.0 (11)	3.0 (11)	w
Total Device Dissipation at 100°C Case Temperature	1.0 †	0.75 ††	1.0	0.75 ††	1.0	1.0 †	1.7	1.7	w
Operating Collector Junction Temperature	175†	175††	200	175††	200	175†	200	200	°C
Storage Temperature Range	—65°C to 200°C								

NOTES:
1. This value applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/C°.
4. Derate linearly to 175°C case temperature at the rate of 13.3 mw/C°.
5. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/C°.
6. Derate linearly to 175°C case temperature at the rate of 10.0 mw/C°.
7. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/C°.
8. Derate linearly to 200°C case temperature at the rate of 10.3 mw/C°.
9. Derate linearly to 175°C free-air temperature at the rate of 3.33 mw/C°.
10. Derate linearly to 200°C free-air temperature at the rate of 4.56 mw/C°.
11. Derate linearly to 200°C case temperature at the rate of 17.2 mw/C°.

†Texas Instruments guarantees its types 2N696, 2N697, 2N1420, and 2N1507 to be capable of the same dissipation as registered and shown for types 2N1613 and 2N1711 with appropriate derating factors shown in Notes 10 and 11.

††Texas Instruments guarantees its types 2N717, 2N718, 2N730, and 2N731 to be capable of the same dissipation as registered and shown for types 2N718A and 2N956 with appropriate derating factors shown in Notes 7 and 8.

*Indicates JEDEC registered data.

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TYPES 2N696, 2N697, 2N717, 2N718, 2N718A, 2N730, 2N731
N-P-N SILICON TRANSISTORS

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N696 (TO-5) MIN	2N696 MAX	2N697 (TO-5) MIN	2N697 MAX	2N717 (TO-18) / 2N730 (TO-5) MIN	MAX	2N718 (TO-18) / 2N731 (TO-5) MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	60		60		60		60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 12									v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 12	40		40		40		40		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$ Except 2N717,2N718: $I_E = 1$ ma	5		5		5		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$		1.0		1.0		1.0		1.0	µa
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$		100		100		100		100	µa
		$V_{CB} = 60$ v, $I_E = 0$									µa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$									µa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100\ k\Omega$									µa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$									µa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$									
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$									
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 12									
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$ See Note 12									
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 12	20	60	40	120	20	60	40	120	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 12									
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.5		1.5		1.5		1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									µmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									µmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.0		2.5		2.0		2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		35		35		35		35	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc						80		80	pf

NOTE 12: These parameters must be measured using pulse techniques. PW $\leq 300\ \mu sec$, Duty Cycle $\leq 2\%$. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	TO-18→ 2N718A						2N956		UNIT
		TO-5→	2N1613		2N1420		2N1507		2N1711		
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	75		60		60		75		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 12					25				v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 12	50		30		30		50		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	7						7		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$				1.0		1.0			μa
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$				100		50			μa
		$V_{CB} = 60$ v, $I_E = 0$		0.010						0.010	μa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		10						10	μa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100$ kΩ						10			μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		0.01				100		0.005	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$							20		
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$	20						35		
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 12	35						75		
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 12	20						35		
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 12	40	120	100	300	100	300	100	300	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 12	20						40		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.5		1.5		1.5		1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc	24	34					24	34	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc	4	8					4	8	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc		3×10^{-4}						5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc		3×10^{-4}						5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc	0.1	0.5					0.1	0.5	μmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc	0.1	1.0					0.1	1.0	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, f = 1 kc	30	100					50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, f = 1 kc	35	150					70	300	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, f = 20 mc	3.0		2.5		2.5		3.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, f = 1 mc		25		35		35		25	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, f = 1 mc		80						80	pf

NOTE 12: These parameters must be measured using pulse techniques. PW ≤ 300 μsec, Duty Cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data

*operating characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	TO-18 → 2N956 TYP	TO-18 → 2N956 MAX	TO-18 → 2N718A TYP	TO-18 → 2N718A MAX	UNIT
		TO-5 → 2N1711		TO-5 → 2N1613		
NF Spot Noise Figure	$V_{CE} = 10$ v, $I_C = 300$ μa, $R_G = 510$ Ω, f = 1 kc	5	8	6	12	db

* switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	TO-18 → 2N718A / TO-5 → 2N1613 TYP	MAX	UNIT
t_T Total Switching Time	See Figure 1	20	30	nsec

*PARAMETER MEASUREMENT INFORMATION

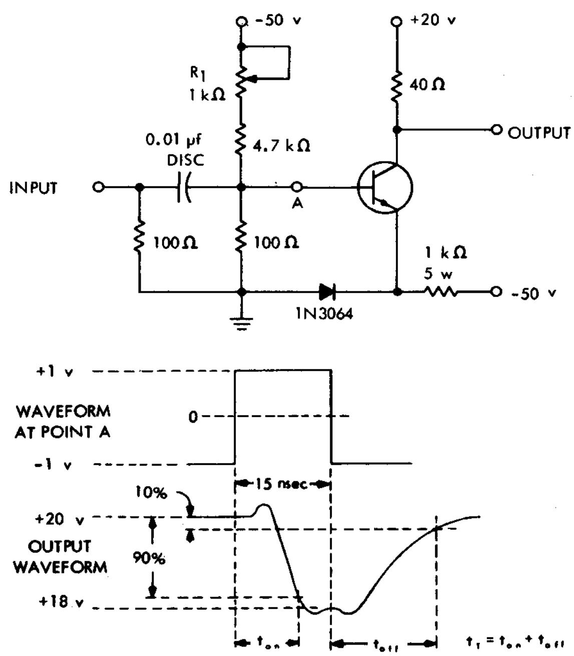


FIGURE 1 — SWITCHING TIME MEASUREMENT CIRCUIT FOR 2N718A AND 2N1613

NOTES: 13. The input waveform is supplied by a mercury relay pulse generator with the following characteristics: $t_r \leq 1$ nsec, $t_f \leq 1$ nsec, PW = 15 nsec. Adjust R_1 and the input pulse amplitude to obtain the specified voltage levels at Point A.

14. Waveforms are monitored on a sampling oscilloscope ($t_r \leq 0.4$ nsec) using a 2000 Ω probe.

*Indicates JEDEC registered data (typical data excluded)

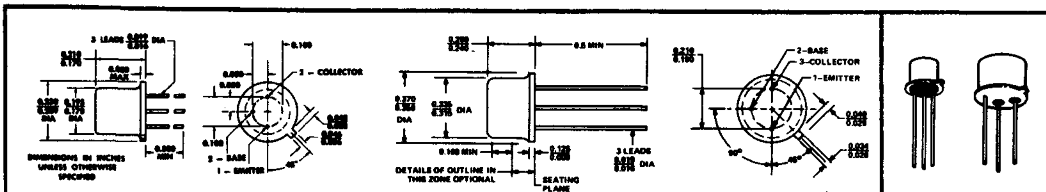
BULLETIN NO. DL-S 733442, MAY 1963—REVISED MARCH 1973

Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

- **High Voltage**
- **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

mechanical data

Device types 2N719, 2N719A, 2N720, 2N720A, 2N870 and 2N871 are in JEDEC TO-18 packages•.
Device types 2N698, 2N699, 2N1889, 2N1890, and 2N1893 are in JEDEC TO-39 packages♦.



TO-18• THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-39♦

•absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N698	2N699	2N719 2N720	2N719A	2N720A	2N870 2N871	2N1889 2N1890	2N1893	UNIT
Collector-Base Voltage	120	120	120	120	120	100	100	120	v
Collector-Emitter Voltage (See Note 1)	80	80	80	80	100	80	80	100	v
Collector-Emitter Voltage (See Note 2)	60			60	80	60	60	80	v
Emitter-Base Voltage	7	5	5	7	7	7	7	7	v
Collector Current				1.0				0.5	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) →	0.8 (3)	0.6 † (5)	0.4 ‡ (7)	0.5 (9)	0.5 (9)	0.5 (9)	0.8 (3)	0.8 (3)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) →	3.0 † (4)	2.0 † (6)	1.5 ‡ (8)	1.8 (10)	1.8 (10)	1.8 (10)	3.0 † (4)	3.0 † (4)	w
Storage Temperature Range	—65°C to 200°C								

NOTES: 1. This values applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This values applies when the base-emitter diode is open-circuited.
3. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
4. Derate linearly to 200°C case temperature at the rate of 17.2 mw/°C.
5. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/°C.
6. Derate linearly to 175°C case temperature at the rate of 13.3 mw/°C.
7. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/°C.
8. Derate linearly to 175°C case temperature at the rate of 10.0 mw/°C.
9. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/°C.
10. Derate linearly to 200°C case temperature at the rate of 10.3 mw/°C.

†Texas Instruments guarantees these devices in TO-39 packages date-coded 7326 or higher to be capable of increased dissipation as follows: 0.8 W at $T_A \le 25°C$ derated linearly to $T_A = 200°C$ at the rate of 4.57 mW/°C, or 10 W at $T_C \le 25°C$ (5.71 W at $T_C = 100°C$) derated linearly to $T_C = 200°C$ at the rate of 57.1 mW/°C.

‡Texas Instruments guarantees its types 2N719 and 2N720 to be capable of the same dissipation as registered and shown for types 2N719A, 2N720A, 2N870, and 2N871 with appropriate derating factors shown in Notes 9 and 10.

•JEDEC registered data.
♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.

USES CHIP N23

TYPES 2N698, 2N699, 2N719, 2N719A, 2N720, 2N720A
N-P-N SILICON TRANSISTORS

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	TO-39→ 2N698 MIN	2N698 MAX	TO-39→ 2N699 MIN	2N699 MAX	TO-18→ 2N719 MIN	2N719 MAX	TO-18→ 2N719A MIN	2N719A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	120				120		120		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 11	60						60		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 11	80		80		80		80		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	7						7		v
		$I_E = 1$ ma, $I_C = 0$					5				v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$				2		2			μa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$						200			μa
		$V_{CB} = 75$ v, $I_E = 0$		0.005						0.010	μa
		$V_{CB} = 75$ v, $I_E = 0$, $T_A = 150°C$		15						15	μa
		$V_{CB} = 90$ v, $I_E = 0$									μa
		$V_{CB} = 90$ v, $I_E = 0$, $T_A = 150°C$									μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 2$ v, $I_C = 0$				100					μa
		$V_{EB} = 5$ v, $I_C = 0$		0.010						0.010	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$									
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 11									
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 11									
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 11	20	60	40	120	20	60	20	60	
V_{BE}	Base-Emitter Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11		0.9						0.9	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11		1.2						1.2	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		5		5		5		5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	20	35	20	30	20	35	20	35	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		10		10		10		10	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		2.5×10^{-4}		2.5×10^{-4}		2.5×10^{-4}		2.5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		5×10^{-4}		3×10^{-4}		5×10^{-4}		5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		0.5	0.1	0.5	0.1	0.5	0.1	0.5	μmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		1.0		1.0		1.0		1.0	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	15		35	100	15		15		
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	25		45		25		25		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.0		2.5		2.0		2.0		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc; Except 2N719: $f = 140$ kc		15		20		20		15	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc; Except 2N719: $f = 140$ kc		85				85		85	pf

NOTE 11 These parameters must be measured using pulse techniques. PW $\leq 300\ \mu$sec., Duty cycle $\leq 2\%$. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data.

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N720		2N720A		2N870		2N871		UNIT
		TO-18→	2N720		2N720A		2N870		2N871		
		TO-39→			2N1893		2N1889		2N1890		
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	120		120		100		100		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 11			80		60		60		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 11	80		100		80		80		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$			7		7		7		v
		$I_E = 1$ ma, $I_C = 0$	5								v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$		2							μa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		200							μa
		$V_{CB} = 75$ v, $I_E = 0$						0.010		0.010	μa
		$V_{CB} = 75$ v, $I_E = 0$, $T_A = 150°C$						15		15	μa
		$V_{CB} = 90$ v, $I_E = 0$				0.010					μa
		$V_{CB} = 90$ v, $I_E = 0$, $T_A = 150°C$				15					μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 2$ v, $I_C = 0$									μa
		$V_{EB} = 5$ v, $I_C = 0$				0.010		0.010		0.010	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$			20		20				
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 11			35		35				
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 11			20		20				
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 11	40	120	40	120	40	120	100	300	
V_{BE}	Base-Emitter Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11				0.9		0.9		0.9	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11				1.2		1.2		1.2	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		5		5		5		5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	20	30	20	30	20	30	20	30	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		10	4	8	4	8	4	8	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		2.5×10^{-4}		1.25×10^{-4}		1.25×10^{-4}		1.5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		3×10^{-4}		1.5×10^{-4}		1.5×10^{-4}		1.5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	0.1	0.5		0.5		0.5		0.3	μmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		1.0		0.5		0.5		0.3	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	35	100	30	100	30	100	50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	45		45		45	150	70	300	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.5		2.5		2.5		3.0		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc; Except 2N720: $f = 140$ kc		20		15		15		15	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc; Except 2N720: $f = 140$ kc		85		85		85		85	pf

NOTE 11: These parameters must be measured using pulse techniques. PW ≤ 300 μsec., Duty cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data.

4

TEXAS INSTRUMENTS
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POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

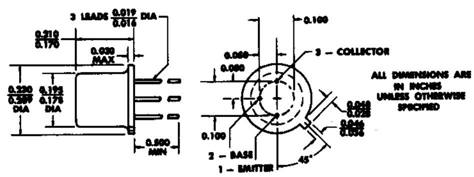
BULLETIN NO. DL-S 7311976, JUNE 1973

FOR MEDIUM-SPEED, MEDIUM-POWER, GENERAL PURPOSE AMPLIFIER APPLICATIONS

- f_T . . . 60 MHz min (2N722)

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−50 V
Collector-Emitter Voltage (See Note 1)	−35 V
Collector-Emitter Voltage (See Note 2)	−50 V
Emitter-Base Voltage	−5 V
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	0.4 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	1.5 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. This value applies when the base-emitter resistance $R_{BE} \leq 10\ \Omega$.
3. Derate linearly to 175°C free-air temperature at the rate of 2.67 mW/°C.
4. Derate linearly to 175°C case temperature at the rate of 10 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP P20

TEXAS INSTRUMENTS
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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		2N721 MIN	2N721 MAX	2N722 MIN	2N722 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$		−50		−50		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100\ mA$, $I_B = 0$,	See Note 5	−35		−35		V
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = -100\ mA$, $R_{BE} = 10\ \Omega$,	See Note 5	−50		−50		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30\ V$, $I_E = 0$			−1		−1	μA
		$V_{CB} = -30\ V$, $I_E = 0$,	$T_A = 150°C$		−100		−100	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -2\ V$, $I_C = 0$			−100		−100	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10\ V$, $I_C = -5\ mA$	See Note 5	15		25		
		$V_{CE} = -10\ V$, $I_C = -150\ mA$		20	45	30	90	
V_{BE}	Base-Emitter Voltage	$I_B = -15\ mA$, $I_C = -150\ mA$,	See Note 5		−1.3		−1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15\ mA$, $I_C = -150\ mA$,	See Note 5		−1.5		−1.5	V
h_{ib}	Small-Signal Common-base Input Impedance	$V_{CB} = -5\ V$, $I_C = -1\ mA$,	f = 1 kHz	25	35	25	35	Ω
		$V_{CB} = -10\ V$, $I_C = -5\ mA$,	f = 1 kHz		10		10	
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = -5\ V$, $I_C = -1\ mA$,	f = 1 kHz		8×10^{-4}		8×10^{-4}	
		$V_{CB} = -10\ V$, $I_C = -5\ mA$,	f = 1 kHz		8×10^{-4}		8×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = -5\ V$, $I_C = -1\ mA$,	f = 1 kHz		1		1	μmho
		$V_{CB} = -10\ V$, $I_C = -5\ mA$,	f = 1 kHz		5		5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5\ V$, $I_C = -1\ mA$,	f = 1 kHz	15	50	25	100	
		$V_{CE} = -10\ V$, $I_C = -5\ mA$,	f = 1 kHz	20		30		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10\ V$, $I_C = -50\ mA$, $T_C = 25°C$	f = 20 MHz,	2.5		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10\ V$, $I_E = 0$,	f = 1 MHz		45		45	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5\ V$, $I_C = 0$,	f = 1 MHz		100		80	pF

NOTE 5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 1 %.
*JEDEC registered data

4

THERMAL INFORMATION

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

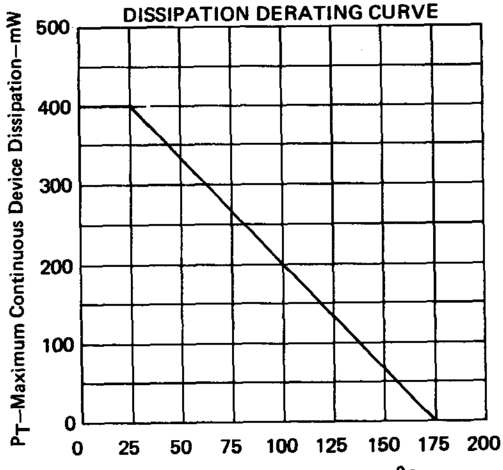


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

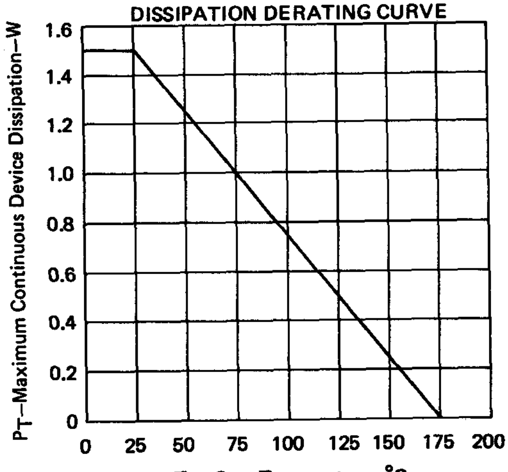


FIGURE 2

TYPES 2N696, 2N697, 2N717, 2N718, 2N718A, 2N730, 2N731, 2N956, 2N1420, 2N1507, 2N1613, 2N1711 N-P-N SILICON TRANSISTORS

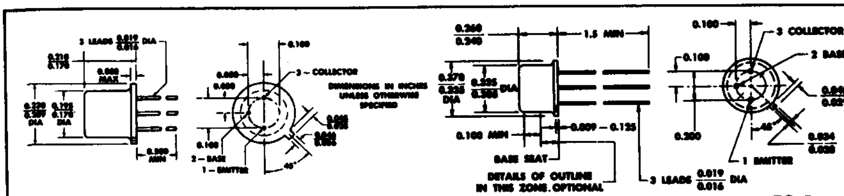
BULLETIN NO. DL-S 693471, MAY 1963—REVISED AUGUST 1969

Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

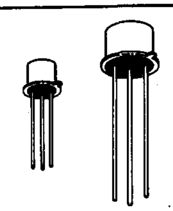
- High Voltage
- Low Leakage
- Useful h_{FE} Over Wide Current Range

*mechanical data

Device types 2N717, 2N718, 2N718A, 2N730, 2N731, and 2N956 are in JEDEC TO-18 packages.
Device types 2N696, 2N697, 2N1420, 2N1507, 2N1613, and 2N1711 are in JEDEC TO-5 packages.



TO-18 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-5



TO-18 TO-5

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N696 2N697	2N717 2N718	2N718A	2N730 2N731	2N956	2N1420 2N1507	2N1613	2N1711	UNIT
Collector-Base Voltage	60	60	75	60	75	60	75	75	v
Collector-Emitter Voltage (See Note 1)	40	40	50	40	50	30	50	50	v
Collector-Emitter Voltage (See Note 2)			32						v
Emitter-Base Voltage	5	5	7	5	7	5	7	7	v
Collector Current				1.0		1.0		1.0	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses)→	0.6 † (3)	0.4 †† (5)	0.5 (7)	0.5 †† (9)	0.5 (7)	0.6 † (3)	0.8 (10)	0.8 (10)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses)→	2.0 † (4)	1.5 †† (6)	1.8 (8)	1.5 †† (6)	1.8 (8)	2.0 † (4)	3.0 (11)	3.0 (11)	w
Total Device Dissipation at 100°C Case Temperature	1.0 †	0.75 ††	1.0	0.75 ††	1.0	1.0 †	1.7	1.7	w
Operating Collector Junction Temperature	175†	175††	200	175††	200	175†	200	200	°C
Storage Temperature Range	—65°C to 200°C								

NOTES:
1. This value applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/C°.
4. Derate linearly to 175°C case temperature at the rate of 13.3 mw/C°.
5. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/C°.
6. Derate linearly to 175°C case temperature at the rate of 10.0 mw/C°.
7. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/C°.
8. Derate linearly to 200°C case temperature at the rate of 10.3 mw/C°.
9. Derate linearly to 175°C free-air temperature at the rate of 3.33 mw/C°.
10. Derate linearly to 200°C free-air temperature at the rate of 4.56 mw/C°.
11. Derate linearly to 200°C case temperature at the rate of 17.2 mw/C°.

†Texas Instruments guarantees its types 2N696, 2N697, 2N1420, and 2N1507 to be capable of the same dissipation as registered and shown for types 2N1613 and 2N1711 with appropriate derating factors shown in Notes 10 and 11.

††Texas Instruments guarantees its types 2N717, 2N718, 2N730, and 2N731 to be capable of the same dissipation as registered and shown for types 2N718A and 2N956 with appropriate derating factors shown in Notes 7 and 8.

*Indicates JEDEC registered data.

USES CHIP N24

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TO-18→ / TO-5→ 2N696		TO-18→ / TO-5→ 2N697		2N717 (TO-18) / 2N730 (TO-18)		2N718 (TO-18) / 2N731 (TO-18)		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	60		60		60		60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 12									v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 12	40		40		40		40		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$ Except 2N717,2N718: $I_E = 1$ ma	5		5		5		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$		1.0		1.0		1.0		1.0	µa
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$		100		100		100		100	µa
		$V_{CB} = 60$ v, $I_E = 0$									µa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$									µa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100$ kΩ									µa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$									µa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$									
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$									
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 12									
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$ See Note 12									
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 12	20	60	40	120	20	60	40	120	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 12									
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.5		1.5		1.5		1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									µmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									µmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc									
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc									
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.0		2.5		2.0		2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		35		35		35		35	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc						80		80	pf

NOTE 12: These parameters must be measured using pulse techniques. PW ≤ 300 µsec, Duty Cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data

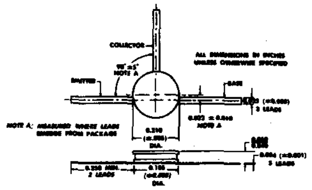
BULLETIN NO. DL-S 652401, MARCH 1962–REVISED OCTOBER 1965

DESIGNED FOR HIGH-SPEED SWITCHING APPLICATIONS

mechanical data

The transistors are in a hermetically sealed welded package meeting the JEDEC TO-50 outline.

* CASE OUTLINE



ALL LEADS INSULATED FROM CASE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	25 v
Collector-Emitter Voltage (see note 1)	15 v
Emitter-Base Voltage	5 v
Collector Current	50 ma
Total Device Dissipation at 25°C Free-Air Temperature (see note 2)	0.3 w
Total Device Dissipation at 25°C Case Temperature (see note 3)	1.2 w
Collector Junction Operating Temperature	175°C
Storage Temperature Range	−65°C to +200°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITONS		MIN	MAX	UNIT
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ v, $I_E = 0$,			0.5	μa
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ v, $I_E = 0$ $T_A = 150°C$			30	μa
I_{CBO}	Collector Cutoff Current	$V_{CB} = 25$ v, $I_E = 0$			10	μa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100$ kΩ			10	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$			10	μa
†$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$		15		v
†$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $R_{BE} = 10\ \Omega$		20		v
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10$ μa, $I_E = 0$		25		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10$ μa, $I_C = 0$		5		v
†h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ v, $I_C = 10$ ma	2N849	20	60	
			2N850	40	120	
†V_{BE}	Base-Emitter Voltage	$I_B = 1$ ma, $I_C = 10$ ma		0.7	0.9	v
†$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ ma, $I_C = 10$ ma			0.6	v
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_E = -10$ ma, f = 100 mc		6		db
C_{ob}	Common-Base Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$, f = 1 mc			5	pf

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		MAX	UNIT
t_{on}	Turn-On Time	$I_{B(1)} = 3$ ma, $I_{B(2)} = -1$ ma		40	nsec
t_{off}	Turn-Off Time	$V_{CC} = 3$ v, $R_L = 270\ \Omega$, (see Circuit A)		75	nsec
t_s	Storage Time	$I_C = 10$ ma, $V_{CC} = 10$ v, (see Circuit B) $R_L = 1$ KΩ, $I_{B(1)} = \lvert I_{B(2)} \rvert = 10$ ma	2N849	25	nsec
			2N850	35	nsec

†These parameters must be measured with a pulse duration of 300 microseconds and a duty cycle of 2 percent.

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 2mw/°C.
3. Derate linearly to 175°C case temperature at the rate of 8mw/°C.

*Indicates JEDEC registered data.

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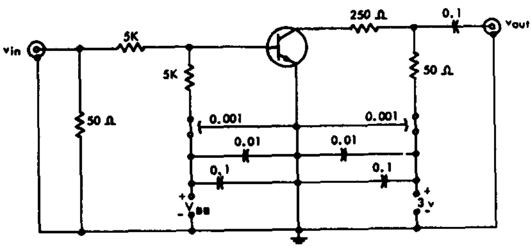
*CIRCUIT A



Conditions For t_{on}

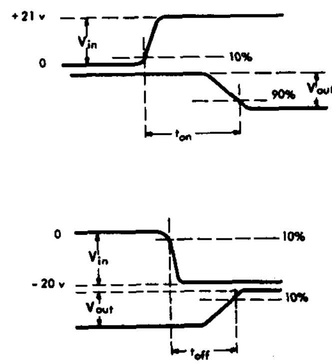
V_{BB} = - 4v

V_{in} = + 21v

Conditions For t_{off}

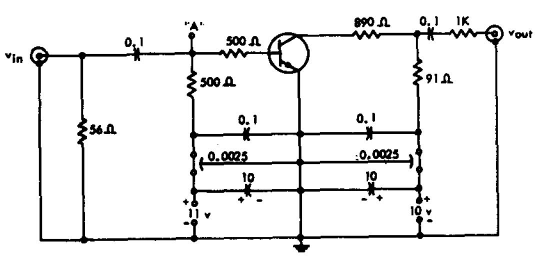
V_{BB} = 17v

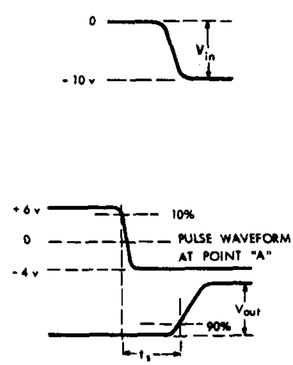
V_{in} = - 20v



INPUT AND OUTPUT PULSE WAVEFORMS

*CIRCUIT B





INPUT AND OUTPUT PULSE WAVEFORMS

NOTES: a) All capacitances in μf.
b) All resistors ±1%, 0.1 w, HFR.
c) Decoupling capacitors (25μf) are placed across the power supply terminals to V_{CC} and V_{BB}.
d) The input to each circuit is supplied by a Model 303 Lumatron Mercury-Relay Pulse Generator (Z_{out} = 50 Ω) or equivalent. Pulse rise time ≤ 1 nsec. PW ≥ 400 nsec, Duty Cycle ≤ 2%.
e) Output waveforms are monitored by a Model 12-AB Lumatron Sampling Oscilloscope (Z_{in} = 50 Ω, rise time ≤ 1 nsec) or equivalent.

*Indicates JEDEC registered data

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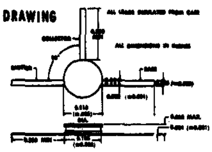
TYPES 2N851, 2N852
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 652400, MARCH 1962—REVISED SEPTEMBER 1965

DESIGNED FOR HIGH-SPEED SWITCHING APPLICATIONS

*OUTLINE DRAWING



***absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)**

Collector-Base Voltage	20 v
Collector-Emitter Voltage (see note 1)	12 v
Emitter-Base Voltage	5 v
Collector Current	200 ma
Total Device Dissipation at 25°C Free-Air Temperature (see note 2)	0.3 w
Total Device Dissipation at 25°C Case Temperature (see note 3)	1.2 w
Collector Junction Operating Temperature	175°C
Storage Temperature Range	−65°C to +200°C

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

	PARAMETER	TEST CONDITIONS		MIN	MAX	UNIT
I_{CES}	Collector Cutoff Current	$V_{CE} = 20$ v, $V_{BE} = 0$			1	μa
I_{CES}	Collector Cutoff Current	$V_{CE} = 20$ v, $V_{BE} = 0$, $T_A = 170°C$			100	μa
I_{CEX}	Collector Cutoff Current	$V_{CE} = 10$ v, $V_{BE} = +0.35$ v, $T_A = 100°C$			30	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$			10	μa
†$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$		12		v
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10$ μa, $I_E = 0$		20		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10$ μa, $I_C = 0$		5		v
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 0.25$ v, $I_C = 1$ ma	2N851	10		
			2N852	20		
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 0.35$ v, $I_C = 10$ ma	2N851	20	60	
			2N852	40	120	
†h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1.0$ v, $I_C = 100$ ma	2N851	10		
			2N852	20		
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 0.35$ v, $I_C = 10$ ma, $T_A = -55°C$	2N851	10		
			2N852	20		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ ma, $I_C = 10$ ma		0.65	0.85	v
†V_{BE}	Base-Emitter Voltage	$I_B = 10$ ma, $I_C = 100$ ma			1.5	v
V_{BE}	Base-Emitter Voltage	$I_B = 1$ ma, $I_C = 10$ ma, $T_A = -55°C$			1.1	v
†V_{BE}	Base-Emitter Voltage	$I_B = 10$ ma, $I_C = 100$ ma, $T_A = -55°C$			1.6	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ ma, $I_C = 10$ ma, $T_A = 170°C$			0.35	v
†$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 10$ ma, $I_C = 100$ ma, $T_A = 170°C$			1.0	v
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 100$ mc		9		db
C_{ob}	Common-Base Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$, $f = 1$ mc			5	pf

***switching characteristics at 25°C free-air temperature**

	PARAMETER	TEST CONDITIONS		MAX	UNIT
t_{on}	Turn-On Time	$I_C \cong 10$ ma in Circuit A		16	nsec
		$I_C \cong 100$ ma in Circuit A		12	nsec
t_{off}	Turn-Off Time	$I_C \cong 10$ ma in Circuit A	2N851	24	nsec
			2N852	24	nsec
		$I_C \cong 100$ ma in Circuit A	2N851	40	nsec
			2N852	45	nsec
t_s	Storage Time	$I_C \cong I_{B(1)} \cong \|I_{B(2)}\| \cong 10$ ma in Circuit B	2N851	14	nsec
			2N852	18	nsec

†These parameters must be measured with a pulse duration of 300 microseconds and a duty cycle of 2 percent.

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 2 mw/°C.
3. Derate linearly to 175°C case temperature at the rate of 8 mw/°C.

*Indicates JEDEC registered data.

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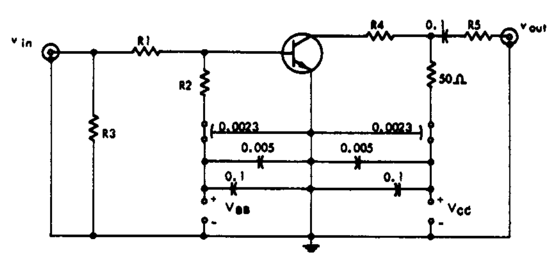
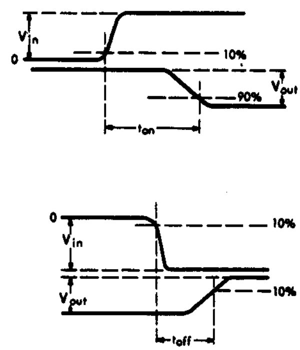
PARAMETER MEASUREMENT INFORMATION

CIRCUIT A





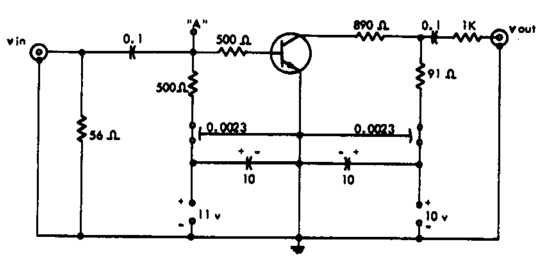
INPUT AND OUTPUT PULSE WAVEFORMS

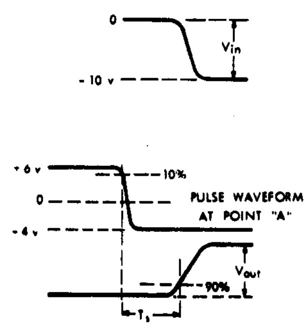
CIRCUIT CONDITIONS

I_C ma*	$I_{B(1)}$ ma*	$I_{B(2)}$ ma*	$V_{BE(0)}$** v	V_{CC} v	$R_1 = R_2$ Ω	R_3 Ω	R_4 Ω	R_5 Ω	t_{on} V_{BB}, v	t_{on} V_{in}, v	t_{off} V_{BB}, v	t_{off} V_{in}, v
10	3	−1.5	−1.5	3.0	3.3 K	50	220	0	−3.0	15.0	12.0	−15.0
100	40	−20.0	−2.4	6.0	330(b)	56	0	1 K	−4.5	20.0	15.3(d)	−20.0

*Approximate values.
**Prior base-emitter voltage, "OFF" state.

CIRCUIT B





INPUT AND OUTPUT PULSE WAVEFORMS

NOTES: a) All capacitances in μf.
b) All resistors ± 1%, 0.1 w, HFR except R2 is 0.5 w at 100 ma.
.) Decoupling capacitors ($25 \mu f$) are placed across the power supply terminals to V_{CC} and V_{BB}.
d) V_{BB} is pulsed for 1.5 sec at less than 10% duty cycle for 100 ma t_{off} to keep case temperature below 30°C.
e) The input to each circuit is supplied by a Model 303 Lumatron Mercury-Relay Pulse Generator ($Z_{out} = 50\ \Omega$) or equivalent. Pulse rise time ≤ 1 nsec. PW ≥ 300 nsec, Duty Cycle ≤ 2%.
f) Output waveforms are monitored by a Model 12-AB Lumatron Sampling Oscilloscope ($Z_{in} = 50\ \Omega$, rise time ≤ 1nsec) or equivalent.

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TYPES 2N698, 2N699, 2N719, 2N719A, 2N720, 2N720A, 2N870, 2N871, 2N1889, 2N1890, 2N1893
N-P-N SILICON TRANSISTORS

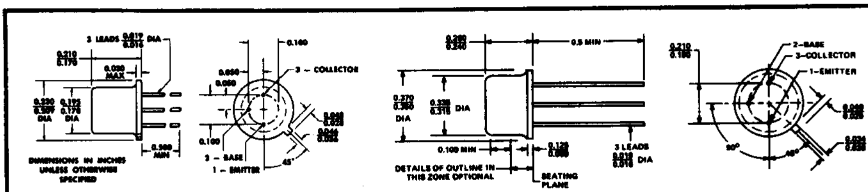
BULLETIN NO. DL-S 733442, MAY 1963—REVISED MARCH 1973

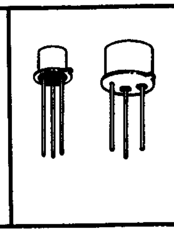
Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

- **High Voltage** • **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

mechanical data

Device types 2N719, 2N719A, 2N720, 2N720A, 2N870 and 2N871 are in JEDEC TO-18 packages*.
Device types 2N698, 2N699, 2N1889, 2N1890, and 2N1893 are in JEDEC TO-39 packages♦.





TO-18* THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-39♦

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N698	2N699	2N719 2N720	2N719A	2N720A	2N870 2N871	2N1889 2N1890	2N1893	UNIT
Collector-Base Voltage	120	120	120	120	120	100	100	120	v
Collector-Emitter Voltage (See Note 1)	80	80	80	80	100	80	80	100	v
Collector-Emitter Voltage (See Note 2)	60			60	80	60	60	80	v
Emitter-Base Voltage	7	5	5	7	7	7	7	7	v
Collector Current				1.0				0.5	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) →	0.8 (3)	0.6 † (5)	0.4 ‡ (7)	0.5 (9)	0.5 (9)	0.5 (9)	0.8 (3)	0.8 (3)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) →	3.0 † (4)	2.0 † (6)	1.5 ‡ (8)	1.8 (10)	1.8 (10)	1.8 (10)	3.0 † (4)	3.0 † (4)	w
Storage Temperature Range	—65°C to 200°C								

NOTES:
1. This values applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This values applies when the base-emitter diode is open-circuited.
3. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
4. Derate linearly to 200°C case temperature at the rate of 17.2 mw/°C.
5. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/°C.
6. Derate linearly to 175°C case temperature at the rate of 13.3 mw/°C.
7. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/°C.
8. Derate linearly to 175°C case temperature at the rate of 10.0 mw/°C.
9. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/°C.
10. Derate linearly to 200°C case temperature at the rate of 10.3 mw/°C.

†Texas Instruments guarantees these devices in TO-39 packages date-coded 7326 or higher to be capable of increased dissipation as follows: 0.8 W at $T_A \leq 25°C$ derated linearly to $T_A = 200°C$ at the rate of 4.57 mW/°C, or 10 W at $T_C \leq 25°C$ (5.71 W at $T_C = 100°C$) derated linearly to $T_C = 200°C$ at the rate of 57.1 mW/°C.

‡Texas Instruments guarantees its types 2N719 and 2N720 to be capable of the same dissipation as registered and shown for types 2N719A, 2N720A, 2N870, and 2N871 with appropriate derating factors shown in Notes 9 and 10.

*JEDEC registered data.
♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.

USES CHIP N23

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS (TO-18 ▸ / TO-39 ▸)	2N720 MIN	2N720 MAX	2N720A / 2N1893 MIN	2N720A / 2N1893 MAX	2N870 / 2N1889 MIN	2N870 / 2N1889 MAX	2N871 / 2N1890 MIN	2N871 / 2N1890 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	120		120		100		100		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 11			80		60		60		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 11	80		100		80		80		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$			7		7		7		v
		$I_E = 1$ ma, $I_C = 0$	5								v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$		2							µa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		200							µa
		$V_{CB} = 75$ v, $I_E = 0$						0.010		0.010	µa
		$V_{CB} = 75$ v, $I_E = 0$, $T_A = 150°C$						15		15	µa
		$V_{CB} = 90$ v, $I_E = 0$				0.010					µa
		$V_{CB} = 90$ v, $I_E = 0$, $T_A = 150°C$				15					µa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 2$ v, $I_C = 0$									µa
		$V_{EB} = 5$ v, $I_C = 0$				0.010		0.010		0.010	µa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$			20		20				
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 11			35		35				
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 11			20		20				
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 11	40	120	40	120	40	120	100	300	
V_{BE}	Base-Emitter Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11				0.9		0.9		0.9	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11				1.2		1.2		1.2	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		5		5		5		5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	20	30	20	30	20	30	20	30	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		10	4	8	4	8	4	8	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		2.5×10^{-4}		1.25×10^{-4}		1.25×10^{-4}		1.5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		3×10^{-4}		1.5×10^{-4}		1.5×10^{-4}		1.5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	0.1	0.5		0.5		0.5		0.3	µmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		1.0		0.5		0.5		0.3	µmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	35	100	30	100	30	100	50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	45		45		45	150	70	300	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.5		2.5		2.5		3.0		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc; Except 2N720: $f = 140$ kc		20		15		15		15	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc; Except 2N720: $f = 140$ kc		85		85		85		85	pf

NOTE 11: These parameters must be measured using pulse techniques. PW ≤ 300 µsec., Duty cycle $\leq 2\%$. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data.

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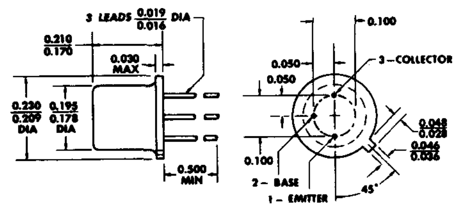
BULLETIN NO. DL-S 733561, MAY 1963—REVISED MARCH 1973

HIGHLY RELIABLE, VERSATILE DEVICES CHARACTERIZED ESPECIALLY FOR SMALL-SIGNAL APPLICATIONS

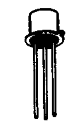
- High Voltage • Low Leakage
- Useful h_{FE} Over Wide Current Range
- Both Common-Emitter and Common-Base Small-Signal Characterization

mechanical data

2N910, 2N911, 2N912 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

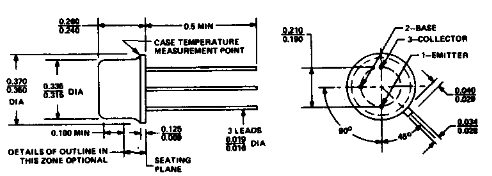


ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

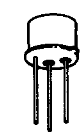


ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE*

2N1973, 2N1974, 2N1975 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N910 2N911 2N912	2N1973 2N1974 2N1975
Collector-Base Voltage	← 100 v* →	
Collector-Emitter Voltage (See Note 1)	← 80 v* →	
Collector-Emitter Voltage (See Note 2)	← 60 v* →	
Emitter-Base Voltage	← 7 v* →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 3 and 4)	0.5 w*	0.8 w*
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Notes 5 and 6)	1.8 w*	10 w† / 3 w*
Storage Temperature Range	−65°C to 200°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTES:
1. This value applies when the base-emitter resistance $R_{BE} \leq 10\ \Omega$.
2. This value applies when the base-emitter diode is open-circuited.
3. For 2N910, 2N911, and 2N912, derate linearly to 200°C free-air temperature at the rate of 2.86 mw/°C.
4. For 2N1973, 2N1974, and 2N1975, derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
5. For 2N910, 2N911, and 2N912, derate linearly to 200°C case temperature at the rate of 10.3 mw/°C.
6. For 2N1973, 2N1974, and 2N1975, derate linearly to 200°C case temperature at the rates of 57.1 mw/°C for the 10-watt rating and 17.2 mw/°C for the 3-watt (JEDEC registered) rating.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

USES CHIP N23

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS (TO-18 → / TO-39 →)	2N910 / 2N1973 MIN	2N910 / 2N1973 MAX	2N911 / 2N1974 MIN	2N911 / 2N1974 MAX	2N912 / 2N1975 MIN	2N912 / 2N1975 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	100		100		100		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$ (See Note 7)	60		60		60		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$ (See Note 7)	80		80		80		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	7.0		7.0		7.0		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 75$ v, $I_E = 0$		25		25		25	na
		$V_{CB} = 75$ v, $I_E = 0$, $T_A = 150°C$		15		15		15	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		25		25		25	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$	35		20		10		
		$V_{CE} = 10$ v, $I_C = 10$ ma (See Note 7)	75		35		15		
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$ (See Note 7)	30		15		10		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ ma, $I_C = 10$ ma	0.6	0.8	0.6	0.8	0.6	0.8	v
		$I_B = 5$ ma, $I_C = 50$ ma		0.9		0.9		0.9	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ ma, $I_C = 10$ ma		0.4		0.4		0.4	v
		$I_B = 5$ ma, $I_C = 50$ ma		1.2		1.2		1.2	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	20	30	20	30	20	30	ohm
		$V_{CB} = 5$ v, $I_C = 5$ ma, $f = 1$ kc	4.0	8.0	4.0	8.0	4.0	8.0	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		3×10^{-4}		1.25×10^{-4}		1.25×10^{-4}	
		$V_{CB} = 5$ v, $I_C = 5$ ma, $f = 1$ kc		4×10^{-4}		1.75×10^{-4}		1.75×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		0.5		0.5		0.5	μmho
		$V_{CB} = 5$ v, $I_C = 5$ ma, $f = 1$ kc		1.0		1.0		1.0	μmho
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ v, $I_C = 5$ ma, $f = 1$ kc		1800		1000		600	ohm
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	76	200	36	90	18	50	
		$V_{CE} = 5$ v, $I_C = 5$ ma, $f = 1$ kc	80	200	40	100	20	50	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 5$ v, $I_C = 5$ ma, $f = 1$ kc		100		50		25	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	3.0		2.5		2.0		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		15		15		15	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc		85		85		85	pf

*operating characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS (TO-18 → / TO-39 →)	2N910 / 2N1973 MAX	2N911 / 2N1974 MAX	2N912 / 2N1975 MAX	UNIT
NF Spot Noise Figure	$V_{CB} = 10$ v, $I_C = 300\ \mu a$, $R_G = 510\ \Omega$, $f = 1$ kc, Noise Bandwidth $= 200$ cps	12	15	18	db

NOTE 7 : These parameters must be measured using pulse techniques. PW $\leq$ 300 μsec, Duty Cycle $\leq$ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC Registered Data.

4

TEXAS INSTRUMENTS
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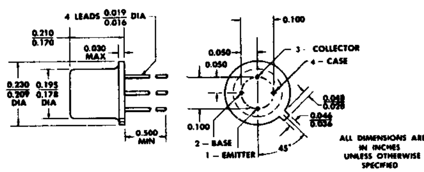
TYPE 2N917
N-P-N SILICON TRANSISTOR

BULLETIN NO. DL-S 655549, JUNE 1964—REVISED SEPTEMBER 1965

DESIGNED FOR USE IN VHF AND UHF AMPLIFIER AND OSCILLATOR APPLICATIONS

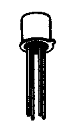
- **Guaranteed Unneutralized Power Gain — 9 db min at 200 Mc**
- **Low C_{obo} — 1.7 pf max**
- **Low Noise Figure — 3 db typ at 60 Mc**

*mechanical data



THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE

ALL JEDEC TO-72† DIMENSIONS AND NOTES ARE APPLICABLE



†TO-72 outline is same as TO-18 outline with the addition of a fourth lead.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	30 v
Collector-Emitter Voltage (See Note 1)	15 v
Emitter-Base Voltage	3 v
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	200 mw
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	300 mw
Operating Collector Junction Temperature	200°C
Storage Temperature Range	−65°C to 200°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 1\ \mu a$, $I_E = 0$	30		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 3$ ma, $I_B = 0$, See Note 4	15		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$	3		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ v, $I_E = 0$		1	na
		$V_{CB} = 15$ v, $I_E = 0$, $T_A = 150°C$		0.1	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ v, $I_C = 3$ ma	20	200	
V_{BE}	Base-Emitter Voltage	$I_B = 0.15$ ma, $I_C = 3$ ma		0.87	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.15$ ma, $I_C = 3$ ma		0.5	v
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 4$ ma, $f = 100$ Mc	5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 140$ kc		1.7	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 140$ kc		1.6	pf
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 10$ v, $I_C = 4$ ma, $f = 40$ Mc		75	psec

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 1.14 mw/C°.
3. Derate linearly to 200°C case temperature at the rate of 1.72 mw/C°.
4. This parameter must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 1%.

† The fourth lead (case) is floating for all measurements except Power Gain. For this parameter the fourth lead is grounded.

*Indicates JEDEC registered data.

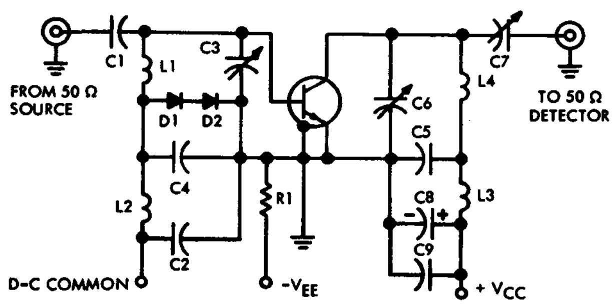
USES CHIP N22

*operating characteristics at 25°C free-air temperature

	PARAMETER	TEST CONDITIONS†	MIN	MAX	UNIT
NF	Spot Noise Figure	$V_{CE} = 6$ v, $I_C = 1$ ma, $R_G = 400\ \Omega$, $f = 60$ Mc		6	db
G_{pe}	Unneutralized Small-Signal Common-Emitter Insertion Power Gain	$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 200$ Mc, See Figure 1	9		db
P_o	Oscillator Power Output	$V_{CC} = 15$ v, $I_C = 8$ ma, $f = 500$ Mc, See Figure 2	10		mw

† The fourth lead (case) is floating for all measurements except Power Gain. For this parameter the fourth lead is grounded.

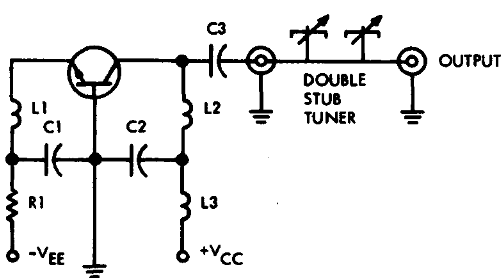
* PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

C1, C2, and C9: 0.05 μf
C3: 1.5 - 10 pf
C4 and C5: 1000 pf
C6 and C7: 3 - 15 pf
C8: 25 μf
R1: 2.2 kΩ
L1: 1T #12 AWG, 2 cm ID
L2 and L3: 200 Mc RFC
L4: 1/2 T #12 AWG, 3 cm ID
D1 and D2: 1N3063 (or equivalent)

FIGURE 1 — UNNEUTRALIZED 200-Mc INSERTION POWER GAIN TEST CIRCUIT



C1 and C2: 1000 pf
C3: 75 pf
R1: 2.2 kΩ
L1 and L3: 500 Mc RFC
L2: 2T #16 AWG, 3/8" OD, 1 1/4" length
Double Stub Tuner consists of the following plumbing (or equivalent):

- 2 GR Type 874 TEE
- 1 GR Type 874-D20 Adjustable Stub
- 1 GR Type 874-LA Adjustable Line
- 1 GR Type 874-WN3 Short-Circuit Termination

FIGURE 2 — 500-Mc OSCILLATOR POWER OUTPUT TEST CIRCUIT

* Indicates JEDEC registered data

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TYPE 2N918
N-P-N SILICON TRANSISTOR

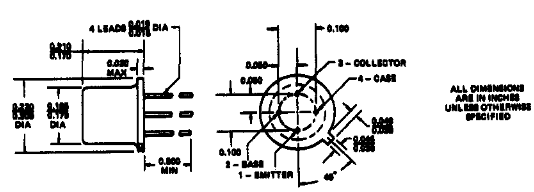
BULLETIN NO. DL-S 7311989, MARCH 1973

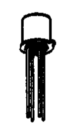
FOR VHF AND UHF AMPLIFIER AND OSCILLATOR APPLICATIONS

- **Low Noise Figure . . . 6 dB max at 60 MHz**
- **High Neutralized Power Gain . . . 15 dB min at 200 MHz**
- **High Oscillator Power Output . . . 30 mW min at 500 MHz**

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE





ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	30 V
Collector-Emitter Voltage (See Note 1)	15 V
Emitter-Base Voltage	3 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	200 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	300 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	MIN	TYP	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 1\ \mu A$, $I_E = 0$	30			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 3$ mA, $I_B = 0$, See Note 4	15			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	3			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ V, $I_E = 0$			10	nA
		$V_{CB} = 15$ V, $I_E = 0$, $T_A = 150°C$			1	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V, $I_C = 3$ mA	20			
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA, $I_C = 10$ mA			1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA			0.4	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 100$ MHz	6	9		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 140$ kHz			1.7	pF
		$V_{CB} = 0$, $I_E = 0$, $f = 140$ kHz			3	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 140$ kHz			2	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 10$ V, $I_E = -4$ mA, $f = 79.8$ MHz		8		ps

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 1.14 mW/°C.
3. Derate linearly to 200°C case temperature at the rate of 1.71 mW/°C.
4. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†The fourth lead (case) is floating for all measurements except power gain. For this measurement, the fourth lead is grounded.

USES CHIP N22

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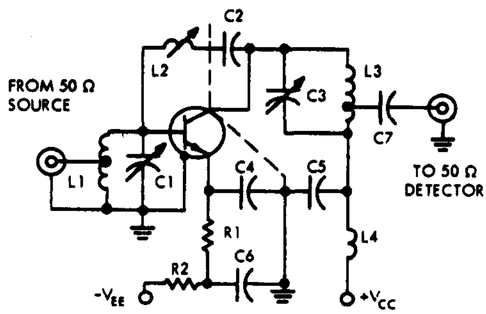
*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
F	Spot Noise Figure	V_{CE} = 6 V, I_C = 1 mA, R_G = 400 Ω, f = 60 MHz		6	dB
G_{pe}	Neutralized Small-Signal Common-Emitter Insertion Power Gain	V_{CB} = 12 V, I_C = 6 mA, f = 200 MHz See Figure 1	15		dB
P_O	Oscillator Power Output	V_{CB} = 15 V, I_C = 8 mA, f = 500 MHz See Figure 2	30		mW
η	Collector Efficiency		25%		

*PARAMETER MEASUREMENT INFORMATION

CIRCUIT SCHEMATIC



NEUTRALIZATION ADJUSTMENT PROCEDURE

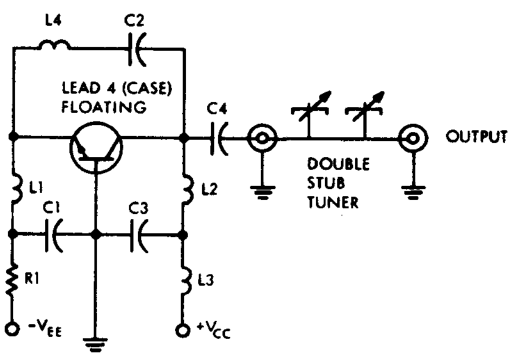
After tuning amplifier as for normal gain measurement, reverse input and output connections and tune L2 for minimum indication on detector. This sequence is repeated until optimum settings are obtained for all variables.

CIRCUIT COMPONENT INFORMATION

C1: 3–12 pF
C2 and C7: 1000 pF
C3: 1.5–7.5 pF
C4 and C5: 0.01 μF
C6: 0.05 μF
R1: 100 Ω
R2: 1 kΩ
L1: 3½ T #16 AWG, 5/16" ID, 7/16" length
Turns Ratio ≈ 2 to 1
L2: 0.4–0.65 μH, Miller #4303 (or equivalent).
L3: 8 T #16 AWG 1/8" ID, 7/8" length,
Turns Ratio ≈ 8 to 1
L4: 200 MHz RFC

FIGURE 1—NEUTRALIZED 200-MHz INSERTION POWER GAIN

CIRCUIT SCHEMATIC



CIRCUIT COMPONENT INFORMATION

C1 and C3: 1000 pF
C2: 50 pF
C4: 75 pF
R1: 2.2 kΩ
L1, L3, and L4: 0.2 μH, Ohmite Z460 (or equivalent).
L2: 2 T #16 AWG, 3/8" OD, 1-1/4" length
Double-Stub Tuner consists of the following plumbing (or equivalent):
- 2 GR Type 874 Tee
- 1 GR Type 874–D20 Adjustable Stub
- 1 GR Type 874–LA Adjustable Line
- 1 GR Type 874–WN3 Short-Circuit Termination

FIGURE 2—500-MHz OSCILLATOR POWER OUTPUT

*JEDEC registered data
†The fourth lead (case) is floating for all measurements except power gain. For this measurement, the fourth lead is grounded.

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TYPE D2T918
DUAL N-P-N SILICON TRANSISTOR

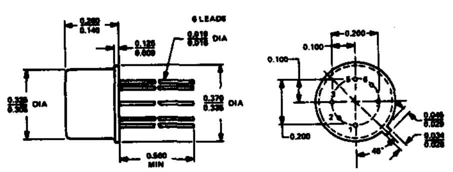
BULLETIN NO. DL-S 7311977, MARCH 1973

TWO TRANSISTORS IN ONE PACKAGE FOR VHF AND UHF AMPLIFIER AND OSCILLATOR APPLICATIONS

- Low Noise Figure . . . 6 dB max at 60 MHz
- High Neutralized Power Gain . . . 15 dB min at 200 MHz
- High Oscillator Power Output . . . 30 mW min at 500 MHz

mechanical data

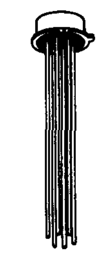
ALL LEADS INSULATED FROM CASE



Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



4

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	30 V
Collector-Emitter Voltage (See Note 1)	15 V
Emitter-Base Voltage	3 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2): Each Triode	200 mW
Total Device	300 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 1\ \mu A$, $I_E = 0$	30			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 3$ mA, $I_B = 0$, See Note 3	15			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	3			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ V, $I_E = 0$			10	nA
		$V_{CB} = 15$ V, $I_E = 0$, $T_A = 150°C$			1	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V, $I_C = 3$ mA	20			
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA, $I_C = 10$ mA			1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA			0.4	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA, f = 100 MHz	6	9		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz			1.7	pF
		$V_{CB} = 0$, $I_E = 0$, f = 1 MHz			3	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, f = 1 MHz			2	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 10$ V, $I_E = -4$ mA, f = 79.8 MHz		8		ps

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rates of 1.33 mW/°C for each triode and 2 mW/°C for the total device.
3. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

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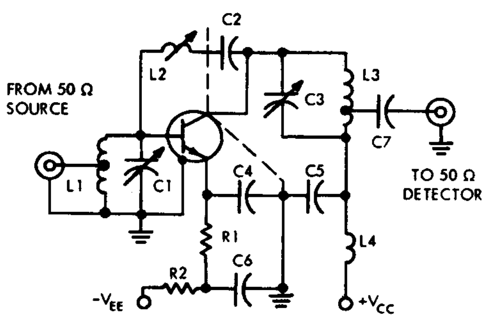
operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
F	Spot Noise Figure	V_{CE} = 6 V, I_C = 1 mA, R_G = 400 Ω, f = 60 MHz		6	dB
G_{pe}	Neutralized Small-Signal Common-Emitter Insertion Power Gain	V_{CB} = 12 V, I_C = 6 mA, f = 200 MHz See Figure 1	15		dB
P_O	Oscillator Power Output	V_{CB} = 15 V, I_C = 8 mA, f = 500 MHz See Figure 2	30		mW
η	Collector Efficiency		25%		

PARAMETER MEASUREMENT INFORMATION

CIRCUIT SCHEMATIC



NEUTRALIZATION ADJUSTMENT PROCEDURE

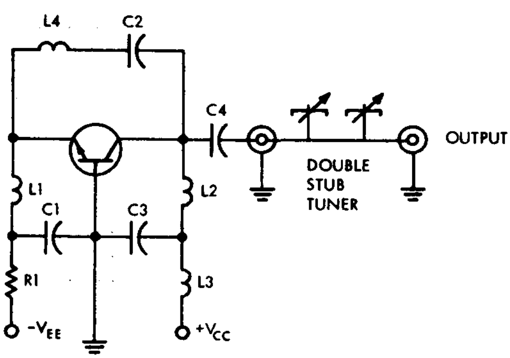
After tuning amplifier as for normal gain measurement, reverse input and output connections and tune L2 for minimum indication on detector. This sequence is repeated until optimum settings are obtained for all variables.

CIRCUIT COMPONENT INFORMATION

C1: 3–12 pF
C2 and C7: 1000 pF
C3: 1.5–7.5 pF
C4 and C5: 0.01 μF
C6: 0.05 μF
R1: 100 Ω
R2: 1 kΩ
L1: 3½ T #16 AWG, 5/16" ID, 7/16" length
Turns Ratio ≈ 2 to 1
L2: 0.4–0.65 μH, Miller #4303 (or equivalent).
L3: 8 T #16 AWG 1/8" ID, 7/8" length,
Turns Ratio ≈ 8 to 1
L4: 200 MHz RFC

FIGURE 1—NEUTRALIZED 200-MHz INSERTION POWER GAIN

CIRCUIT SCHEMATIC



CIRCUIT COMPONENT INFORMATION

C1 and C3: 1000 pF
C2: 50 pF
C4: 75 pF
R1: 2.2 kΩ
L1, L3, and L4: 0.2 μH, Ohmite Z460 (or equivalent).
L2: 2 T #16 AWG, 3/8" OD, 1-1/4" length
Double-Stub Tuner consists of the following plumbing (or equivalent):
2 GR Type 874 Tee
1 GR Type 874—D20 Adjustable Stub
1 GR Type 874—LA Adjustable Line
1 GR Type 874—WN3 Short-Circuit Termination

FIGURE 2—500-MHz OSCILLATOR POWER OUTPUT

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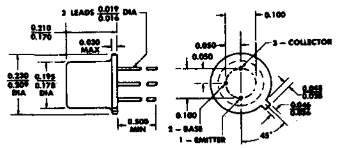
BULLETIN NO. DL-S 653553, MAY 1963—REVISED SEPTEMBER 1965

4

FOR LOW-LEVEL, LOW-NOISE, HIGH-GAIN, AMPLIFIER APPLICATIONS

- Guaranteed h_{FE} at 10 μa, $T_A = -55°C$ and 25°C
- Guaranteed Low-Noise Characteristics at 10 μa
- Usable at Collector Currents as Low as 1 μa

*mechanical data



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	45 v
Collector-Emitter Voltage (See Note 1)	45 v
Emitter-Base Voltage	5 v
Collector Current	30 ma
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	300 mw
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	600 mw
Operating Collector Junction Temperature	175°C
Storage Temperature Range	−65°C to +200°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 2.0 mw/C°.
3. Derate linearly to 175°C case temperature at the rate of 4.0 mw/C°.

*Indicates JEDEC registered data

USES CHIP N11

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	2N929 MIN	2N929 MAX	2N930 MIN	2N930 MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$, (See Note 4)	45		45		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10$ na $I_C = 0$	5		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ v, $I_E = 0$		10		10	na
I_{CES}	Collector Cutoff Current (See Note 5)	$V_{CE} = 45$ v, $V_{BE} = 0$		10		10	na
		$V_{CE} = 45$ v, $V_{BE} = 0$, $T_A = 170°C$		10		10	μa
I_{CEO}	Collector Cutoff Current	$V_{CE} = 5$ v, $I_B = 0$		2		2	na
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		10		10	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 10$ μa	40	120	100	300	
		$V_{CE} = 5$ v, $I_C = 10$ μa, $T_A = -55°C$	10		20		
		$V_{CE} = 5$ v, $I_C = 500$ μa	60		150		
		$V_{CE} = 5$ v, $I_C = 10$ ma, (See Note 4)		350		600	
V_{BE}	Base-Emitter Voltage	$I_B = 0.5$ ma, $I_C = 10$ ma, (See Note 4)	0.6	1.0	0.6	1.0	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ ma, $I_C = 10$ ma, (See Note 4)		1.0		1.0	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_E = -1$ ma, f = 1 kc	25	32	25	32	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_E = -1$ ma, f = 1 kc	0	6.0×10^{-4}	0	6.0×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_E = -1$ ma, f = 1 kc	0	1.0	0	1.0	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, f = 1 kc	60	350	150	600	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 500$ μa, f = 30 mc	1.0		1.0		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$, f = 1 mc		8		8	pf

***operating characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	2N929 MAX	2N930 MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CE} = 5$ v, $I_C = 10$ μa, $R_G = 10$ kΩ Noise Bandwidth 10 cps to 15.7 kc	4	3	db

NOTES: 4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.
5. I_{CES} may be used in place of I_{CBO} for circuit stability calculations.
*Indicates JEDEC registered data.

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TYPES 2N696, 2N697, 2N717, 2N718, 2N718A, 2N730, 2N731, 2N956, 2N1420, 2N1507, 2N1613, 2N1711 N-P-N SILICON TRANSISTORS

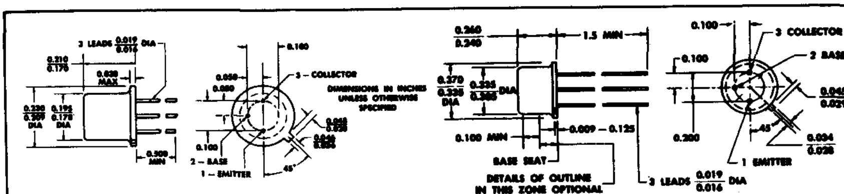
BULLETIN NO. DL-S 693471, MAY 1963—REVISED AUGUST 1969

Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

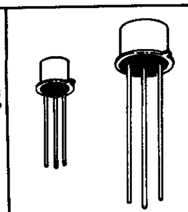
- **High Voltage**
- **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

*mechanical data

Device types 2N717, 2N718, 2N718A, 2N730, 2N731, and 2N956 are in JEDEC TO-18 packages.
Device types 2N696, 2N697, 2N1420, 2N1507, 2N1613, and 2N1711 are in JEDEC TO-5 packages.



TO-18 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-5



TO-18 TO-5

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N696 2N697	2N717 2N718	2N718A	2N730 2N731	2N956	2N1420 2N1507	2N1613	2N1711	UNIT
Collector-Base Voltage	60	60	75	60	75	60	75	75	v
Collector-Emitter Voltage (See Note 1)	40	40	50	40	50	30	50	50	v
Collector-Emitter Voltage (See Note 2)			32						v
Emitter-Base Voltage	5	5	7	5	7	5	7	7	v
Collector Current				1.0		1.0		1.0	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) →	0.6 † (3)	0.4 †† (5)	0.5 (7)	0.5 †† (9)	0.5 (7)	0.6 † (3)	0.8 (10)	0.8 (10)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) →	2.0 † (4)	1.5 †† (6)	1.8 (8)	1.5 †† (6)	1.8 (8)	2.0 † (4)	3.0 (11)	3.0 (11)	w
Total Device Dissipation at 100°C Case Temperature	1.0 †	0.75 ††	1.0	0.75 ††	1.0	1.0 †	1.7	1.7	w
Operating Collector Junction Temperature	175†	175††	200	175††	200	175†	200	200	°C
Storage Temperature Range	—65°C to 200°C								

NOTES:
1. This value applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/C°.
4. Derate linearly to 175°C case temperature at the rate of 13.3 mw/C°.
5. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/C°.
6. Derate linearly to 175°C case temperature at the rate of 10.0 mw/C°.
7. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/C°.
8. Derate linearly to 200°C case temperature at the rate of 10.3 mw/C°.
9. Derate linearly to 175°C free-air temperature at the rate of 3.33 mw/C°.
10. Derate linearly to 200°C free-air temperature at the rate of 4.56 mw/C°.
11. Derate linearly to 200°C case temperature at the rate of 17.2 mw/C°.

†Texas Instruments guarantees its types 2N696, 2N697, 2N1420, and 2N1507 to be capable of the same dissipation as registered and shown for types 2N1613 and 2N1711 with appropriate derating factors shown in Notes 10 and 11.

††Texas Instruments guarantees its types 2N717, 2N718, 2N730, and 2N731 to be capable of the same dissipation as registered and shown for types 2N718A and 2N956 with appropriate derating factors shown in Notes 7 and 8.

*Indicates JEDEC registered data.

USES CHIP N24

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	TO-18 → 2N718A / TO-5 → 2N1613 MIN	2N718A / 2N1613 MAX	2N1420 MIN	2N1420 MAX	2N1507 MIN	2N1507 MAX	TO-18 → 2N956 / TO-5 → 2N1711 MIN	2N956 / 2N1711 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a, I_E = 0$	75		60		60		75		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 12					25				v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 12	50		30		30		50		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a, I_C = 0$	7						7		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$				1.0		1.0			μa
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$				100		50			μa
		$V_{CB} = 60$ v, $I_E = 0$		0.010						0.010	μa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		10						10	μa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100$ kΩ						10			μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		0.01				100		0.005	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$							20		
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$	20						35		
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 12	35						75		
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 12	20						35		
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 12	40	120	100	300	100	300	100	300	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 12	20						40		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.5		1.5		1.5		1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	24	34					24	34	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	4	8					4	8	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		3×10^{-4}						5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		3×10^{-4}						5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	0.1	0.5					0.1	0.5	μmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	0.1	1.0					0.1	1.0	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	30	100					50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	35	150					70	300	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	3.0		2.5		2.5		3.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		25		35		35		25	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc		80						80	pf

See switching characteristics for types 2N718A and 2N1613 on pages 4-30 or 4-72.

*operating characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	TO-18 → 2N956 / TO-5 → 2N1711 TYP	2N956 / 2N1711 MAX	TO-18 → 2N718A / TO-5 → 2N1613 TYP	2N718A / 2N1613 MAX	UNIT
NF Spot Noise Figure	$V_{CE} = 10$ v, $I_C = 300\ \mu a$, $R_G = 510\ \Omega$, f 1 kc	5	8	6	12	db

NOTE 12: These parameters must be measured using pulse techniques. PW $\leq$ 300 μsec, Duty Cycle $\leq$ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data

4

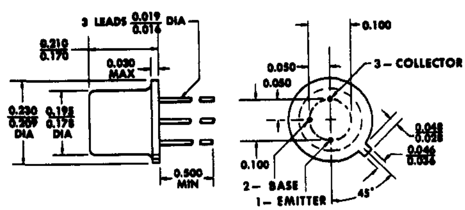
TYPE 2N997
N-P-N DARLINGTON-CONNECTED SILICON TRANSISTOR

BULLETIN NO. DL-S 7311677, MARCH 1972—REVISED MARCH 1973

TWO TRIODES INTERNALLY CONNECTED IN DARLINGTON CONFIGURATION

- Very High Gain . . . 1000 min at 100 μA
- Low Leakage . . . 10 nA max at 60 V
- Rugged Internal Connections

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	75 V
Collector-Emitter Voltage (See Note 1)	40 V
Emitter-Base Voltage	7 V
Continuous Collector Current	300 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.5 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.5 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	75		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 4	40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V, $I_E = 0$		10	nA
		$V_{CB} = 60$ V, $I_E = 0$, $T_A = 150°C$		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 100\ \mu A$	1000		
		$V_{CE} = 10$ V, $I_C = 10$ mA	4000		
		$V_{CE} = 10$ V, $I_C = 100$ mA, See Note 4	7000	70 000	
		$V_{CE} = 10$ V, $I_C = 100$ mA, $T_A = -55°C$, See Note 4	1000		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 100$ mA, See Note 4	0.9	1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 100$ mA, See Note 4		1.6	V
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz		35	pF

NOTES:
1. This value applies when the emitter-base diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 3.33 mW/°C.
3. Derate linearly to 175°C case temperature at the rate of 10 mW/°C.
4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq$ 2%.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP N23

TEXAS INSTRUMENTS
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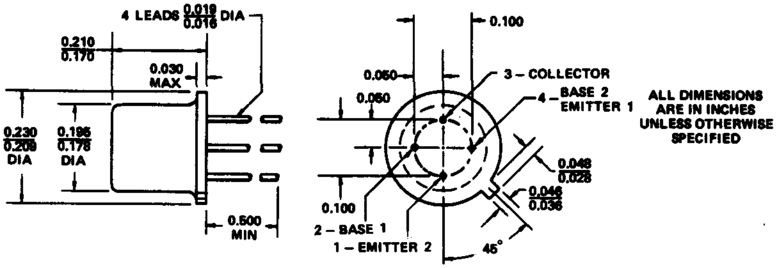
TWO TRIODES INTERNALLY CONNECTED IN DARLINGTON CONFIGURATION

- Very High h_{FE} . . . 1600 min at 10 mA
- Low I_{CBO} . . . 10 nA max at 90 V
- Rugged Internal Connections

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	100 V
Collector-Emitter Voltage (See Note 1)	60 V
Emitter-Base Voltage	15 V
Continuous Collector Current	500 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.5 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.8 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. This value applies when the emitter-base diodes are open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.86 mW/°C.
3. Derate linearly to 200°C case temperature at the rate of 10.3 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES TWO N23 CHIPS

TYPE 2N998
N-P-N DARLINGTON-CONNECTED SILICON TRANSISTOR

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30\ mA$, $I_B = 0$, See Note 4	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	15		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 90\ V$, $I_E = 0$		10	nA
		$V_{CB} = 90\ V$, $I_E = 0$, $T_A = 150°C$		15	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 10\ V$, $I_C = 0$		10	nA
h_{FE}	Static Forward Current Transfer Ratio (Total Device)	$V_{CE} = 5\ V$, $I_C = 1\ mA$	800		
		$V_{CE} = 5\ V$, $I_C = 10\ mA$, See Note 4	1600	8000	
		$V_{CE} = 5\ V$, $I_C = 100\ mA$, See Note 4	2000		
h_{FE}	Static Forward Current Transfer Ratio (Each Triode)	$V_{CE} = 5\ V$, $I_C = 10\ mA$, See Note 4	25		
V_{BE}	Base-Emitter Voltage	$I_B = 0.5\ mA$, $I_C = 50\ mA$, See Note 4		1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5\ mA$, $I_C = 50\ mA$, See Note 4		1.2	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	1000		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$, $f = 1\ MHz$		30	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$, $f = 1\ MHz$		50	pF

4

***operating characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 10\ V$, $I_C = 0.1\ mA$, $I_{B2} = -20\ \mu A$, $R_G = 5\ k\Omega$, $f = 1\ kHz$, $B = 200\ Hz$		6	dB

NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq$ 1%.
*JEDEC registered data
†All measurements except h_{FE} (each triode) and F are made with the emitter-1, base-2 terminal (lead 4) open.

THERMAL INFORMATION

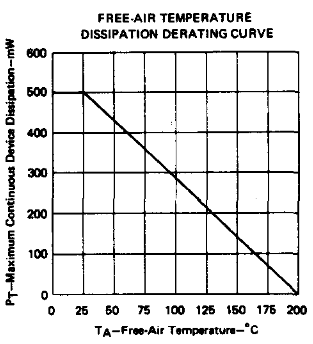


FIGURE 1

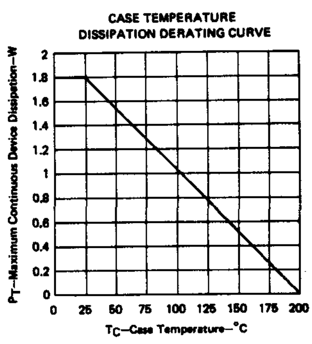


FIGURE 2

PRINTED IN U.S.A. 673

TYPE 2N999
N-P-N DARLINGTON-CONNECTED SILICON TRANSISTOR

BULLETIN NO. DL-S 7312011, JUNE 1973

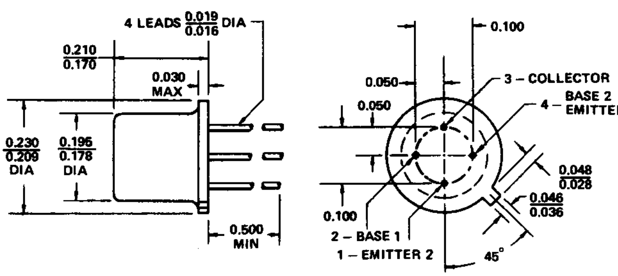
TWO TRIODES INTERNALLY CONNECTED IN DARLINGTON CONFIGURATION

- Very High h_{FE} . . . 4000 min at 10 mA
- Low I_{CBO} . . . 10 nA max at 60 V
- Rugged Internal Connections

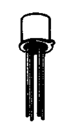
4

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	60 V
Collector-Emitter Voltage (See Note 1)	60 V
Emitter-Base Voltage	15 V
Continuous Collector Current	500 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.5 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.8 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES:
1. This value applies when the emitter-base diodes are open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.86 mW/°C.
3. Derate linearly to 200°C case temperature at the rate of 10.3 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES TWO N23 CHIPS

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 4	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	15		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V, $I_E = 0$		10	nA
		$V_{CB} = 60$ V, $I_E = 0$, $T_A = 150°C$		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 10$ V, $I_C = 0$		10	nA
h_{FE}	Static Forward Current Transfer Ratio (Total Device)	$V_{CE} = 10$ V, $I_C = 0.1$ mA	1000		
		$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 4	4000		
		$V_{CE} = 10$ V, $I_C = 100$ mA, See Note 4	7000	70,000	
		$V_{CE} = 10$ V, $I_C = 100$ mA, $T_A = -55°C$, See Note 4	1000		
h_{FE}	Static Forward Current Transfer Ratio (Each Triode)	$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 4	25		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA, $I_C = 100$ mA, See Note 4		1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 100$ mA, See Note 4		1.6	V
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 140 kHz		20	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, f = 140 kHz		10	pF

*JEDEC registered data
†All measurements except h_{FE} (each triode) are made with the emitter-1, base-2 terminal (lead 4) open.
NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 1%.

THERMAL INFORMATION

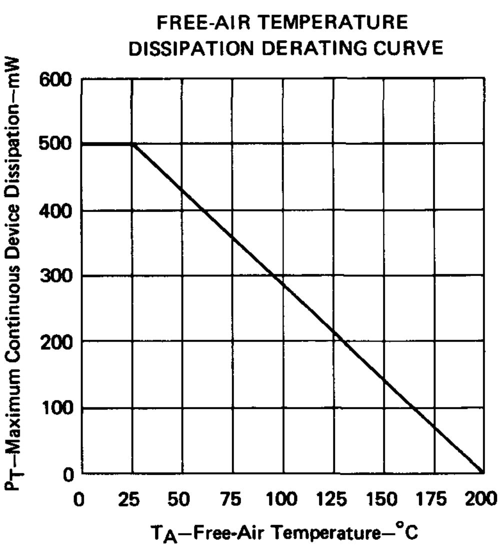

FIGURE 1

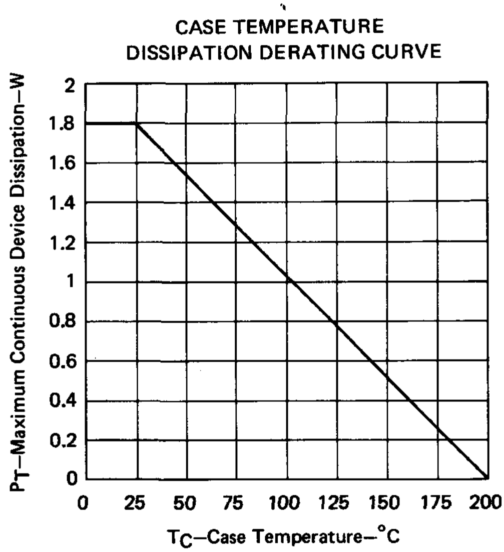

FIGURE 2

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4

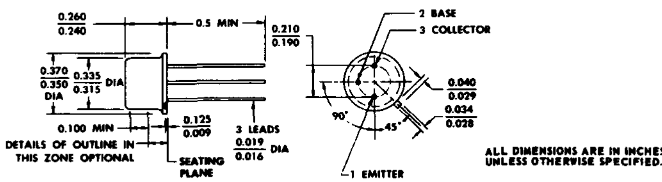
BULLETIN NO. DL-S 731775, JUNE 1961—REVISED MARCH 1973

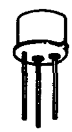
GENERAL PURPOSE MEDIUM-POWER TRANSISTORS

- **2 Watts at 25°C Case Temperature**
- **Complements to 2N696 and 2N697**
- **10-ohm Saturation Resistance (max)**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

4

absolute maximum ratings at 25°C ambient temperature (unless otherwise noted)

Collector-Base Voltage	−50v
Collector-Emitter Voltage (See note 1)	−35v
Emitter-Base Voltage	−5v
Collector Current	−600 ma
Total Device Dissipation at 25°C case temperature (See note 2)	2.0w
Total Device Dissipation at 100°C case temperature (See note 2)	1.0w
Total Device Dissipation at 25°C ambient temperature (See note 3)	0.6w
Operating Junction Temperature	175°C
Storage Temperature Range	−65°C to 200°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C case temperature at the rate of 13.3 mW/°C.
3. Derate linearly to 175°C ambient temperature at the rate of 4 mW/°C.

USES CHIP P20

electrical characteristics at 25°C ambient temperature (unless otherwise noted)

Parameter		Test Conditions	Type	Min.	Max.	Unit
I_{CBO}	Collector Reverse Current	$V_{CB} = -30$ v, $I_E = 0$			—1.0	μa
I_{CBO}	Collector Reverse Current	$V_{CB} = -30$ v, $I_E = 0$ $T_A = +150°C$			—100	μa
I_{EBO}	Emitter Reverse Current	$V_{EB} = -2$ v, $I_C = 0$			—100	μa
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\mu$a, $I_E = 0$		—50		v
*$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ ma, $I_B = 0$		—35		v
*$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ ma, $R_{BE} = 10$ ohms		—50		v
*h_{FE}	DC Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -150$ ma	2N1131 2N1132	20 30	45 90	
*h_{FE}	DC Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -5$ ma	2N1131 2N1132	15 25		
*V_{BE}	Base-Emitter Voltage	$I_B = -15$ ma, $I_C = -150$ ma			—1.3	v
*$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ ma, $I_C = -150$ ma			—1.5	v
h_{fe}	AC Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -50$ ma $f = 20$ mc	2N1131 2N1132	2.5 3		
C_{ib}	Common-Base Input Capacitance	$V_{EB} = -0.5$ v, $I_C = 0$ $f = 1$ mc			80	pf
C_{ob}	Common-Base Output Capacitance	$V_{CB} = -10$ v, $I_E = 0$ $f = 1$ mc			45	pf
h_{fe}	AC Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ v, $I_C = -1$ ma $f = 1$ kc	2N1131 2N1132	15 25	50 100	
h_{fe}	AC Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -5$ ma $f = 1$ kc	2N1131 2N1132	20 30		
h_{ib}	AC Common-Base Input Impedance	$V_{CB} = -5$ v, $I_E = 1$ ma $f = 1$ kc $V_{CB} = -10$ v, $I_E = 5$ ma $f = 1$ kc		25	35 10	ohms ohms
h_{ob}	AC Common-Base Output Admittance	$V_{CB} = -5$ v, $I_E = 1$ ma $f = 1$ kc $V_{CB} = -10$ v, $I_E = 5$ ma $f = 1$ kc		0 0	1 5	μ mho μ mho
h_{rb}	AC Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = -5$ v, $I_E = 1$ ma $f = 1$ kc $V_{CB} = -10$ v, $I_E = 5$ ma $f = 1$ kc		0 0	8×10^{-4} 8×10^{-4}	

*These measurements must be made with a pulse duration ≤300 microseconds and a duty cycle ≤2 percent.

4

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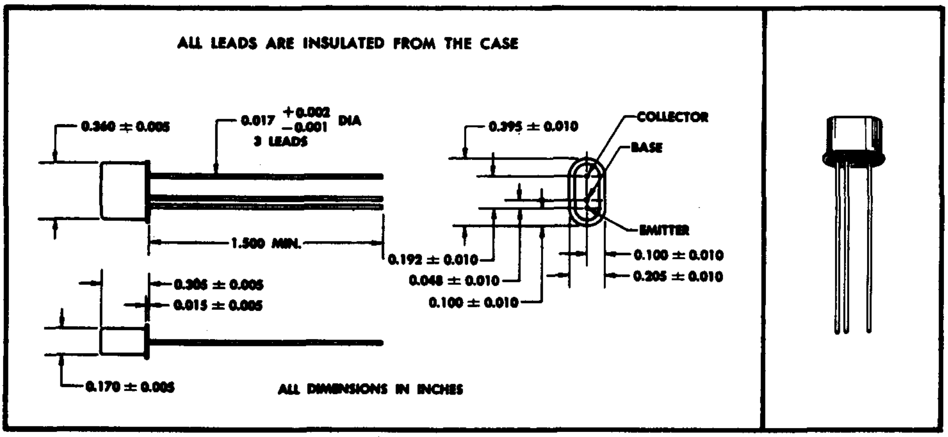
Oval Welded Package

mechanical data

The transistor is in an oval welded package with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram.



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	45 v
Emitter-Base Voltage	1 v
Collector Current	25 ma
Emitter Current	−25 ma
Total Device Dissipation (See Note 1)	150 mw
Total Device Dissipation at 100°C Free-Air Temperature	100 mw
Total Device Dissipation at 150°C Free-Air Temperature	50 mw
Collector Junction Operating Temperature	+175°C
Storage Temperature Range	−65°C to +175°C

NOTE 1: For dissipation at advanced temperatures, see Derating Curve.

*Indicates JEDEC registered data.

TYPES 2N1149 THRU 2N1153
N-P-N GROWN-JUNCTION SILICON TRANSISTORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

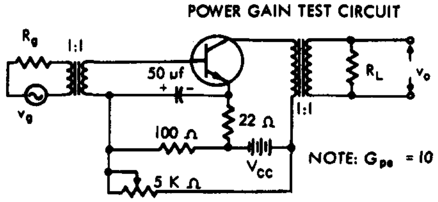
parameter		test conditions	types	min*	typ	max*	unit
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v $I_E = 0$	ALL			2	μa
		$V_{CB} = 30$ v $I_E = 0$, $T_A = 150°C$	ALL		3		μa
		$V_{CB} = 5$ v $I_E = 0$, $T_A = 100°C$	ALL			10	μa
		$V_{CB} = 5$ v $I_E = 0$, $T_A = 150°C$	ALL		0.5	50	μa
BV_{CBO}	Collector-Base Breakdown Voltage	$I_C = 50$ μa $I_E = 0$	ALL	45			v
$r_{CE(sat)}$	DC Collector-Emitter Saturation Resistance	$I_B = 2.2$ ma $I_C = 5$ ma	ALL		100	200	ohm
C_{ob}	Common-Base Output Capacitance	$V_{CB} = 5$ v $I_E = 0$, f = 1 mc	ALL		7		pf
f_{hfb}	Common-Base Alpha Cutoff Frequency	$V_{CB} = 5$ v $I_E = -1$ ma	2N1149	8	12		mc
			2N1150		13		
			2N1151		14		
			2N1152		15		
			2N1153		16		
h_{fb}	AC Common-Base Forward Current Transfer Ratio	$V_{CB} = 5$ v $I_E = -1$ ma, f = 1 kc	2N1149	−0.9	−0.925	−0.953	
			2N1150	−0.948	−0.96	−0.976	
			2N1151	−0.948	−0.975	−0.989	
			2N1152	−0.9735	−0.98	−0.989	
			2N1153	−0.987	−0.99	−0.997	
h_{ib}	AC Common-Base Input Impedance	$V_{CB} = 5$ v $I_E = -1$ ma, f = 1 kc	ALL	30	42	80	ohm
h_{ob}	AC Common-Base Output Admittance	$V_{CB} = 5$ v $I_E = -1$ ma, f = 1 kc	ALL	0	0.4	1.2	μmho
h_{rb}	AC Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v $I_E = -1$ ma, f = 1 kc	2N1149	0	120×10^{-6}	500×10^{-6}	
			2N1150	0	250×10^{-6}	1000×10^{-6}	
			2N1151	0	400×10^{-6}	1000×10^{-6}	
			2N1152	0	400×10^{-6}	1000×10^{-6}	
			2N1153	0	400×10^{-6}	1000×10^{-6}	

*Indicates JEDEC registered data

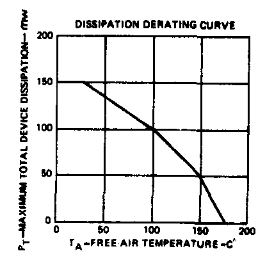
functional tests at 25°C free-air temperature

parameter		test conditions	types	min	typ	max	unit
G_{pe}	Common-Emitter Power Gain	$V_{CE} = 20$ v $I_E = -2$ ma, $R_G = 1$ KΩ $R_L = 20$ KΩ, f = 1 kc $V_g = 0.02$ v	2N1149		35		db
			2N1150		39		
			2N1151		39		
			2N1152		42		
			2N1153		42.5		
NF	Spot Noise Figure	$V_{CE} = 5$ v $I_E = -1$ ma, $R_G = 1$ KΩ f = 1 kc, BW = 1 cycle/sec	ALL		20		db

POWER GAIN TEST CIRCUIT



NOTE: $G_{pe} = 10 \log \frac{4 R_g}{R_L} \left(\frac{V_o}{V_g}\right)^2$



TEXAS INSTRUMENTS
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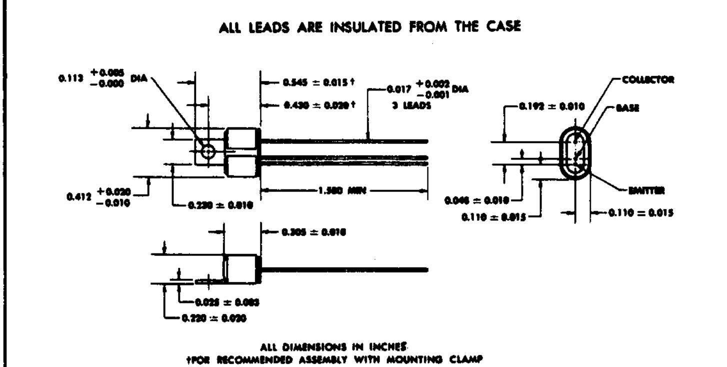
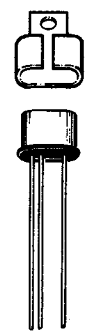
BULLETIN NO. DL-S 682269, JANUARY 1962—REVISED MAY 1968

FORMERLY TYPES 951, 952, AND 953, RESPECTIVELY

mechanical data

The transistor is in an oval welded package with glass-to-metal hermetic seal between case and leads. Unit weight is approximately 1 gram. The mounting clamp is hardware supplied with the transistor.





*absolute maximum ratings at 25°C case temperature (unless otherwise noted)

	2N1154	2N1155	2N1156
Collector-Base Voltage	50 v	80 v	120 v
Collector Current	60 ma	50 ma	40 ma
Total Device Dissipation (See Note 1)	← 750 mw →		
Total Device Dissipation at 100°C Case Temperature	← 300 mw →		
Total Device Dissipation at 125°C Case Temperature	← 150 mw →		
Collector Junction Operating Temperature	← 150°C →		
Storage Temperature Range	← −55°C to 150°C →		

NOTE 1: Derate linearly to 150°C case temperature at the rate of 6 mw/°C.
*Indicates JEDEC registered data

TEXAS INSTRUMENTS
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POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C case temperature

parameter		test conditions	type	min	max	unit
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50$ v $I_E = 0$	2N1154		5	μa
		$V_{CB} = 80$ v $I_E = 0$	2N1155		6	μa
		$V_{CB} = 120$ v $I_E = 0$	2N1156		8	μa
V_{BE}	Base-Emitter Voltage	$I_B = 2.2$ ma $I_C = 20$ ma	2N1154		1	v
		$I_B = 2.2$ ma $I_C = 15$ ma	2N1155		1	v
		$I_B = 2.2$ ma $I_C = 10$ ma	2N1156		1	v
$r_{CE(sat)}$	DC Collector-Emitter Saturation Resistance	$I_B = 2.2$ ma $I_C = 20$ ma	2N1154		300	ohm
		$I_B = 2.2$ ma $I_C = 15$ ma	2N1155		350	ohm
		$I_B = 2.2$ ma $I_C = 10$ ma	2N1156		400	ohm
h_{fb}	AC Common-Base Forward Current Transfer Ratio	$V_{CB} = 10$ v $I_E = -5$ ma $f = 1$ kc	2N1154 2N1155 2N1156	−0.9	−1	
h_{ib}	AC Common-Base Input Impedance	$V_{CB} = 10$ v $I_E = -5$ ma $f = 1$ kc	2N1154 2N1155 2N1156		30	ohm
h_{ob}	AC Common-Base Output Admittance	$V_{CB} = 10$ v $I_E = -5$ ma $f = 1$ kc	2N1154 2N1155 2N1156		2	μmho
h_{rb}	AC Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 10$ v $I_E = -5$ ma $f = 1$ kc	2N1154 2N1155 2N1156		300×10^{-6}	

*functional tests at 25°C case temperature

parameter		test conditions	type	min	max	unit
G_{pe}	Common-Emitter Power Gain (See Circuit)	$V_{CE} = 28$ v $I_C = 20$ ma $R_L = 1$ kΩ $f = 1$ kc $V_g = 0.2$ v	2N1154	30		db
		$V_{CE} = 45$ v $I_C = 15$ ma $R_L = 2$ kΩ $f = 1$ kc $V_g = 0.2$ v	2N1155	30		db
		$V_{CE} = 67.5$ v $I_C = 10$ ma $R_L = 4$ kΩ $f = 1$ kc $V_g = 0.2$ v	2N1156	30		db

*Indicates JEDEC registered data

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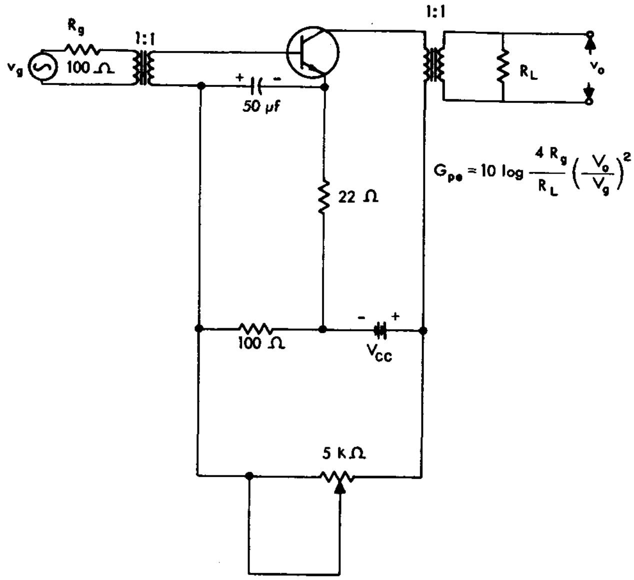
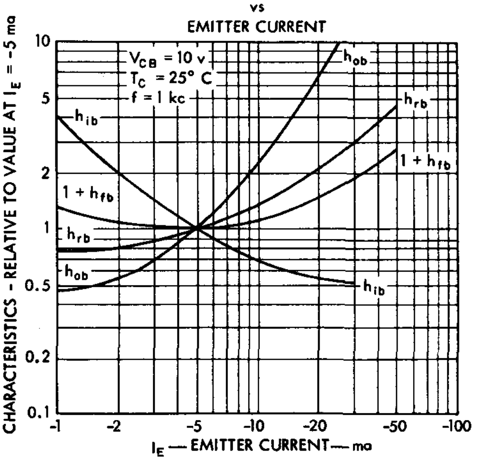
4

POWER GAIN TEST CIRCUIT

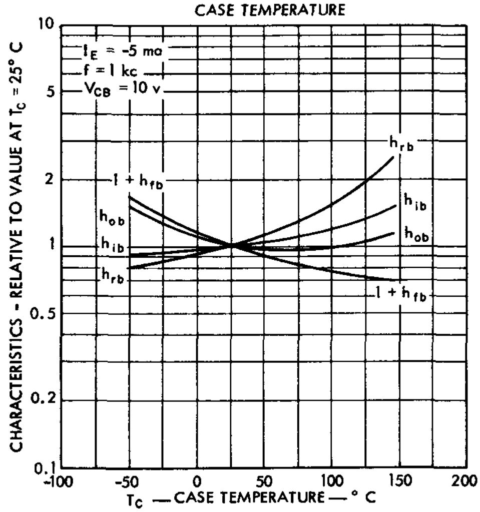


TYPICAL CHARACTERISTICS

COMMON-BASE CHARACTERISTICS
vs
EMITTER CURRENT



COMMON BASE CHARACTERISTICS
vs
CASE TEMPERATURE



TEXAS INSTRUMENTS
INCORPORATED
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TYPES 2N696, 2N697, 2N717, 2N718, 2N718A, 2N730, 2N731, 2N956, 2N1420, 2N1507, 2N1613, 2N1711
N-P-N SILICON TRANSISTORS

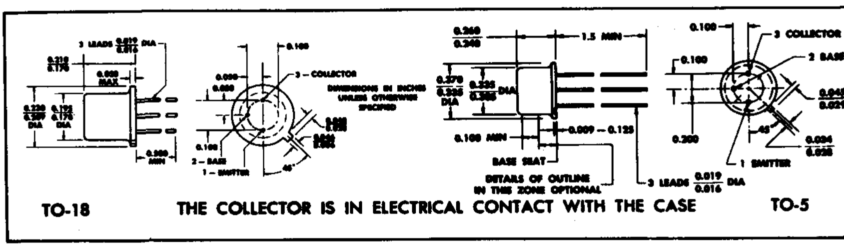
BULLETIN NO. DL-S 693471, MAY 1963–REVISED AUGUST 1969

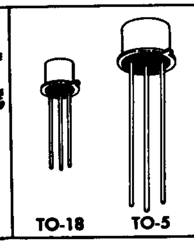
Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

- **High Voltage** • **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

*mechanical data

Device types 2N717, 2N718, 2N718A, 2N730, 2N731, and 2N956 are in JEDEC TO-18 packages.
Device types 2N696, 2N697, 2N1420, 2N1507, 2N1613, and 2N1711 are in JEDEC TO-5 packages.





*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N696 2N697	2N717 2N718	2N718A	2N730 2N731	2N956	2N1420 2N1507	2N1613	2N1711	UNIT
Collector-Base Voltage	60	60	75	60	75	60	75	75	v
Collector-Emitter Voltage (See Note 1)	40	40	50	40	50	30	50	50	v
Collector-Emitter Voltage (See Note 2)			32						v
Emitter-Base Voltage	5	5	7	5	7	5	7	7	v
Collector Current				1.0		1.0		1.0	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) →	0.6 † (3)	0.4 †† (5)	0.5 (7)	0.5 †† (9)	0.5 (7)	0.6 † (3)	0.8 (10)	0.8 (10)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) →	2.0 † (4)	1.5 †† (6)	1.8 (8)	1.5 †† (6)	1.8 (8)	2.0 † (4)	3.0 (11)	3.0 (11)	w
Total Device Dissipation at 100°C Case Temperature	1.0 †	0.75 ††	1.0	0.75 ††	1.0	1.0 †	1.7	1.7	w
Operating Collector Junction Temperature	175†	175††	200	175††	200	175†	200	200	°C
Storage Temperature Range	—65°C to 200°C								

NOTES: 1. This value applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/C°.
4. Derate linearly to 175°C case temperature at the rate of 13.3 mw/C°.
5. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/C°.
6. Derate linearly to 175°C case temperature at the rate of 10.0 mw/C°.
7. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/C°.
8. Derate linearly to 200°C case temperature at the rate of 10.3 mw/C°.
9. Derate linearly to 175°C free-air temperature at the rate of 3.33 mw/C°.
10. Derate linearly to 200°C free-air temperature at the rate of 4.56 mw/C°.
11. Derate linearly to 200°C case temperature at the rate of 17.2 mw/C°.

†Texas Instruments guarantees its types 2N696, 2N697, 2N1420, and 2N1507 to be capable of the same dissipation as registered and shown for types 2N1613 and 2N1711 with appropriate derating factors shown in Notes 10 and 11.

††Texas Instruments guarantees its types 2N717, 2N718, 2N730, and 2N731 to be capable of the same dissipation as registered and shown for types 2N718A and 2N956 with appropriate derating factors shown in Notes 7 and 8.

*Indicates JEDEC registered data.

USES CHIP N24

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TO-18 → 2N718A TO-5 → 2N1613		2N1420		2N1507		2N956 2N1711		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a, I_E = 0$	75		60		60		75		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 12					25				v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 12	50		30		30		50		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a, I_C = 0$	7						7		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$				1.0		1.0			μa
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$				100		50			μa
		$V_{CB} = 60$ v, $I_E = 0$		0.010						0.010	μa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		10						10	μa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100$ kΩ						10			μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		0.01				100		0.005	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$							20		
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$	20						35		
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 12	35						75		
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 12	20						35		
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 12	40	120	100	300	100	300	100	300	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 12	20						40		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.5		1.5		1.5		1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc	24	34					24	34	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc	4	8					4	8	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc		3×10^{-4}						5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc		3×10^{-4}						5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc	0.1	0.5					0.1	0.5	μmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc	0.1	1.0					0.1	1.0	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, f = 1 kc	30	100					50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, f = 1 kc	35	150					70	300	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, f = 20 mc	3.0		2.5		2.5		3.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, f = 1 mc		25		35		35		25	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, f = 1 mc		80						80	pf

See operating and switching characteristics for types 2N718A, 2N956, 2N1613, and 2N1711 on page 4-30.

NOTE 12: These parameters must be measured using pulse techniques. PW ≤ 300 μsec, Duty Cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data

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TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE 2N1566
N-P-N SILICON TRANSISTOR

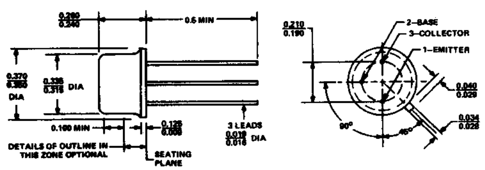
BULLETIN NO. DL-S 7311958, MARCH 1973

FOR GENERAL PURPOSE AMPLIFIER APPLICATIONS

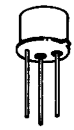
- $V_{(BR)CEO}$ . . . 60 V Min
- h_{FE} . . . 60 to 200

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	80 V
Collector-Emitter Voltage (See Note 1)	60 V
Emitter-Base Voltage	5 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	600 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	80*		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 3	60*		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40$ V, $I_E = 0$		1*	µA
		$V_{CB} = 40$ V, $I_E = 0$, $T_A = 150°C$		100	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		10*	µA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 5$ mA, See Note 3	60*	200*	
V_{BE}	Base-Emitter Voltage	$I_B = 2$ mA, $I_C = 10$ mA, See Note 3	0.35*	1.5*	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 2$ mA, $I_C = 10$ mA, See Note 3		1*	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ V, $I_C = 5$ mA, f = 1 kHz		1.8*	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ mA, f = 1 kHz	60		
		$V_{CE} = 5$ V, $I_C = 5$ mA, f = 1 kHz	80*	200*	
		$V_{CE} = 5$ V, $I_C = 5$ mA, $T_A = -55°C$, f = 1 kHz	40		
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 5$ mA, f = 30 MHz	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_E = 0$, f = 1 MHz		10*	pF

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 4 mW/°C.
3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

♦The JEDEC registered outline for this device is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP N23

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N696, 2N697, 2N717, 2N718, 2N718A, 2N730, 2N731, 2N956, 2N1420, 2N1507, 2N1613, 2N1711 N-P-N SILICON TRANSISTORS

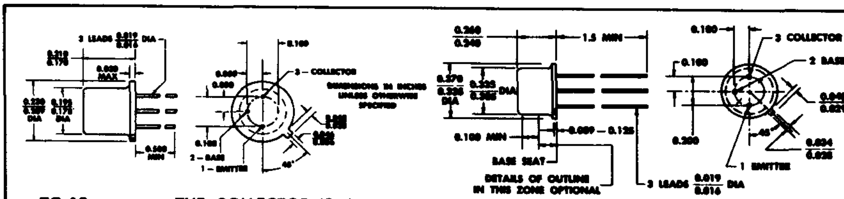
BULLETIN NO. DL-S 693471, MAY 1963—REVISED AUGUST 1969

Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

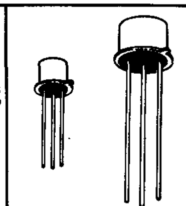
- **High Voltage** • **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

*mechanical data

Device types 2N717, 2N718, 2N718A, 2N730, 2N731, and 2N956 are in JEDEC TO-18 packages.
Device types 2N696, 2N697, 2N1420, 2N1507, 2N1613, and 2N1711 are in JEDEC TO-5 packages.



TO-18 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-5



TO-18 TO-5

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N696 2N697	2N717 2N718	2N718A	2N730 2N731	2N956	2N1420 2N1507	2N1613	2N1711	UNIT
Collector-Base Voltage	60	60	75	60	75	60	75	75	v
Collector-Emitter Voltage (See Note 1)	40	40	50	40	50	30	50	50	v
Collector-Emitter Voltage (See Note 2)			32						v
Emitter-Base Voltage	5	5	7	5	7	5	7	7	v
Collector Current				1.0		1.0		1.0	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) →	0.6 † (3)	0.4 †† (5)	0.5 (7)	0.5 †† (9)	0.5 (7)	0.6 † (3)	0.8 (10)	0.8 (10)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) →	2.0 † (4)	1.5 †† (6)	1.8 (8)	1.5 †† (6)	1.8 (8)	2.0 † (4)	3.0 (11)	3.0 (11)	w
Total Device Dissipation at 100°C Case Temperature	1.0 †	0.75 ††	1.0	0.75 ††	1.0	1.0 †	1.7	1.7	w
Operating Collector Junction Temperature	175†	175††	200	175††	200	175†	200	200	°C
Storage Temperature Range	—65°C to 200°C								

NOTES: 1. This value applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/C°.
4. Derate linearly to 175°C case temperature at the rate of 13.3 mw/C°.
5. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/C°.
6. Derate linearly to 175°C case temperature at the rate of 10.0 mw/C°.
7. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/C°.
8. Derate linearly to 200°C case temperature at the rate of 10.3 mw/C°.
9. Derate linearly to 175°C free-air temperature at the rate of 3.33 mw/C°.
10. Derate linearly to 200°C free-air temperature at the rate of 4.56 mw/C°.
11. Derate linearly to 200°C case temperature at the rate of 17.2 mw/C°.

†Texas Instruments guarantees its types 2N696, 2N697, 2N1420, and 2N1507 to be capable of the same dissipation as registered and shown for types 2N1613 and 2N1711 with appropriate derating factors shown in Notes 10 and 11.

††Texas Instruments guarantees its types 2N717, 2N718, 2N730, and 2N731 to be capable of the same dissipation as registered and shown for types 2N718A and 2N956 with appropriate derating factors shown in Notes 7 and 8.

*Indicates JEDEC registered data.

USES CHIP N24

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TO-18 → 2N718A / TO-5 → 2N1613 MIN	MAX	2N1420 MIN	MAX	2N1507 MIN	MAX	2N956 / 2N1711 MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a, I_E = 0$	75		60		60		75		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 12					25				v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 12	50		30		30		50		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a, I_C = 0$	7						7		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$				1.0		1.0			µa
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$				100		50			µa
		$V_{CB} = 60$ v, $I_E = 0$		0.010						0.010	µa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		10						10	µa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100\ k\Omega$						10			µa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		0.01				100		0.005	µa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$							20		
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$	20						35		
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 12	35						75		
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 12	20						35		
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 12	40	120	100	300	100	300	100	300	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 12	20						40		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12		1.5		1.5		1.5		1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	24	34					24	34	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	4	8					4	8	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		3×10^{-4}						5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		3×10^{-4}						5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	0.05	0.5					0.05	0.5	µmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	0.1	1.0					0.1	1.0	µmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	30	100					50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	35	150					70	300	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	3.0		2.5		2.5		3.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		25		35		35		25	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc		80						80	pf

*operating characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	TO-18 → 2N956 / TO-5 → 2N1711 TYP	MAX	TO-18 → 2N718A / TO-5 → 2N1613 TYP	MAX	UNIT
NF Spot Noise Figure	$V_{CE} = 10$ v, $I_C = 300\ \mu a$, $R_G = 510\ \Omega$, $f = 1$ kc	5	8	6	12	db

* switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	TO-18 → 2N718A / TO-5 → 2N1613 TYP	MAX	UNIT
t_T Total Switching Time	See Figure 1♦	20	30	nsec

NOTE 12: These parameters must be measured using pulse techniques. PW ≤ 300 µsec, Duty Cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data

♦The referenced figure is shown on page 4-30.

TYPES 2N1671, 2N1671A, 2N1671B, 2N2160
P-N BAR-TYPE SILICON UNIJUNCTION TRANSISTORS

BULLETIN NO. DL-S 683189, OCTOBER 1962—REVISED MAY 1968

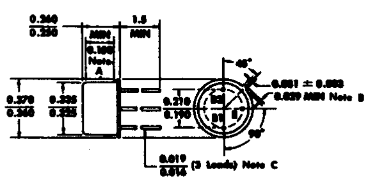
Designed for Medium-Power Switching, Oscillator and Pulse Timing Circuits

- **Highly Stable Negative Resistance and Firing Voltage**
- **Low Firing Current**
- **High Pulse Current Capabilities**
- **Simplified Circuit Design**

*mechanical data

Package outline is similar to JEDEC TO-5 except for lead position. Approximately weight is 1 gram.

*ALL LEADS INSULATED FROM CASE.

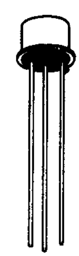


NOTES A. This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.010.

B. Measured from max. diameter of the actual device.

C. The specified lead diameter applies in the zone between 0.050 and 0.250 from the base seat. Between 0.250 and 1.5 maximum of 0.021 diameter is held. Outside of these zones the lead diameter is not controlled.

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N1671 2N1671A 2N1671B	2N2160
Emitter-Base Reverse Voltage	−30 v	
Emitter-Base Reverse Voltage below 140°C Junction Temperature		−30 v
Interbase Voltage	35 v	35 v
RMS Emitter Current	50 ma	
DC Emitter Current		70 ma
Peak Emitter Current (See Note 1)	2 a	
Peak Emitter Current below 140°C Junction Temperature		2 a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 2 & 3)	450 mw	450 mw
Operating Temperature Range (See Note 3)	−65°C to 140°C	
Storage Temperature Range (See Note 4)	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	260°C

NOTES: 1. Capacitor discharge — 10 μf or less, 30 volts or less — total interbase power dissipation must be limited by external circuitry.
2. Derate linearly to 140°C free-air temperature at the rate of 3.9 mw/°C. (2N1671 series only, thermal resistance to case = 0.16°C/mw.)
3. Texas Instruments guarantees a maximum operating temperature of 175°C free-air. Derate linearly at the rate of 3 mw/°C.
4. Texas Instruments guarantees a maximum storage temperature of 175°C.

*Indicates JEDEC registered data

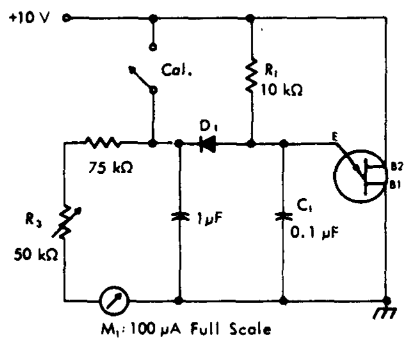
TYPES 2N1671, 2N1671A, 2N1671B, 2N2160
P-N BAR-TYPE SILICON UNIJUNCTION TRANSISTORS

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N1671		2N1671A		2N1671B		2N2160		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
r_{BB}	Static Interbase Resistance	$V_{B2B1} = 3$ v, $I_E = 0$	4.7	9.1	4.7	9.1	4.7	9.1	4.0	12	kΩ
η	Intrinsic Standoff Ratio	$V_{B2B1} = 10$ v, See Figure 1	0.47	0.62	0.47	0.62	0.47	0.62	0.47	0.80	
$I_{B2(mod)}$	Modulated Interbase Current	$V_{B2B1} = 10$ v, $I_E = 50$ ma	6.8	22	6.8	22	6.8	22	6.8	30	ma
I_{EB2O}	Emitter Reverse Current	$V_{B2E} = 30$ v, $I_{B1} = 0$		−12		−12		−0.2		−12	μa
I_P	Peak-Point Emitter Current	$V_{B2B1} = 25$ v		25		25		6		25	μa
$V_{EB1(sat)}$	Emitter Saturation Voltage	$V_{B2B1} = 10$ v, $I_E = 50$ ma		5		5		5			v
I_V	Valley-Point Emitter Current	$V_{B2B1} = 20$ v, $R_{B2} = 100\ \Omega$	8		8		8		8		ma
V_{OB1}	Base-One Peak Pulse Voltage	$V_1 = 20$ v, $R_{B1} = 20\ \Omega$, See Figure 2			3		3		3		v

*Indicates JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



η — Intrinsic Standoff Ratio — This parameter is defined in terms of the peak-point voltage, V_p, by means of the equation: $V_p = \eta V_{B2B1} + V_F$, where V_F is about 0.56 volt at 25°C and decreases with temperature at about 2 millivolts/deg.

The circuit used to measure η is shown in the figure. In this circuit, R_1, C_1 and the unijunction transistor form a relaxation oscillator, and the remainder of the circuit serves as a peak-voltage detector with the diode D_1 automatically subtracting the voltage V_F. To use the circuit, the "cal" button is pushed, and R_3 is adjusted to make the current meter M_1 read full scale. The "cal" button then is released and the value of η is read directly from the meter, with $\eta = 1$ corresponding to full-scale deflection of 100 μA.

D_1: 1N457, or equivalent, with the following characteristics:
$V_F = 0.565$ V at $I_F = 50$ μA,
$I_R \leq 2$ μA at $V_R = 20$ V

FIGURE 1 — TEST CIRCUIT FOR INTRINSIC STANDOFF RATIO (η)

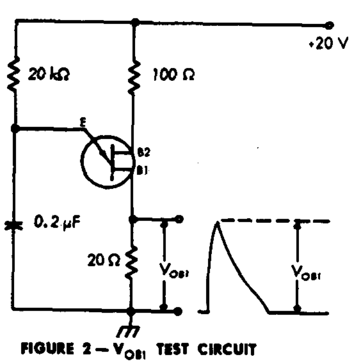


FIGURE 2 — V_{OB1} TEST CIRCUIT

EMITTER—BASE-ONE VOLTAGE vs EMITTER CURRENT

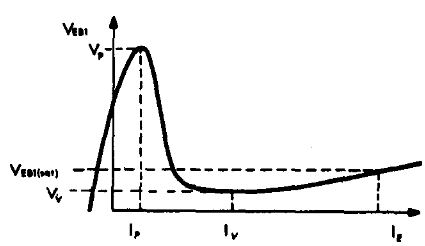


FIGURE 3 — GENERAL STATIC EMITTER CHARACTERISTIC CURVE

TYPES 2N696, 2N697, 2N717, 2N718, 2N718A, 2N730, 2N731, 2N956, 2N1420, 2N1507, 2N1613, 2N1711
N-P-N SILICON TRANSISTORS

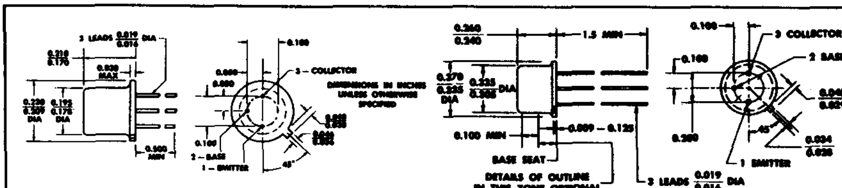
BULLETIN NO. DL-S 693471, MAY 1963—REVISED AUGUST 1969

Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

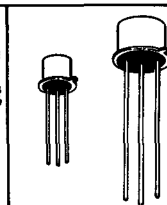
- High Voltage
- Low Leakage
- Useful h_{FE} Over Wide Current Range

*mechanical data

Device types 2N717, 2N718, 2N718A, 2N730, 2N731, and 2N956 are in JEDEC TO-18 packages.
Device types 2N696, 2N697, 2N1420, 2N1507, 2N1613, and 2N1711 are in JEDEC TO-5 packages.



TO-18 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-5



TO-18 TO-5

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N696 2N697	2N717 2N718	2N718A	2N730 2N731	2N956	2N1420 2N1507	2N1613	2N1711	UNIT
Collector-Base Voltage	60	60	75	60	75	60	75	75	v
Collector-Emitter Voltage (See Note 1)	40	40	50	40	50	30	50	50	v
Collector-Emitter Voltage (See Note 2)			32						v
Emitter-Base Voltage	5	5	7	5	7	5	7	7	v
Collector Current				1.0		1.0		1.0	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) →	0.6 † (3)	0.4 †† (5)	0.5 (7)	0.5 †† (9)	0.5 (7)	0.6 † (3)	0.8 (10)	0.8 (10)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) →	2.0 † (4)	1.5 †† (6)	1.8 (8)	1.5 †† (6)	1.8 (8)	2.0 † (4)	3.0 (11)	3.0 (11)	w
Total Device Dissipation at 100°C Case Temperature	1.0 †	0.75 ††	1.0	0.75 ††	1.0	1.0 †	1.7	1.7	w
Operating Collector Junction Temperature	175†	175††	200	175††	200	175†	200	200	°C
Storage Temperature Range	—65°C to 200°C								

NOTES:
1. This value applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/C°.
4. Derate linearly to 175°C case temperature at the rate of 13.3 mw/C°.
5. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/C°.
6. Derate linearly to 175°C case temperature at the rate of 10.0 mw/C°.
7. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/C°.
8. Derate linearly to 200°C case temperature at the rate of 10.3 mw/C°.
9. Derate linearly to 175°C free-air temperature at the rate of 3.33 mw/C°.
10. Derate linearly to 200°C free-air temperature at the rate of 4.56 mw/C°.
11. Derate linearly to 200°C case temperature at the rate of 17.2 mw/C°.

†Texas Instruments guarantees its types 2N696, 2N697, 2N1420, and 2N1507 to be capable of the same dissipation as registered and shown for types 2N1613 and 2N1711 with appropriate derating factors shown in Notes 10 and 11.

††Texas Instruments guarantees its types 2N717, 2N718, 2N730, and 2N731 to be capable of the same dissipation as registered and shown for types 2N718A and 2N956 with appropriate derating factors shown in Notes 7 and 8.

*Indicates JEDEC registered data.

USES CHIP N24

TYPES 2N718A, 2N956, 2N1420, 2N1507, 2N1613, 2N1711
N-P-N SILICON TRANSISTORS

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	TO-18 → / TO-5 →	2N718A / 2N1613 MIN	2N718A / 2N1613 MAX	2N1420 MIN	2N1420 MAX	2N1507 MIN	2N1507 MAX	2N956 / 2N1711 MIN	2N956 / 2N1711 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a, I_E = 0$		75		60		60		75		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 12						25				v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 12		50		30		30		50		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a, I_C = 0$		7						7		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$					1.0		1.0			μa
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$					100		50			μa
		$V_{CB} = 60$ v, $I_E = 0$			0.010						0.010	μa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$			10						10	μa
I_{CER}	Collector Cutoff Current	$V_{CE} = 20$ v, $R_{BE} = 100$ kΩ							10			μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$			0.01				100		0.005	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$								20		
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$		20						35		
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 12		35						75		
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 12		20						35		
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 12		40	120	100	300	100	300	100	300	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 12		20						40		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12			1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 12			1.5		1.5		1.5		1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc		24	34					24	34	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc		4	8					4	8	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc			3×10^{-4}						5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc			3×10^{-4}						5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, f = 1 kc		0.1	0.5					0.1	0.5	μmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, f = 1 kc		0.1	1.0					0.1	1.0	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, f = 1 kc		30	100					50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, f = 1 kc		35	150					70	300	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, f = 20 mc		3.0		2.5		2.5		3.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, f = 1 mc			25		35		35		25	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, f = 1 mc			80						80	pf

See switching characteristics for types 2N718A and 2N613 on pages 4-30 or 4-72.

***operating characteristics at 25°C free-air temperature**

PARAMETER	TEST CONDITIONS	TO-18 → / TO-5 →	2N956 / 2N1711 TYP	2N956 / 2N1711 MAX	2N718A / 2N1613 TYP	2N718A / 2N1613 MAX	UNIT
NF Spot Noise Figure	$V_{CE} = 10$ v, $I_C = 300\ \mu a$, $R_G = 510\ \Omega$, f = 1 kc		5	8	6	12	db

NOTE 12: These parameters must be measured using pulse techniques. PW ≤ 300 μsec, Duty Cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N698, 2N699, 2N719, 2N719A, 2N720, 2N720A, 2N870, 2N871, 2N1889, 2N1890, 2N1893
N-P-N SILICON TRANSISTORS

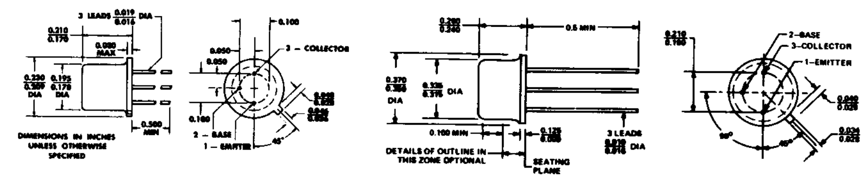
BULLETIN NO. DL-S 733442, MAY 1963—REVISED MARCH 1973

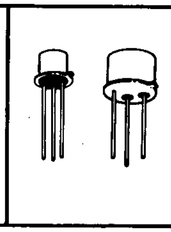
Highly Reliable, Versatile Devices Designed for Amplifier, Switching and Oscillator Applications from <0.1 ma to >150 ma, dc to 30 mc

- **High Voltage** • **Low Leakage**
- **Useful h_{FE} Over Wide Current Range**

mechanical data

Device types 2N719, 2N719A, 2N720, 2N720A, 2N870 and 2N871 are in JEDEC TO-18 packages*.
Device types 2N698, 2N699, 2N1889, 2N1890, and 2N1893 are in JEDEC TO-39 packages◆.





TO-18* THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE TO-39◆

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N698	2N699	2N719 2N720	2N719A	2N720A	2N870 2N871	2N1889 2N1890	2N1893	UNIT
Collector-Base Voltage	120	120	120	120	120	100	100	120	v
Collector-Emitter Voltage (See Note 1)	80	80	80	80	100	80	80	100	v
Collector-Emitter Voltage (See Note 2)	60			60	80	60	60	80	v
Emitter-Base Voltage	7	5	5	7	7	7	7	7	v
Collector Current				1.0				0.5	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note Indicated in Parentheses) →	0.8 (3)	0.6 † (5)	0.4 ‡ (7)	0.5 (9)	0.5 (9)	0.5 (9)	0.8 (3)	0.8 (3)	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note Indicated in Parentheses) →	3.0 † (4)	2.0 † (6)	1.5 ‡ (8)	1.8 (10)	1.8 (10)	1.8 (10)	3.0 † (4)	3.0 † (4)	w
Storage Temperature Range	—65°C to 200°C								

NOTES:
1. This values applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This values applies when the base-emitter diode is open-circuited.
3. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
4. Derate linearly to 200°C case temperature at the rate of 17.2 mw/°C.
5. Derate linearly to 175°C free-air temperature at the rate of 4.0 mw/°C.
6. Derate linearly to 175°C case temperature at the rate of 13.3 mw/°C.
7. Derate linearly to 175°C free-air temperature at the rate of 2.67 mw/°C.
8. Derate linearly to 175°C case temperature at the rate of 10.0 mw/°C.
9. Derate linearly to 200°C free-air temperature at the rate of 2.86 mw/°C.
10. Derate linearly to 200°C case temperature at the rate of 10.3 mw/°C.

†Texas Instruments guarantees these devices in TO-39 packages date-coded 7326 or higher to be capable of increased dissipation as follows: 0.8 W at $T_A \leq 25°C$ derated linearly to $T_A = 200°C$ at the rate of 4.57 mW/°C, or 10 W at $T_C \leq 25°C$ (5.71 W at $T_C = 100°C$) derated linearly to $T_C = 200°C$ at the rate of 57.1 mW/°C.

‡Texas Instruments guarantees its types 2N719 and 2N720 to be capable of the same dissipation as registered and shown for types 2N719A, 2N720A, 2N870, and 2N871 with appropriate derating factors shown in Notes 9 and 10.

*JEDEC registered data.
◆The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.

USES CHIP N23

TYPES 2N720, 2N720A, 2N870, 2N871, 2N1889, 2N1890, 2N1893
N-P-N SILICON TRANSISTORS

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TO-18→ 2N720		2N720A		2N870		2N871		UNIT
			TO-39→		2N1893		2N1889		2N1890		
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	120		120		100		100		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 11			80		60		60		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 11	80		100		80		80		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$			7		7		7		v
		$I_E = 1$ ma, $I_C = 0$	5								v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$		2							µa
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		200							µa
		$V_{CB} = 75$ v, $I_E = 0$						0.010		0.010	µa
		$V_{CB} = 75$ v, $I_E = 0$, $T_A = 150°C$						15		15	µa
		$V_{CB} = 90$ v, $I_E = 0$				0.010					µa
		$V_{CB} = 90$ v, $I_E = 0$, $T_A = 150°C$				15					µa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 2$ v, $I_C = 0$									µa
		$V_{EB} = 5$ v, $I_C = 0$				0.010		0.010		0.010	µa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$			20		20				
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 11			35		35				
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 11			20		20				
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 11	40	120	40	120	40	120	100	300	
V_{BE}	Base-Emitter Voltage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11				0.9		0.9		0.9	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		1.3		1.3		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Volage	$I_B = 5$ ma, $I_C = 50$ ma, See Note 11				1.2		1.2		1.2	v
		$I_B = 15$ ma, $I_C = 150$ ma, See Note 11		5		5		5		5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	20	30	20	30	20	30	20	30	ohm
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		10	4	8	4	8	4	8	ohm
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		2.5×10^{-4}		1.25×10^{-4}		1.25×10^{-4}		1.5×10^{-4}	
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		3×10^{-4}		1.5×10^{-4}		1.5×10^{-4}		1.5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	0.1	0.5		0.5		0.5		0.3	µmho
		$V_{CB} = 10$ v, $I_C = 5$ ma, $f = 1$ kc		1.0		0.5		0.5		0.3	µmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	35	100	30	100	30	100	50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	45		45		45	150	70	300	
$\lvert h_{fe}\rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.5		2.5		2.5		3.0		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc; Except 2N720: $f = 140$ kc		20		15		15		15	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc; Except 2N720: $f = 140$ kc		85		85		85		85	pf

NOTE 11: These parameters must be measured using pulse techniques. PW ≤ 300 µsec., Duty cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC registered data.

TEXAS INSTRUMENTS
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TYPES 2N910, 2N911, 2N912, 2N1973, 2N1974, 2N1975
N-P-N SILICON TRANSISTORS

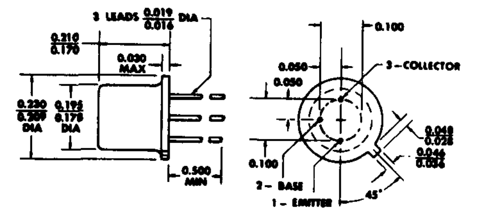
BULLETIN NO. DL-S 733561, MAY 1963—REVISED MARCH 1973

HIGHLY RELIABLE, VERSATILE DEVICES CHARACTERIZED ESPECIALLY FOR SMALL-SIGNAL APPLICATIONS

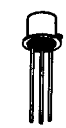
- High Voltage • Low Leakage
- Useful h_{FE} Over Wide Current Range
- Both Common-Emitter and Common-Base Small-Signal Characterization

mechanical data

2N910, 2N911, 2N912 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

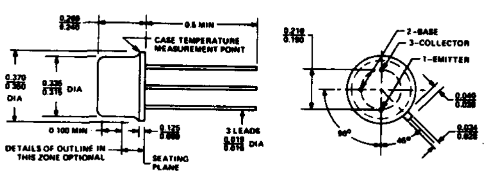


ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE*

2N1973, 2N1974, 2N1975 THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N910 2N911 2N912	2N1973 2N1974 2N1975
Collector-Base Voltage	← 100 v* →	
Collector-Emitter Voltage (See Note 1)	← 80 v* →	
Collector-Emitter Voltage (See Note 2)	← 60 v* →	
Emitter-Base Voltage	← 7 v* →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 3 and 4)	0.5 w*	0.8 w*
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Notes 5 and 6)	1.8 w*	10 w† / 3 w*
Storage Temperature Range	−65°C to 200°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTES:
1. This value applies when the base-emitter resistance $R_{BE} \leq 10\ \Omega$.
2. This value applies when the base-emitter diode is open-circuited.
3. For 2N910, 2N911, and 2N912, derate linearly to 200°C free-air temperature at the rate of 2.86 mw/°C.
4. For 2N1973, 2N1974, and 2N1975, derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
5. For 2N910, 2N911, and 2N912, derate linearly to 200°C case temperature at the rate of 10.3 mw/°C.
6. For 2N1973, 2N1974, and 2N1975, derate linearly to 200°C case temperature at the rates of 57.1 mw/°C for the 10-watt rating and 17.2 mw/°C for the 3-watt (JEDEC registered) rating.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

USES CHIP N23

TYPES 2N910, 2N911, 2N912, 2N1973, 2N1974, 2N1975
N-P-N SILICON TRANSISTORS

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TO-18 → 2N910		TO-18 → 2N911		TO-18 → 2N912		UNIT
		TO-39 → 2N1973		TO-39 → 2N1974		TO-39 → 2N1975		
		MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$ Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	100		100		100		v
$V_{(BR)CEO}$ Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$ (See Note 7)	60		60		60		v
$V_{(BR)CER}$ Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$ (See Note 7)	80		80		80		v
$V_{(BR)EBO}$ Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	7.0		7.0		7.0		v
I_{CBO} Collector Cutoff Current	$V_{CB} = 75$ v, $I_E = 0$		25		25		25	na
	$V_{CB} = 75$ v, $I_E = 0$, $T_A = 150°C$		15		15		15	μa
I_{EBO} Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		25		25		25	na
h_{FE} Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$	35		20		10		
	$V_{CE} = 10$ v, $I_C = 10$ ma (See Note 7)	75		35		15		
	$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$ (See Note 7)	30		15		10		
V_{BE} Base-Emitter Voltage	$I_B = 1$ ma, $I_C = 10$ ma	0.6	0.8	0.6	0.8	0.6	0.8	v
	$I_B = 5$ ma, $I_C = 50$ ma		0.9		0.9		0.9	v
$V_{CE(sat)}$ Collector-Emitter Saturation Voltage	$I_B = 1$ ma, $I_C = 10$ ma		0.4		0.4		0.4	v
	$I_B = 5$ ma, $I_C = 50$ ma		1.2		1.2		1.2	v
h_{ib} Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	20	30	20	30	20	30	ohm
	$V_{CB} = 5$ v, $I_C = 5$ ma, $f = 1$ kc	4.0	8.0	4.0	8.0	4.0	8.0	ohm
h_{rb} Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		3×10^{-4}		1.25×10^{-4}		1.25×10^{-4}	
	$V_{CB} = 5$ v, $I_C = 5$ ma, $f = 1$ kc		4×10^{-4}		1.75×10^{-4}		1.75×10^{-4}	
h_{ob} Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		0.5		0.5		0.5	μmho
	$V_{CB} = 5$ v, $I_C = 5$ ma, $f = 1$ kc		1.0		1.0		1.0	μmho
h_{ie} Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ v, $I_C = 5$ ma, $f = 1$ kc		1800		1000		600	ohm
h_{fe} Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	76	200	36	90	18	50	
	$V_{CE} = 5$ v, $I_C = 5$ ma, $f = 1$ kc	80	200	40	100	20	50	
h_{oe} Small-Signal Common-Emitter Output Admittance	$V_{CE} = 5$ v, $I_C = 5$ ma, $f = 1$ kc		100		50		25	μmho
$\lvert h_{fe} \rvert$ Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	3.0		2.5		2.0		
C_{ob} Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		15		15		15	pf
C_{ib} Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc		85		85		85	pf

*operating characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	TO-18 → 2N910	TO-18 → 2N911	TO-18 → 2N912	UNIT
		TO-39 → 2N1973	TO-39 → 2N1974	TO-39 → 2N1975	
		MAX	MAX	MAX	
NF Spot Noise Figure	$V_{CB} = 10$ v, $I_C = 300\ \mu a$, $R_G = 510\ \Omega$, $f = 1$ kc, Noise Bandwidth = 200 cps	12	15	18	db

NOTE 7: These parameters must be measured using pulse techniques. PW ≤ 300 µsec, Duty Cycle ≤ 2%. Pulse width must be such that halving or doubling does not cause a change greater than the required accuracy of the measurement.

*Indicates JEDEC Registered Data.

TEXAS INSTRUMENTS
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TYPES 2N2060, 2N2223, 2N2223A
DUAL N-P-N SILICON TRANSISTORS

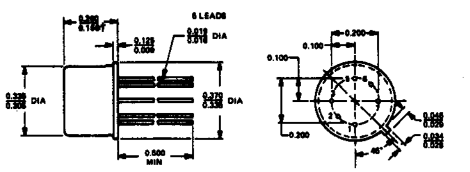
BULLETIN NO. DL-S 7211678, MARCH 1972

TWO TRANSISTORS IN ONE PACKAGE FOR DIFFERENTIAL AMPLIFIER APPLICATIONS

- Medium Power
- High Operating Voltage

*mechanical data

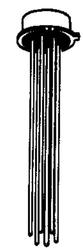
ALL LEADS INSULATED FROM CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2



†Applicable to 2N2223 and 2N2223A only. Registered minimum dimension for 2N2060 is 0.140.

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*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2060		2N2223 2N2223A		UNIT
	EACH TRIODE	TOTAL DEVICE	EACH TRIODE	TOTAL DEVICE	
Collector-Base Voltage	100		100		V
Collector-Emitter Voltage (See Note 1)	80		80		V
Collector-Emitter Voltage (See Note 2)	60		60		V
Emitter-Base Voltage	7		7		V
Continuous Collector Current	500		500		mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	0.5	0.6	0.5	0.6	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Notes 4 and 5)	1.5	3	1.6	3	W
Continuous Device Dissipation at 100°C Case Temperature	0.86	1.7	0.91	1.7	W
Operating Collector Junction Temperature	200		200		°C
Storage Temperature Range	−65°C to 200°C				
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C				

NOTES:
1. These values apply when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. These values apply when the base-emitter diode is open-circuited.
3. Derate linearly to 200°C free-air temperature at the rate of 2.86 mW/°C for each triode and 3.43 mW/°C for total device.
4. Derate 2N2060 linearly to 200°C case temperature at the rate of 8.6 mW/°C for each triode and 17.2 mW/°C for total device.
5. Derate 2N2223 and 2N2223A linearly to 200°C case temperature at the rate of 9.1 mW/°C for each triode and 17.2 mW/°C for total device.
6. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
7. This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 1%.
8. The lower of the two h_{FE} reading is taken as h_{FE1}.
9. This parameter is measured in an amplifier with response down 3 dB at 25 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP N23

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 6)

PARAMETER		TEST CONDITIONS	2N2060 MIN	2N2060 MAX	2N2223, 2N2223A MIN	2N2223, 2N2223A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	100		100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$, See Note 7	60		60		V
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ mA, $R_{BE} = 10\ \Omega$, See Note 7	80		80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	7		7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 80$ V, $I_E = 0$		2		10	nA
		$V_{CB} = 80$ V, $I_E = 0$, $T_A = 150°C$		10		15	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		2		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 10\ \mu A$	25	75	15		
		$V_{CE} = 5$ V, $I_C = 100\ \mu A$	30	90	25	150	
		$V_{CE} = 5$ V, $I_C = 1$ mA	40	120			
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 7	50	150	50	200	
V_{BE}	Base-Emitter Voltage	$I_B = 5$ mA, $I_C = 50$ mA		0.9		0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ mA, $I_C = 50$ mA		1.2		1.2	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz	20	30	20	30	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz				3×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz				0.5	μmho
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz	1000	4000			Ω
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz	50	150	40	200	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz		16			μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 50$ mA, $f = 20$ MHz	3		2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz		15		15	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 1$ MHz		85		85	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N2060 MIN	2N2060 MAX	2N2223 MIN	2N2223 MAX	2N2223A MIN	2N2223A MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward Current Gain Balance Ratio	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, See Note 8	0.9	1	0.8	1	0.9	1	
		$V_{CE} = 5$ V, $I_C = 1$ mA, See Note 8	0.9	1					
$\lvert V_{BE1} - V_{BE2} \rvert$	Base-Emitter-Voltage Differential	$V_{CE} = 5$ V, $I_C = 100\ \mu A$		5		15		5	mV
		$V_{CE} = 5$ V, $I_C = 1$ mA		5					mV
$\left\lvert \frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A} \right\rvert$	Base-Emitter-Voltage-Differential Temperature Gradient	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, From $T_A = -55°C$ to $T_A = 125°C$		10		25		25	$\mu V/°C$

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 6)

PARAMETER		TEST CONDITIONS	2N2060 MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 10$ V, $I_C = 300\ \mu A$, $R_G = 510\ \Omega$, $f = 1$ kHz	8	dB
$\overline{F}$	Average Noise Figure	$V_{CE} = 10$ V, $I_C = 300\ \mu A$, $R_G = 1$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 9	8	dB

*JEDEC registered data

TEXAS INSTRUMENTS
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TYPES 2N2102, 2N2102A
N-P-N SILICON TRANSISTORS

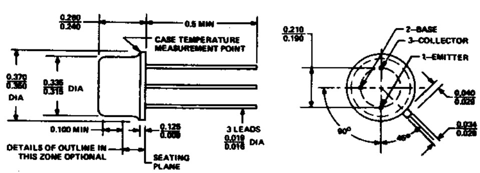
BULLETIN NO. DL-S 7311946, MARCH 1973

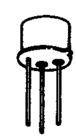
FOR MEDIUM-POWER, GENERAL PURPOSE APPLICATIONS

- High Breakdown Voltage Combined with Low Saturation Voltage
- h_{FE} . . . Guaranteed from 10 μA to 1 A

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE◆

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

Collector-Base Voltage	120 V*
Collector-Emitter Voltage (See Note 1)	65 V*
Collector-Emitter Voltage (See Note 2)	80 V*
Emitter-Base Voltage	7 V*
Continuous Collector Current	1 A*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	1 W*
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	10 W† / 5 W*
Storage Temperature Range	−65°C to 200°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C*

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies when the base-emitter resistance $R_{BE} \leq 10\ \Omega$.
3. Derate linearly to 200°C free-air temperature at the rate of 5.71 mW/°C.
4. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mW/°C. Derate the 5-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 28.6 mW/°C.

◆The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

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*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2102 MIN	2N2102 MAX	2N2102A MIN	2N2102A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	120		120		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 100\ mA$, $I_B = 0$, See Note 5	65		65		V
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100\ mA$, $R_{BE} = 10\ \Omega$, See Note 5	80		80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 0.1\ mA$, $I_C = 0$	7		7		V
V_{RT}	Reach-Through Voltage	$V_{EB(fl)} = 1.5\ V$, $I_E = 0$, See Note 6	120		120		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60\ V$, $I_E = 0$		2		2	nA
		$V_{CB} = 60\ V$, $I_E = 0$, $T_C = 150°C$		2		2	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5\ V$, $I_C = 0$		2		2	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 10\ \mu A$	10		10		
		$V_{CE} = 10\ V$, $I_C = 100\ \mu A$	20		20		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$, See Note 5	35		35		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$, $T_C = -55°C$, See Note 5	20		20		
		$V_{CE} = 10\ V$, $I_C = 150\ mA$, See Note 5	40	120	40	120	
		$V_{CE} = 10\ V$, $I_C = 500\ mA$, See Note 5	25		25		
		$V_{CE} = 10\ V$, $I_C = 1\ A$, See Note 5	10		10		
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$, See Note 5		1.1		1.1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$, See Note 5		0.5		0.3	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	24	34	24	34	Ω
		$V_{CE} = 10\ V$, $I_C = 5\ mA$, $f = 1\ kHz$	4	8	4	8	
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$		3×10^{-4}		3×10^{-4}	
		$V_{CE} = 10\ V$, $I_C = 5\ mA$, $f = 1\ kHz$		3×10^{-4}		3×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	0.08	0.5	0.08	0.5	μmho
		$V_{CE} = 10\ V$, $I_C = 5\ mA$, $f = 1\ kHz$	0.08	1	0.08	1	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	30	100	30	100	
		$V_{CE} = 10\ V$, $I_C = 5\ mA$, $f = 1\ kHz$	35	150	35	150	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 50\ mA$, $f = 20\ MHz$	3		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$, $f = 1\ MHz$		15		15	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$, $f = 1\ MHz$		80		80	pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
6. V_{RT} is determined by measuring the emitter-base floating potential, $V_{EB(fl)}$. Collector-base voltage, V_{CB}, is increased until $V_{EB(fl)} = 1.5\ V$; this value of $V_{CB} = (V_{RT} + 1.5\ V)$.

*thermal characteristics

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	35	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	175	°C/W

*JEDEC registered data.

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***operating characteristics at 25°C case temperature**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 10$ V, $I_C = 0.3$ mA, $f = 1$ kHz, $R_G = 1$ kΩ		6	dB

***switching characteristics at 25°C case temperature**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_T	Total Switching Time	See Figure 1		30	ns

*PARAMETER MEASUREMENT INFORMATION

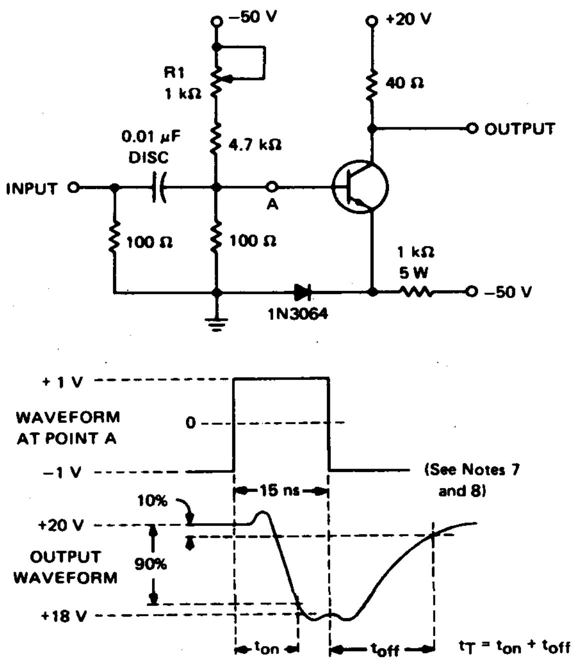

FIGURE 1—SWITCHING TIME MEASUREMENT CIRCUIT

NOTES: 7. The input waveform is supplied by a mercury relay pulse generator with the following characteristics: $t_r \leq 1$ ns, $t_f \leq 1$ ns, $t_w = 15$ ns, $Z_{out} = 50$ Ω. Adjust R1 and the input pulse amplitude to obtain the specified voltage levels at Point A.

8. Waveforms are monitored on a sampling oscilloscope ($t_r \leq 0.4$ ns) using a 2-kΩ probe.

*JEDEC registered data

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TYPES 2N1671, 2N1671A, 2N1671B, 2N2160
P-N BAR-TYPE SILICON UNIJUNCTION TRANSISTORS

BULLETIN NO. DL-S 683189, OCTOBER 1962—REVISED MAY 1968

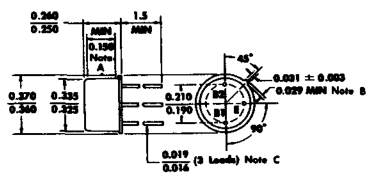
Designed for Medium-Power Switching, Oscillator and Pulse Timing Circuits

- **Highly Stable Negative Resistance and Firing Voltage**
- **Low Firing Current**
- **High Pulse Current Capabilities**
- **Simplified Circuit Design**

mechanical data

Package outline similar to JEDEC TO-5 except for lead position. Approximate weight 1 gram.

*ALL LEADS INSULATED FROM CASE.

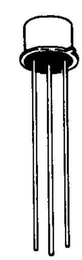


NOTES A. This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.010.

B. Measured from max. diameter of the actual device.

C. The specified lead diameter applies in the zone between 0.050 and 0.250 from the base seat. Between 0.250 and 1.5 maximum of 0.021 diameter is held. Outside of these zones the lead diameter is not controlled.

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N1671 2N1671A 2N1671B	2N2160
Emitter-Base Reverse Voltage	−30 v	
Emitter-Base Reverse Voltage below 140°C Junction Temperature		−30 v
Interbase Voltage	35 v	35 v
RMS Emitter Current	50 ma	
DC Emitter Current		70 ma
Peak Emitter Current (See Note 1)	2 a	
Peak Emitter Current below 140°C Junction Temperature		2 a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 2 & 3)	450 mw	450 mw
Operating Temperature Range (See Note 3)	−65°C to 140°C	
Storage Temperature Range (See Note 4)	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	260°C

NOTES: 1. Capacitor discharge — 10 μf or less, 30 volts or less — total interbase power dissipation must be limited by external circuitry.
2. Derate linearly to 140°C free-air temperature at the rate of 3.9 mw/°C. (2N1671 series only, thermal resistance to case = 0.16°C/mw.)
3. Texas Instruments guarantees a maximum operating temperature of 175°C free-air. Derate linearly at the rate of 3 mw/°C.
4. Texas Instruments guarantees a maximum storage temperature of 175°C.

*Indicates JEDEC registered data

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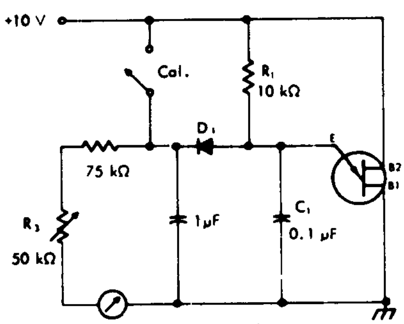
*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N1671		2N1671A		2N1671B		2N2160		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
r_{BB}	Static Interbase Resistance	$V_{B2B1} = 3$ v, $I_E = 0$	4.7	9.1	4.7	9.1	4.7	9.1	4.0	12	kΩ
η	Intrinsic Standoff Ratio	$V_{B2B1} = 10$ v, See Figure 1	0.47	0.62	0.47	0.62	0.47	0.62	0.47	0.80	
$I_{B2(mod)}$	Modulated Interbase Current	$V_{B2B1} = 10$ v, $I_E = 50$ ma	6.8	22	6.8	22	6.8	22	6.8	30	ma
I_{EB2O}	Emitter Reverse Current	$V_{B2E} = 30$ v, $I_{B1} = 0$		−12		−12		−0.2		−12	μa
I_P	Peak-Point Emitter Current	$V_{B2B1} = 25$ v		25		25		6		25	μa
$V_{EB1(sat)}$	Emitter Saturation Voltage	$V_{B2B1} = 10$ v, $I_E = 50$ ma		5		5		5			v
I_V	Valley-Point Emitter Current	$V_{B2B1} = 20$ v, $R_{B2} = 100\ \Omega$	8		8		8		8		ma
V_{OB1}	Base-One Peak Pulse Voltage	$V_1 = 20$ v, $R_{B1} = 20\ \Omega$, See Figure 2			3		3		3		v

*Indicates JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



η — Intrinsic Standoff Ratio — This parameter is defined in terms of the peak-point voltage, V_p, by means of the equation: $V_p = \eta V_{B2B1} + V_F$, where V_F is about 0.56 volt at 25°C and decreases with temperature at about 2 millivolts/deg.

The circuit used to measure η is shown in the figure. In this circuit, R_1, C_1 and the unijunction transistor form a relaxation oscillator, and the remainder of the circuit serves as a peak-voltage detector with the diode D_1 automatically subtracting the voltage V_F. To use the circuit, the "cal" button is pushed, and R_3 is adjusted to make the current meter M_1 read full scale. The "cal" button then is released and the value of η is read directly from the meter, with $\eta = 1$ corresponding to full-scale deflection of 100 μA.

D_1: 1N457, or equivalent, with the following characteristics:
$V_F = 0.565$ V at $I_F = 50$ μA,
$I_R \leq 2$ μA at $V_R = 20$ V

FIGURE 1 — TEST CIRCUIT FOR INTRINSIC STANDOFF RATIO (η)

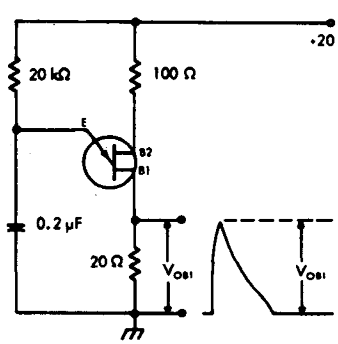


FIGURE 2 — V_{OB1} TEST CIRCUIT

EMITTER—BASE-ONE VOLTAGE vs EMITTER CURRENT

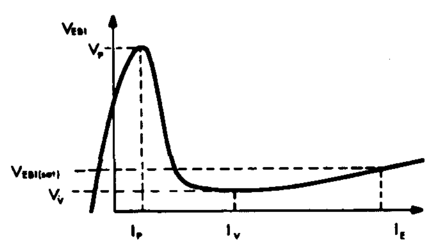


FIGURE 3 — GENERAL STATIC EMITTER CHARACTERISTIC CURVE

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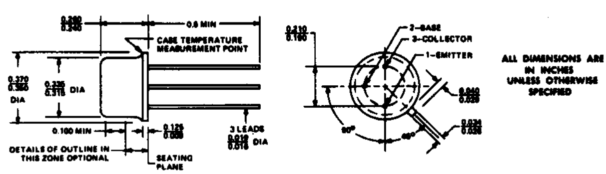
BULLETIN NO. DL-S 733571, MARCH 1963–REVISED MARCH 1973

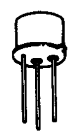
FOR MEDIUM-POWER SWITCHING AND AMPLIFIER APPLICATIONS

- **High Breakdown Voltage Combined with Very Low Saturation Voltage**
- **h_{FE}—Guaranteed from 100 μa to 1 amp**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2192 2N2192A	2N2193 2N2193A	2N2194 2N2194A	2N2243 2N2243A	UNIT
Collector-Base Voltage	60*	80*	60*	120*	v
Collector-Emitter Voltage (See Note 1)	40*	50*	40*	80*	v
Emitter-Base Voltage	5*	8*	5*	7*	v
Collector Current	1*	1*	1*	1*	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.8*	0.8*	0.8*	0.8*	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	10† 2.8*	10† 2.8*	10† 2.8*	10† 2.8*	w
Storage Temperature Range	−65°C to 200°C*				
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C*				

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mw/°C. Derate the 2.8-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 16 mw/°C.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	2N2192 2N2192A MIN	2N2192 2N2192A MAX	2N2193 2N2193A MIN	2N2193 2N2193A MAX	2N2194 2N2194A MIN	2N2194 2N2194A MAX	UNIT
$V_{(BR)CBO}$ Collector-Base Breakdown Voltage	$I_C = 100\ \mu a, I_E = 0$	60		80		60		v
$V_{(BR)CEO}$ Collector-Emitter Breakdown Voltage	$I_C = 25$ ma, $I_B = 0$, See Note 4	40		50		40		v
$V_{(BR)EBO}$ Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	5		8		5		v
I_{CBO} Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$		10				10	na
	$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$		15				25	μa
	$V_{CB} = 60$ v, $I_E = 0$				10			na
	$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$				25			μa
I_{EBO} Emitter Cutoff Current	$V_{EB} = 3$ v, $I_C = 0$		50				50	na
	$V_{EB} = 5$ v, $I_C = 0$				50			na
h_{FE} Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$	15		15				
	$V_{CE} = 10$ v, $I_C = 10$ ma	75		30		15		
	$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$	35		20				
	$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 4	100	300	40	120	20	60	
	$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 4	35		20		12		
	$V_{CE} = 10$ v, $I_C = 1$ a, See Note 4	15		15				
	$V_{CE} = 1$ v, $I_C = 150$ ma, See Note 4	70		30		15		
V_{BE} Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma		1.3		1.3		1.3	v
$V_{CE(sat)}$ Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma — 2N2192–2N2194		0.35		0.35		0.35	v
	$I_B = 15$ ma, $I_C = 150$ ma — 2N2192A–2N2194A		0.25		0.25		0.25	v
$\|h_{fe}\|$ Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 20$ mc	2.5		2.5		2.5		
C_{ob} Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		20		20		20	pf

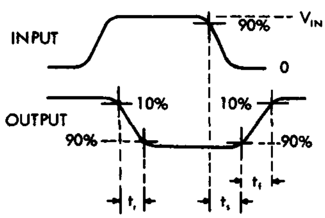
*switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	2N2192 2N2192A 2N2193 2N2193A 2N2194 2N2194A MAX	UNIT
t_r Rise Time	See Figure 1	70	nsec
t_s Storage Time	See Figure 1	150	nsec
t_f Fall Time	See Figure 1	50	nsec

NOTE 4: These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle $\leq$ 2%.

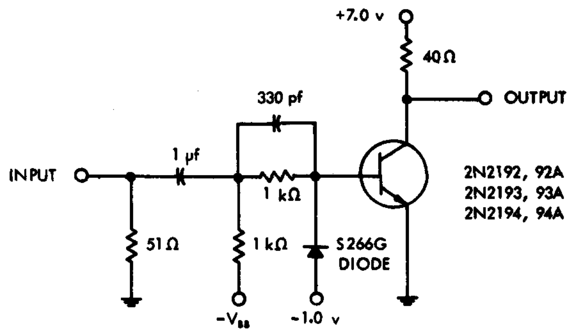
*Indicates JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



See Notes a and b

VOLTAGE WAVEFORMS



TEST CIRCUIT

CIRCUIT CONDITIONS

	2N2192, 92A	2N2193, 93A 2N2194, 94A
V_{IN}	7.5 v	15 v
V_{BB}	7.5 v	15 v

*FIGURE 1 — SWITCHING TIMES — t_r, t_f, t_s

NOTES: a. The input waveform is supplied by a generator with the following characteristics: t_r = 20 nsec, t_f = 20 nsec, Z_{out} = 50 Ω, PW = 10 µsec, PRR = 5 kc.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r < 14 nsec, R_{in} = 10 MΩ, C_{in} = 11.5 pf.

*Indicates JEDEC registered data

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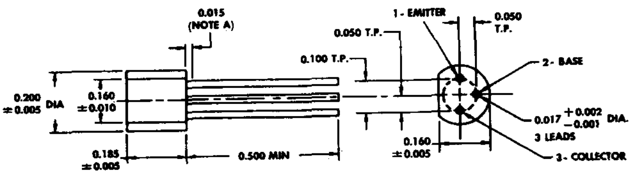
PRINTED IN U.S.A. 373

SILECT† TRANSISTORS‡
FOR MEDIUM-POWER SWITCHING AND AMPLIFIER APPLICATIONS

- High $V_{(BR)CBO}$ . . . 80 V Min (A5T2193)
- h_{FE} Guaranteed from 100 μA to 1 A
- f_T . . . 50 MHz Min
- Electrically Similar to 2N2192A, 2N2193A

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES:
- A. Lead diameter is not controlled in this area.
- B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
- C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T2192	A5T2193
Collector-Base Voltage	60 V	80 V
Collector-Emitter Voltage (See Note 1)	40 V	50 V
Emitter-Base Voltage	5 V	8 V
Continuous Collector Current	1 A	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	1.25 W	
Continuous Device Dissipation at (or below) 25°C Case and Lead Temperature (See Note 4)	1.6 W	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.
4. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N23

TYPES A5T2192, A5T2193
N-P-N SILICON TRANSISTORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

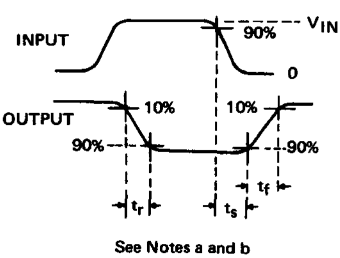
PARAMETER		TEST CONDITIONS	A5T2192		A5T2193		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	60		80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 25\ mA$, $I_B = 0$, See Note 5	40		50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	5		8		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30\ V$, $I_E = 0$		10			nA
		$V_{CB} = 30\ V$, $I_E = 0$, $T_A = 100°C$		1			μA
		$V_{CB} = 60\ V$, $I_E = 0$				10	nA
		$V_{CB} = 60\ V$, $I_E = 0$, $T_A = 100°C$				2	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3\ V$, $I_C = 0$		50			nA
		$V_{EB} = 5\ V$, $I_C = 0$				50	
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 100\ \mu A$	15		15		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$, See Note 5	75		30		
		$V_{CE} = 10\ V$, $I_C = 150\ mA$, See Note 5	100	300	40	120	
		$V_{CE} = 10\ V$, $I_C = 500\ mA$, See Note 5	35		20		
		$V_{CE} = 10\ V$, $I_C = 1\ A$, See Note 5	15		15		
		$V_{CE} = 1\ V$, $I_C = 150\ mA$, See Note 5	70		30		
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$, See Note 5		1.3		1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$, See Note 5		0.25		0.25	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 50\ mA$, $f = 20\ MHz$	2.5		2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$, $f = 1\ MHz$		20		20	pF

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T2192		A5T2193		UNIT
			MIN	MAX	MIN	MAX	
t_r	Rise Time	See Figure 1		70		70	ns
t_s	Storage Time	See Figure 1		150		150	ns
t_f	Fall Time	See Figure 1		50		50	ns

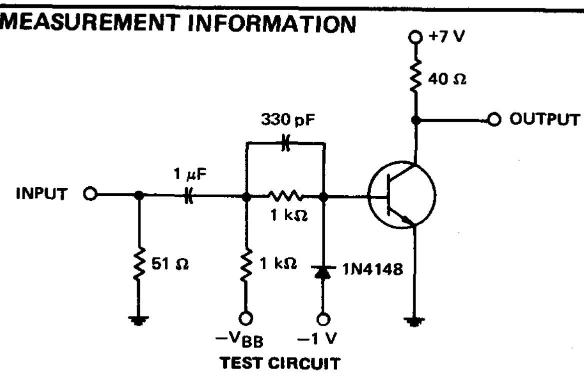
NOTE 5: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

PARAMETER MEASUREMENT INFORMATION



See Notes a and b

VOLTAGE WAVEFORMS



TEST CIRCUIT

CIRCUIT CONDITIONS

	A5T2192	A5T2193
V_{IN}	7.5 V	15 V
V_{BB}	7.5 V	15 V

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $t_r = 20\ ns$, $t_f = 20\ ns$, $Z_{out} = 50\ \Omega$, $t_w = 10\ \mu s$, PRR = 5 kHz.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 14\ ns$, $R_{in} = 10\ M\Omega$, $C_{in} = 11.5\ pF$.

FIGURE 1—SWITCHING TIMES

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TYPES 2N2217 THRU 2N2222, 2N2218A, 2N2219A, 2N2221A, 2N2222A
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 7311916, MARCH 1973

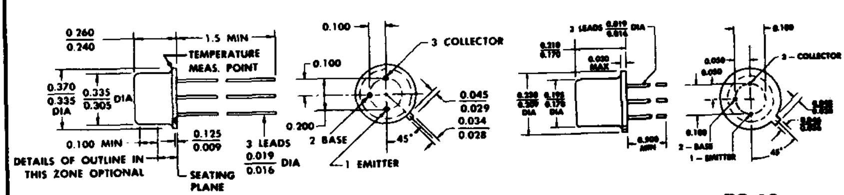
DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **h_{FE} . . . Guaranteed from 100 μA to 500 mA**
- **High f_T at 20 V, 20 mA . . . 300 MHz (2N2219A, 2N2222A)**
  250 MHz (all others)
- **2N2218, 2N2221 for Complementary Use with 2N2904, 2N2906**
- **2N2219, 2N2222 for Complementary Use with 2N2905, 2N2906**

*mechanical data

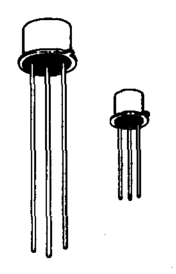
Device types 2N2217, 2N2218, 2N2218A, 2N2219, and 2N2219A are in JEDEC TO-5 packages.
Device types 2N2220, 2N2221, 2N2221A, 2N2222, and 2N2222A are in JEDEC TO-18 packages.

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



TO-5 TO-18

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



TO-5 TO-18

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2217 2N2218 2N2219	2N2218A 2N2219A	2N2220 2N2221 2N2222	2N2221A 2N2222A	UNIT
Collector-Base Voltage	60	75	60	75	V
Collector-Emitter Voltage (See Note 1)	30	40	30	40	V
Emitter-Base Voltage	5	6	5	6	V
Continuous Collector Current	0.8	0.8	0.8	0.8	A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 2 and 3)	0.8	0.8	0.5	0.5	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Notes 4 and 5)	3	3	1.8	1.8	W
Operating Collector Junction Temperature Range	–65 to 175				°C
Storage Temperature Range	–65 to 200				°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230				°C

NOTES:
1. These values apply between 0 and 500 mA collector current when the base-emitter diode is open-circuited.
2. Derate 2N2217, 2N2218, 2N2218A, 2N2219, and 2N2219A linearly to 175°C free-air temperature at the rate of 5.33 mW/°C.
3. Derate 2N2220, 2N2221, 2N2221A, 2N2222, and 2N2222A linearly to 175°C free-air temperature at the rate of 3.33 mW/°C.
4. Derate 2N2217, 2N2218, 2N2218A, 2N2219, and 2N2219A linearly to 175°C case temperature at the rate of 20.0 mW/°C.
5. Derate 2N2220, 2N2221, 2N2221A, 2N2222, and 2N2222A linearly to 175°C case temperature at the rate of 12.0 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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2N2217 THRU 2N2222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TO-5→ 2N2217 MIN	2N2217 MAX	2N2218 MIN	2N2218 MAX	2N2219 MIN	2N2219 MAX	UNIT
				TO-18→ 2N2220 MIN	2N2220 MAX	2N2221 MIN	2N2221 MAX	2N2222 MIN	2N2222 MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		60		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$,	See Note 6	30		30		30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		5		5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50\ V$, $I_E = 0$			10		10		10	nA
		$V_{CB} = 50\ V$, $I_E = 0$,	$T_A = 150°C$		10		10		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3\ V$, $I_C = 0$			10		10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 100\ \mu A$				20		35		
		$V_{CE} = 10\ V$, $I_C = 1\ mA$		12		25		50		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$	See Note 6	17		35		75		
		$V_{CE} = 10\ V$, $I_C = 150\ mA$		20	60	40	120	100	300	
		$V_{CE} = 10\ V$, $I_C = 500\ mA$				20		30		
		$V_{CE} = 1\ V$, $I_C = 150\ mA$		10		20		50		
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$	See Note 6		1.3		1.3		1.3	V
		$I_B = 50\ mA$, $I_C = 500\ mA$					2.6		2.6	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$	See Note 6		0.4		0.4		0.4	V
		$I_B = 50\ mA$, $I_C = 500\ mA$					1.6		1.6	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 20\ V$, $I_C = 20\ mA$, $f = 100\ MHz$		2.5		2.5		2.5		
f_T	Transition Frequency	$V_{CE} = 20\ V$, $I_C = 20\ mA$,	See Note 7	250		250		250		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$,	$f = 1\ MHz$		8		8		8	pF
$h_{ie(real)}$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 20\ V$, $I_C = 20\ mA$, $f = 300\ MHz$			60		60		60	Ω

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
7. To obtain f_T, the $\lvert h_{fe} \rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†		TYP	UNIT
t_d	Delay Time	$V_{CC} = 30\ V$, $I_C = 150\ mA$, $I_{B(1)} = 15\ mA$,		5	ns
t_r	Rise Time	$V_{BE(off)} = -0.5\ V$,	See Figure 1	15	ns
t_s	Storage Time	$V_{CC} = 30\ V$, $I_C = 150\ mA$, $I_{B(1)} = 15\ mA$,		190	ns
t_f	Fall Time	$I_{B(2)} = -15\ mA$,	See Figure 2	23	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data

2N2218A, 2N2219A, 2N2221A, 2N2222A

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TO-5 → 2N2218A / TO-18 → 2N2221A MIN	2N2218A / 2N2221A MAX	TO-5 → 2N2219A / TO-18 → 2N2222A MIN	2N2219A / 2N2222A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		75		75		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$,	See Note 6	40		40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60\ V$, $I_E = 0$			10		10	nA
		$V_{CB} = 60\ V$, $I_E = 0$,	$T_A = 150°C$		10		10	μA
I_{CEV}	Collector Cutoff Current	$V_{CE} = 60\ V$, $V_{BE} = -3\ V$			10		10	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = 60\ V$, $V_{BE} = -3\ V$			−20		−20	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3\ V$, $I_C = 0$			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 100\ \mu A$		20		35		
		$V_{CE} = 10\ V$, $I_C = 1\ mA$		25		50		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$	See Note 6	35		75		
		$V_{CE} = 10\ V$, $I_C = 150\ mA$		40	120	100	300	
		$V_{CE} = 10\ V$, $I_C = 500\ mA$		25		40		
		$V_{CE} = 1\ V$, $I_C = 150\ mA$		20		50		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$, $T_A = -55°C$		15		35		
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$	See Note 6	0.6	1.2	0.6	1.2	V
		$I_B = 50\ mA$, $I_C = 500\ mA$			2		2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$	See Note 6		0.3		0.3	V
		$I_B = 50\ mA$, $I_C = 500\ mA$			1		1	
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10\ V$, $I_C = 1\ mA$	f = 1 kHz	1	3.5	2	8	kΩ
		$V_{CE} = 10\ V$, $I_C = 10\ mA$		0.2	1	0.25	1.25	
h_{fe}	Small-Signal Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 1\ mA$		30	150	50	300	
		$V_{CE} = 10\ V$, $I_C = 10\ mA$		50	300	75	375	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 1\ mA$			5×10^{-4}		8×10^{-4}	
		$V_{CE} = 10\ V$, $I_C = 10\ mA$			2.5×10^{-4}		4×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10\ V$, $I_C = 1\ mA$		3	15	5	35	μmho
		$V_{CE} = 10\ V$, $I_C = 10\ mA$		10	100	25	200	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 20\ V$, $I_C = 20\ mA$,	f = 100 MHz	2.5		3		
f_T	Transition Frequency	$V_{CE} = 20\ V$, $I_C = 20\ mA$,	See Note 7	250		300		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$,	f = 100 kHz		8		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$,	f = 100 kHz		25		25	pF
$h_{ie(real)}$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 20\ V$, $I_C = 20\ mA$,	f = 300 MHz		60		60	Ω
$r_b'C_c$	Collector-Base Time Constant	$V_{CE} = 20\ V$, $I_C = 20\ mA$,	f = 31.8 MHz		150		150	ps

NOTES: 6. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

7. To obtain f_T, the $\lvert h_{fe} \rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.

*JEDEC registered data

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*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TO-5 → 2N2218A / TO-18 → 2N2221A MAX	TO-5 → 2N2219A / TO-18 → 2N2222A MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 10\ V$, $I_C = 100\ \mu A$, $R_G = 1\ k\Omega$, $f = 1\ kHz$		4	dB

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	TO-5 → 2N2218A / TO-18 → 2N2221A MAX	TO-5 → 2N2219A / TO-18 → 2N2222A MAX	UNIT
t_d	Delay Time	$V_{CC} = 30\ V$, $I_C = 150\ mA$, $I_{B(1)} = 15\ mA$, $V_{BE(off)} = -0.5\ V$, See Figure 1	10	10	ns
t_r	Rise Time		25	25	ns
τ_A	Active Region Time Constant‡		2.5	2.5	ns
t_s	Storage Time	$V_{CC} = 30\ V$, $I_C = 150\ mA$, $I_{B(1)} = 15\ mA$, $I_{B(2)} = -15\ mA$, See Figure 2	225	225	ns
t_f	Fall Time		60	60	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

‡Under the given conditions τ_A is equal to $\frac{t_r}{10}$.

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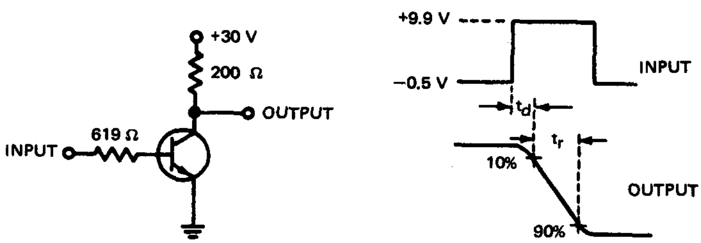
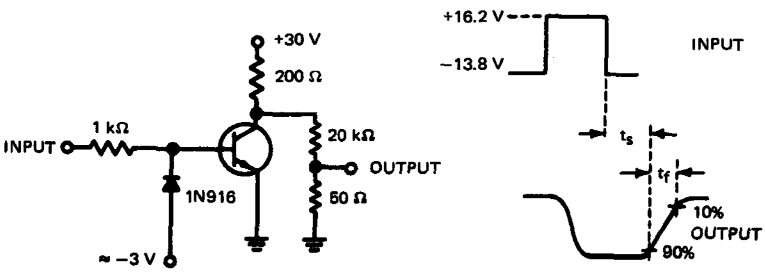
*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 1—DELAY AND RISE TIMES



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 2—STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: For Figure 1, $t_r \leq 2$ ns, $t_w \leq 200$ ns, duty cycle ≤ 2%; for Figure 2, $t_f \leq 5$ ns, $t_w \approx 100\ \mu s$, duty cycle ≤ 17%.

b. *All waveforms are monitored on an oscilloscope with the following characteristics:* $t_r \leq 5$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 12$ pF.

*JEDEC registered data

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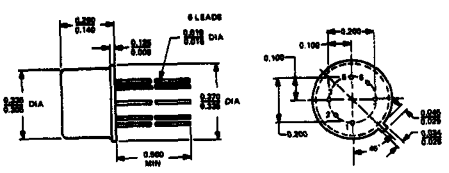
TWO GENERAL PURPOSE TRANSISTORS IN ONE PACKAGE

- Each Triode Electrically Simliar to 2N2218, 2N2218A, 2N2219, 2N2219A Transistors
- For Complementary Use with D2T2904, D2T2904A, D2T2905, D2T2905A Dual P-N-P Transistors

mechanical data

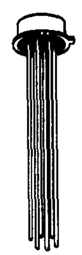
ALL LEADS INSULATED FROM CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2



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absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		D2T2218 D2T2219	D2T2218A D2T2219A	UNIT
Collector-Base Voltage		60	75	V
Collector-Emitter Voltage (See Note 1)		30	40	V
Emitter-Base Voltage		5	6	V
Continuous Collector Current		800		mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	Each Triode	400		mW
	Total Device	600		mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	Each Triode	1		W
	Total Device	2		W
Storage Temperature Range		−65 to 200		°C
Lead Temperature 1/16 Inch from Case for 10 Seconds		300		°C

NOTES: 1. These values apply between 0 and 500 mA collector current when the base-emitter is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.28 mW/°C for each triode and 3.43 mW/°C for the total device.
3. Derate linearly to 200°C case temperature at the rates of 5.7 mW/°C for each triode and 11.4 mW/°C for the total device.

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D2T2218, D2T2219

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			D2T2218 MIN	D2T2218 MAX	D2T2219 MIN	D2T2219 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA,	$I_B = 0$,	See Note 4	30		30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$		5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50$ V,	$I_E = 0$			10		10	nA
		$V_{CB} = 50$ V,	$I_E = 0$,	$T_A = 150°C$		10		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V,	$I_C = 0$			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 100\ \mu A$		20		35		
		$V_{CE} = 10$ V,	$I_C = 1$ mA		25		50		
		$V_{CE} = 10$ V,	$I_C = 10$ mA	See Note 4	35		75		
		$V_{CE} = 10$ V,	$I_C = 150$ mA		40	120	100	300	
		$V_{CE} = 10$ V,	$I_C = 500$ mA		20		30		
		$V_{CE} = 1$ V,	$I_C = 150$ mA		20		50		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ mA,	$I_C = 150$ mA	See Note 4		1.3		1.3	V
		$I_B = 50$ mA,	$I_C = 500$ mA			2.6		2.6	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ mA,	$I_C = 150$ mA	See Note 4		0.4		0.4	V
		$I_B = 50$ mA,	$I_C = 500$ mA			1.6		1.6	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 20$ V,	$I_C = 20$ mA,	f = 100 MHz	2.5		2.5		
f_T	Transition Frequency	$V_{CE} = 20$ V,	$I_C = 20$ mA,	See Note 5	250		250		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V,	$I_E = 0$,	f = 1 MHz		8		8	pF
$h_{ie(real)}$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 20$ V,	$I_C = 20$ mA,	f = 300 MHz		60		60	Ω

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
5. To obtain f_T, the $\lvert h_{fe} \rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†			TYP	UNIT
t_d	Delay Time	$V_{CC} = 30$ V,	$I_C = 150$ mA,	$I_{B(1)} = 15$ mA,	5	ns
t_r	Rise Time	$V_{BE(off)} = -0.5$ V,		See Figure 1	15	ns
t_s	Storage Time	$V_{CC} = 30$ V,	$I_C = 150$ mA,	$I_{B(1)} = 15$ mA,	190	ns
t_f	Fall Time	$I_{B(2)} = -15$ mA,		See Figure 2	23	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

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D2T2218A, D2T2219A

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		D2T2218A MIN	D2T2218A MAX	D2T2219A MIN	D2T2219A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		75		75		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$,	See Note 4	40		40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V, $I_E = 0$			10		10	nA
		$V_{CB} = 60$ V, $I_E = 0$,	$T_A = 150°C$		10		10	μA
I_{CEV}	Collector Cutoff Current	$V_{CE} = 60$ V, $V_{BE} = -3$ V			10		10	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = 60$ V, $V_{BE} = -3$ V			−20		−20	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V, $I_C = 0$			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 100\ \mu A$		20		35		
		$V_{CE} = 10$ V, $I_C = 1$ mA		25		50		
		$V_{CE} = 10$ V, $I_C = 10$ mA	See Note 4	35		75		
		$V_{CE} = 10$ V, $I_C = 150$ mA		40	120	100	300	
		$V_{CE} = 10$ V, $I_C = 500$ mA		25		40		
		$V_{CE} = 1$ V, $I_C = 150$ mA		20		50		
		$V_{CE} = 10$ V, $I_C = 10$ mA, $T_A = -55°C$		15		35		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ mA, $I_C = 150$ mA	See Note 4	0.6	1.2	0.6	1.2	V
		$I_B = 50$ mA, $I_C = 500$ mA			2		2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ mA, $I_C = 150$ mA	See Note 4		0.3		0.3	V
		$I_B = 50$ mA, $I_C = 500$ mA			1		1	
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ V, $I_C = 1$ mA	f = 1 kHz	1	3.5	2	8	kΩ
		$V_{CE} = 10$ V, $I_C = 10$ mA		0.2	1	0.25	1.25	
h_{fe}	Small-Signal Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA		30	150	50	300	
		$V_{CE} = 10$ V, $I_C = 10$ mA		50	300	75	375	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA			5×10^{-4}		8×10^{-4}	
		$V_{CE} = 10$ V, $I_C = 10$ mA			2.5×10^{-4}		4×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10$ V, $I_C = 1$ mA		3	15	5	35	µmho
		$V_{CE} = 10$ V, $I_C = 10$ mA		10	100	25	200	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 20$ V, $I_C = 20$ mA,	f = 100 MHz	2.5		3		
f_T	Transition Frequency	$V_{CE} = 20$ V, $I_C = 20$ mA,	See Note 5	250		300		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$,	f = 1 MHz		8		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$,	f = 1 MHz		25		25	pF
$h_{ie(real)}$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 20$ V, $I_C = 20$ mA,	f = 300 MHz		60		60	Ω
$r_{b'}C_c$	Collector-Base Time Constant	$V_{CE} = 20$ V, $I_C = 20$ mA,	f = 31.8 MHz		150		150	ps

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

5. To obtain f_T, the $\lvert h_{fe} \rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	D2T2218A	D2T2219A	UNIT
			MAX	MAX	
F	Spot Noise Figure	V_{CE} = 10 V, I_C = 100 μA, R_G = 1 kΩ, f = 1 kHz		4	dB

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	D2T2218A	D2T2219A	UNIT
			MAX	MAX	
t_d	Delay Time	V_{CC} = 30 V, I_C = 150 mA, $I_{B(1)}$ = 15 mA, $V_{BE(off)}$ = −0.5 V, See Figure 1	10	10	ns
t_r	Rise Time		25	25	ns
τ_A	Active Region Time Constant‡		2.5	2.5	ns
t_s	Storage Time	V_{CC} = 30 V, I_C = 150 mA, $I_{B(1)}$ = 15 mA, $I_{B(2)}$ = −15 mA, See Figure 2	225	225	ns
t_f	Fall Time		60	60	ns

†Voltage and current values shown are nominal, exact values vary slightly with transistor parameters.

‡Under the given conditions τ_A is equal to $\frac{t_r}{10}$.

PARAMETER MEASUREMENT INFORMATION

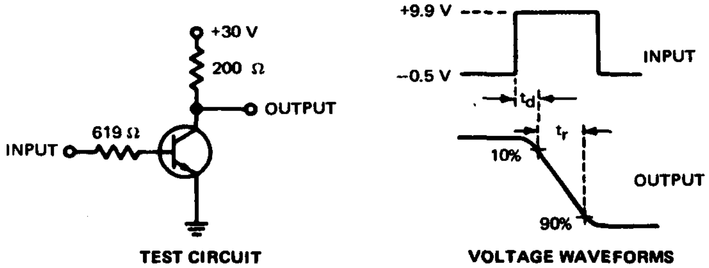


FIGURE 1—DELAY AND RISE TIMES

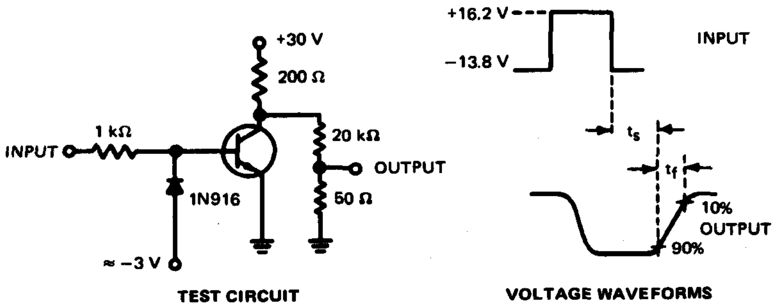


FIGURE 2—STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: For Figure 1, $t_r \leq 2$ ns, $t_w \leq 200$ ns, duty cycle ≤ 2%; for Figure 2, $t_f \leq 5$ ns, $t_w \approx 100$ μs, duty cycle ≤ 17%.
b. All waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pF.

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311317, MAY 1970—REVISED MARCH 1973

SILECT† TRANSISTORS‡

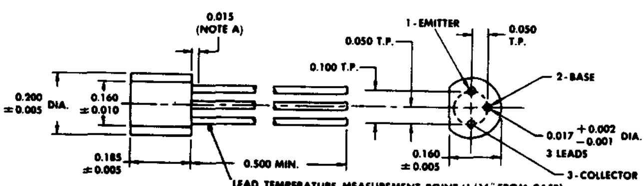
DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

featuring

- High f_T . . . . 350 MHz typ at 10 V, 20 mA
- Low $V_{CE(sat)}$ . . . . 0.13 V typ at 150 mA
- High Maximum I_C . . . . 800 mA
- A5T2222 Electrically Similar to 2N2222, 2N3116, and 2N4952
- TIS109 Processing Includes Operational Aging at 300 mW for 24 Hours
- TIS110 Electrically Similar to 2N4400
- TIS111 Electrically Similar to 2N4401

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T2222 TIS109	TIS110 TIS111
Collector-Base Voltage	60 V	60 V
Collector-Emitter Voltage (See Note 1)	30 V	40 V
Emitter-Base Voltage	5 V	6 V
Continuous Collector Current	← 800 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 625 mW →	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	← 1.25 W →	
Storage Temperature Range	← −65°C to 150°C →	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 260°C →	

NOTES: 1. These values apply between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N24

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		A5T2222 MIN	A5T2222 MAX	TIS109 MIN	TIS109 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$,	See Note 4	30		30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20\ V$, $I_E = 0$					100	nA
		$V_{CB} = 50\ V$, $I_E = 0$			10			nA
		$V_{CB} = 50\ V$, $I_E = 0$,	$T_A = 100°C$		3		3	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3\ V$, $I_C = 0$			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 100\ \mu A$		35		20		
		$V_{CE} = 10\ V$, $I_C = 1\ mA$		50		30		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$	See Note 4	75		40		
		$V_{CE} = 10\ V$, $I_C = 150\ mA$	See Note 4	100	300	100	400	
		$V_{CE} = 10\ V$, $I_C = 500\ mA$	See Note 4	30		20		
		$V_{CE} = 1\ V$, $I_C = 150\ mA$	See Note 4	50		35		
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$	See Note 4		1.3		1.3	V
		$I_B = 50\ mA$, $I_C = 500\ mA$	See Note 4		2.6		2.6	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$	See Note 4		0.4		0.4	V
		$I_B = 50\ mA$, $I_C = 500\ mA$	See Note 4		1.6		1.6	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 20\ mA$,	$f = 100\ MHz$	2.5		2.5		
f_T	Transition Frequency	$V_{CE} = 10\ V$, $I_C = 20\ mA$,	See Note 5	250		250		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$,	$f = 1\ MHz$		8		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$,	$f = 1\ MHz$		25		25	pF
$Re(h_{ie})$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10\ V$, $I_C = 20\ mA$,	$f = 300\ MHz$		60		60	Ω

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS†	TYP	UNIT
t_d Delay Time	$V_{CC} = 30\ V$, $I_C = 150\ mA$, $I_{B(1)} = 15\ mA$,	5	ns
t_r Rise Time	$V_{BE(off)} = -0.5\ V$, See Figure 1♦	15	ns
t_s Storage Time	$V_{CC} = 30\ V$, $I_C = 150\ mA$, $I_{B(1)} = 15\ mA$,	190	ns
t_f Fall Time	$I_{B(2)} = -15\ mA$, See Figure 2♦	23	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

♦The referenced figures are shown under Parameter Measurement Information for types 2N2217 through 2N2222 or TIS109, page 4-96.

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

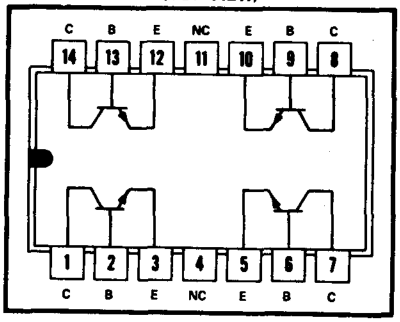
TYPE Q2T2222
QUAD N-P-N SILICON TRANSISTOR

BULLETIN NO. DL-S 7311703, APRIL 1972—REVISED MARCH 1973

DESIGNED FOR MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **High Breakdown Voltage Combined with Very-Low Saturation Voltage**
- **h_{FE} . . . Guaranteed from 100 μA to 500 mA**
- **High f_T . . . 250 MHz Min at 20 V, 20 mA**

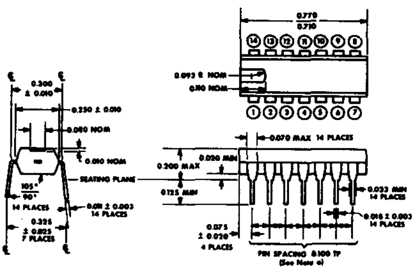
(TOP VIEW)



NC—No internal connection

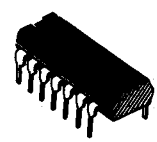
mechanical data

14-PIN PLASTIC DUAL-IN-LINE PACKAGE



NOTES:
a. The true-position pin spacing is 0.100 between centerlines. Each pin centerline is located within 0.010 of its true longitudinal position relative to pins 4 and 11.
b. All dimensions are in inches unless otherwise noted.

Falls Within JEDEC TO-116 and MO-001AA Dimensions



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	60 V	
Collector-Emitter Voltage (See Note 1)	30 V	
Emitter-Base Voltage	5 V	
Continuous Collector Current	0.8 A	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.5 W†	1.5 W†
Storage Temperature Range	−55°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←260°C→	

NOTES: 1. This value applies between 0.01 mA and 500 mA collector current when the emitter-base diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rates of 4 mW/°C for each triode and 12 mW/°C for the total device.

†Previous editions of this data sheet showed higher power dissipation ratings which have been found to be in error. The new ratings correct these errors and do not represent product changes.

USES CHIP N24

TYPE Q2T2222
QUAD N-P-N SILICON TRANSISTOR

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA,	$I_B = 0$,	See Note 3	30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50$ V,	$I_E = 0$			10	nA
		$V_{CB} = 50$ V,	$I_E = 0$,	$T_A = 100°C$		3	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V,	$I_C = 0$			10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 100\ \mu A$		35		
		$V_{CE} = 10$ V,	$I_C = 1$ mA		50		
		$V_{CE} = 10$ V,	$I_C = 10$ mA	See Note 3	75		
		$V_{CE} = 10$ V,	$I_C = 150$ mA		100	300	
		$V_{CE} = 10$ V,	$I_C = 500$ mA		30		
		$V_{CE} = 1$ V,	$I_C = 150$ mA		50		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ mA,	$I_C = 150$ mA	See Note 3		1.3	V
		$I_B = 50$ mA,	$I_C = 500$ mA			2.6	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ mA,	$I_C = 150$ mA	See Note 3		0.4	V
		$I_B = 50$ mA,	$I_C = 500$ mA			1.6	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 20$ mA,	f = 100 MHz	2.5		
f_T	Transition Frequency	$V_{CE} = 10$ V,	$I_C = 20$ mA,	See Note 4	250		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V,	$I_E = 0$,	f = 1 MHz		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V,	$I_C = 0$,	f = 1 MHz		25	pF
$Re(h_{ie})$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ V,	$I_C = 20$ mA,	f = 300 MHz		60	Ω

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

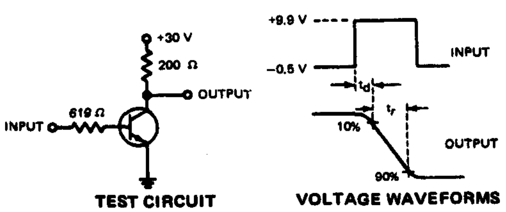
4. To obtain f_T, the $\lvert h_{fe} \rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.

switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS†		TYP	UNIT
t_d Delay Time	$V_{CC} = 30$ V, $I_C = 150$ mA, $I_{B(1)} = 15$ mA,		8	ns
t_r Rise Time	$V_{BE(off)} = -0.5$ V,	See Figure 1	12	ns
t_s Storage Time	$V_{CC} = 30$ V, $I_C = 150$ mA, $I_{B(1)} = 15$ mA,		190	ns
t_f Fall Time	$I_{B(2)} = -15$ mA,	See Figure 2	30	ns

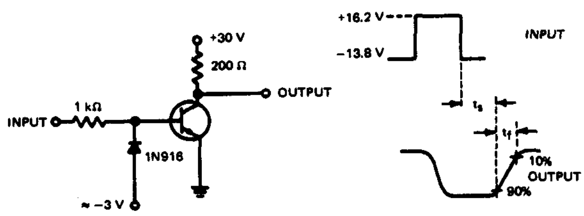
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 1—DELAY AND RISE TIMES



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 2—STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: for figure 1, $t_r \leq 2$ ns, $t_w \leq 200$ ns, duty cycle $\leq 2\%$; for figure 2, $t_f \leq 5$ ns, $t_w \approx 100\ \mu s$, duty cycle $\leq 17\%$.

b. All waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pF.

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

PRINTED IN U.S.A.

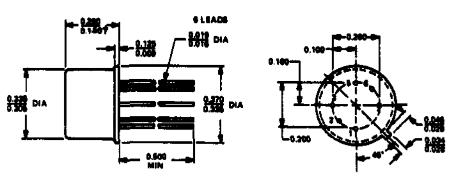
BULLETIN NO. DL-S 7211678, MARCH 1972

TWO TRANSISTORS IN ONE PACKAGE FOR DIFFERENTIAL AMPLIFIER APPLICATIONS

- **Medium Power**
- **High Operating Voltage**

*mechanical data

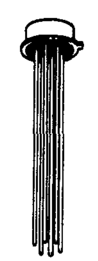
ALL LEADS INSULATED FROM CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2



†Applicable to 2N2223 and 2N2223A only. Registered minimum dimension for 2N2060 is 0.140.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2060		2N2223 2N2223A		UNIT
	EACH TRIODE	TOTAL DEVICE	EACH TRIODE	TOTAL DEVICE	
Collector-Base Voltage	100		100		V
Collector-Emitter Voltage (See Note 1)	80		80		V
Collector-Emitter Voltage (See Note 2)	60		60		V
Emitter-Base Voltage	7		7		V
Continuous Collector Current	500		500		mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	0.5	0.6	0.5	0.6	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Notes 4 and 5)	1.5	3	1.6	3	W
Continuous Device Dissipation at 100°C Case Temperature	0.86	1.7	0.91	1.7	W
Operating Collector Junction Temperature	200		200		°C
Storage Temperature Range	−65°C to 200°C				
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C				

NOTES:
1. These values apply when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. These values apply when the base-emitter diode is open-circuited.
3. Derate linearly to 200°C free-air temperature at the rate of 2.86 mW/°C for each triode and 3.43 mW/°C for total device.
4. Derate 2N2060 linearly to 200°C case temperature at the rate of 8.6 mW/°C for each triode and 17.2 mW/°C for total device.
5. Derate 2N2223 and 2N2223A linearly to 200°C case temperature at the rate of 9.1 mW/°C for each triode and 17.2 mW/°C for total device.
6. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
7. This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 1%.
8. The lower of the two h_{FE} reading is taken as h_{FE1}.
9. This parameter is measured in an amplifier with response down 3 dB at 25 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication. USES CHIP N23

TYPES 2N2060, 2N2223, 2N2223A
DUAL N-P-N SILICON TRANSISTORS

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 6)

PARAMETER		TEST CONDITIONS	2N2060 MIN	2N2060 MAX	2N2223 2N2223A MIN	2N2223 2N2223A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	100		100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30\ mA$, $I_B = 0$, See Note 7	60		60		V
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100\ mA$, $R_{BE} = 10\ \Omega$, See Note 7	80		80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	7		7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 80\ V$, $I_E = 0$		2		10	nA
		$V_{CB} = 80\ V$, $I_E = 0$, $T_A = 150°C$		10		15	µA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5\ V$, $I_C = 0$		2		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 10\ \mu A$	25	75	15		
		$V_{CE} = 5\ V$, $I_C = 100\ \mu A$	30	90	25	150	
		$V_{CE} = 5\ V$, $I_C = 1\ mA$	40	120			
		$V_{CE} = 5\ V$, $I_C = 10\ mA$, See Note 7	50	150	50	200	
V_{BE}	Base-Emitter Voltage	$I_B = 5\ mA$, $I_C = 50\ mA$		0.9		0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5\ mA$, $I_C = 50\ mA$		1.2		1.2	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	20	30	20	30	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio					3×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance					0.5	µmho
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	1000	4000			Ω
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		50	150	40	200	
h_{oe}	Small-Signal Common-Emitter Output Admittance			16			µmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 50\ mA$, $f = 20\ MHz$	3		2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$, $f = 1\ MHz$		15		15	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$, $f = 1\ MHz$		85		85	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N2060 MIN	2N2060 MAX	2N2223 MIN	2N2223 MAX	2N2223A MIN	2N2223A MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward Current Gain Balance Ratio	$V_{CE} = 5\ V$, $I_C = 100\ \mu A$, See Note 8	0.9	1	0.8	1	0.9	1	
		$V_{CE} = 5\ V$, $I_C = 1\ mA$, See Note 8	0.9	1					
$\lvert V_{BE1} - V_{BE2} \rvert$	Base-Emitter-Voltage Differential	$V_{CE} = 5\ V$, $I_C = 100\ \mu A$		5		15		5	mV
		$V_{CE} = 5\ V$, $I_C = 1\ mA$		5					mV
$\left\lvert \frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A} \right\rvert$	Base-Emitter-Voltage-Differential Temperature Gradient	$V_{CE} = 5\ V$, $I_C = 100\ \mu A$, From $T_A = -55°C$ to $T_A = 125°C$		10		25		25	µV/°C

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 6)

PARAMETER		TEST CONDITIONS	2N2060 MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 10\ V$, $I_C = 300\ \mu A$, $R_G = 510\ \Omega$, $f = 1\ kHz$	8	dB
$\overline{F}$	Average Noise Figure	$V_{CE} = 10\ V$, $I_C = 300\ \mu A$, $R_G = 1\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 9	8	dB

*JEDEC registered data

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TYPES 2N2192, 2N2192A, 2N2193, 2N2193A, 2N2194, 2N2194A, 2N2243, 2N2243A N-P-N SILICON TRANSISTORS

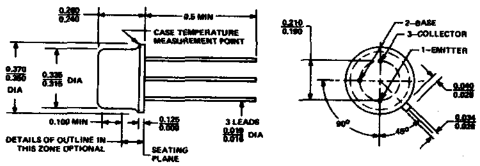
BULLETIN NO. DL-S 733571, MARCH 1963–REVISED MARCH 1973

FOR MEDIUM-POWER SWITCHING AND AMPLIFIER APPLICATIONS

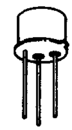
- **High Breakdown Voltage Combined with Very Low Saturation Voltage**
- **h_{FE}–Guaranteed from 100 μa to 1 amp**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2192 2N2192A	2N2193 2N2193A	2N2194 2N2194A	2N2243 2N2243A	UNIT
Collector-Base Voltage	60*	80*	60*	120*	v
Collector-Emitter Voltage (See Note 1)	40*	50*	40*	80*	v
Emitter-Base Voltage	5*	8*	5*	7*	v
Collector Current	1*	1*	1*	1*	a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.8*	0.8*	0.8*	0.8*	w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	10† 2.8*	10† 2.8*	10† 2.8*	10† 2.8*	w
Storage Temperature Range	−65°C to 200°C*				
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C*				

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mw/°C. Derate the 2.8-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 16 mw/°C.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2243 MIN	2N2243 MAX	2N2243A MIN	2N2243A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	120		120		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 25$ ma, $I_B = 0$, See Note 4	80		80		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	7		7		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$		10		10	na
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		15		15	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		50		50	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$	15		15		
		$V_{CE} = 10$ v, $I_C = 10$ ma	30		30		
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$	20		20		
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 4	40	120	40	120	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 4	15		15		
		$V_{CE} = 1$ v, $I_C = 150$ ma, See Note 4	30		30		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma		1.3		1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma		0.35		0.25	v
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, f = 20 mc	2.5		2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, f = 1 mc		15		15	pf

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2243 2N2243A MAX	UNIT
τ_b	Stored-Charge Time Constant	See Figure 1	2.1	μsec

NOTE 4: These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle $\leq$ 2%.

*Indicates JEDEC registered data

PARAMETER MEASUREMENT INFORMATION

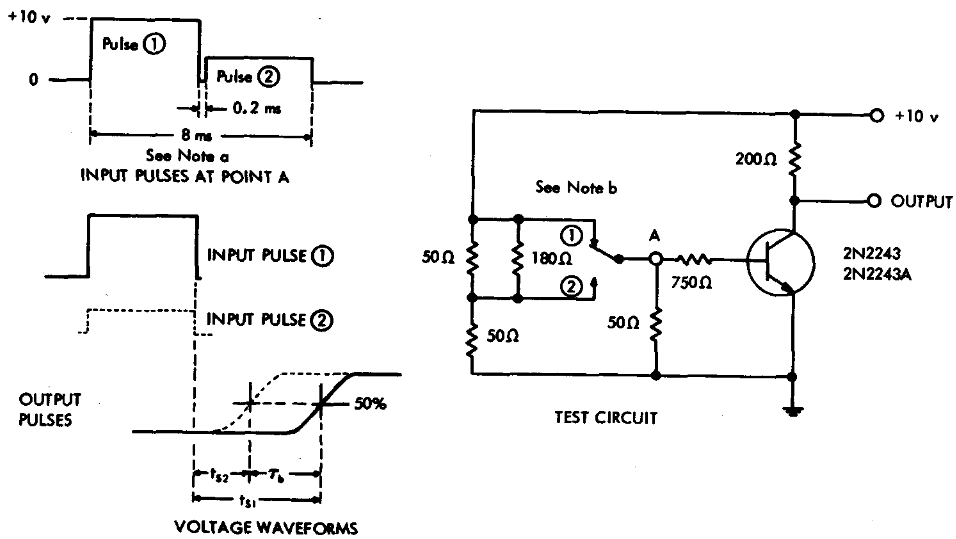

*FIGURE 1 — STORED-CHARGE TIME CONSTANT — τ_b

NOTES: a. Waveforms are monitored on an oscilloscope with the following characteristics: t_r < 14 nsec, R_{in} = 10 MΩ, C_{in} = 11.5 pF.
b. The relay is Clare HG 1005 (or equivalent).

*Indicates JEDEC registered data.

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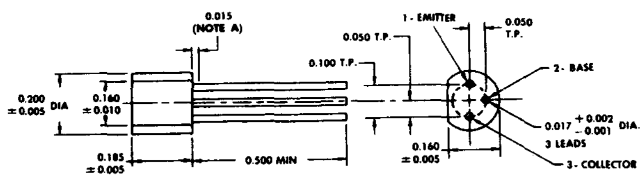
BULLETIN NO. DL-S 7311978, MARCH 1973

SILECT[†] TRANSISTOR[‡]
FOR MEDIUM-POWER SWITCHING AND AMPLIFIER APPLICATIONS

- **High $V_{(BR)CBO}$ . . . 120 V**
- **h_{FE} Guaranteed from 100 μA to 500 mA**
- **f_T . . . 50 MHz Min**
- **Electrically Similar to 2N2243A**

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	120 V
Collector-Emitter Voltage (See Note 1)	80 V
Emitter-Base Voltage	7 V
Continuous Collector Current	1 A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	1.25 W
Continuous Device Dissipation at (or below) 25°C Case-and-Lead Temperature (See Note 4)	1.6 W
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.
4. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

[†]*Trademark of Texas Instruments*
[‡]U.S. Patent No. 3,439,238

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$		120		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 25$ mA, $I_B = 0$,	See Note 5	80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$		7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ V, $I_E = 0$			10	nA
		$V_{CB} = 60$ V, $I_E = 0$,	$T_A = 100°C$		1	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$			50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 100\ \mu A$		15		
		$V_{CE} = 10$ V, $I_C = 10$ mA	See Note 5	30		
		$V_{CE} = 10$ V, $I_C = 150$ mA	See Note 5	40	120	
		$V_{CE} = 10$ V, $I_C = 500$ mA	See Note 5	15		
		$V_{CE} = 1$ V, $I_C = 150$ mA	See Note 5	30		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ mA, $I_C = 150$ mA,	See Note 5		1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ mA, $I_C = 150$ mA,	See Note 5		0.25	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 50$ mA,	f = 20 MHz	2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$,	f = 1 MHz		15	pF

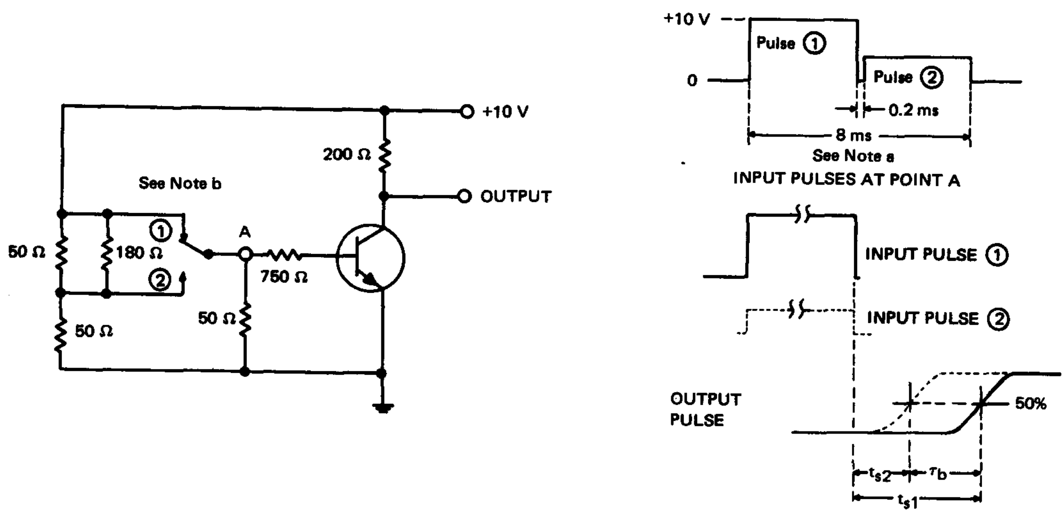
NOTE 5: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $< 2\%$.

4

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
τ_b	Stored-Charge Time Constant	See Figure 1		2.1	μs

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: a. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 14$ ns, $R_{in} = 10\ M\Omega$, $C_{in} = 11.5$ pF.
b. The relay is Clare HG 1005 (or equivalent).

FIGURE 1—STORED-CHARGE TIME CONSTANT— τ_b

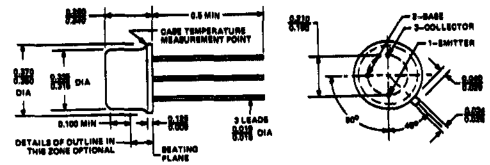
TYPE 2N2270
N-P-N SILICON TRANSISTOR

BULLETIN NO. DL-S 7311947, MARCH 1973

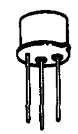
FOR MEDIUM-POWER, GENERAL PURPOSE APPLICATIONS

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

Collector-Base Voltage	60 V*
Collector-Emitter Voltage (See Note 1)	45 V*
Collector-Emitter Voltage (see Note 2)	60 V*
Emitter-Base Voltage	7 V*
Continuous Collector Current	1 A*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (see Note 3)	1 W*
Continuous Device Dissipation at (or below) 25°C Case Temperature (see Note 4)	10 W† / 5 W*
Storage Temperature Range	−65°C to 200°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C† / 255°C*

*electrical characteristics at 25°C case temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 100 mA, I_B = 0, See Note 5	45		V
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	I_C = 100 mA, R_{BE} = 10 Ω, See Note 5	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 0.1 mA, I_C = 0	7		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 V, I_E = 0		50	nA
		V_{CB} = 60 V, I_E = 0, T_C = 150°C		50	μA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		100	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 1 mA	30		
		V_{CE} = 10 V, I_C = 150 mA, See Note 5	50	200	
V_{BE}	Base-Emitter Voltage	I_B = 15 mA, I_C = 150 mA, See Note 5		1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 15 mA, I_C = 150 mA, See Note 5		0.9	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 5 mA, f = 1 kHz	50	275	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 50 mA, f = 20 MHz	5		
f_T	Transition Frequency	V_{CE} = 10 V, I_C = 50 mA, See Note 6	100		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz		15	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	V_{EB} = 0.5 V, I_C = 0, f = 1 MHz		80	pF

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. This value applies when the base-emitter resistance $R_{BE} \leq 10\ \Omega$.
3. Derate linearly to 200°C free-air temperature at the rate of 5.71 mW/°C.
4. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mW/°C. Derate the 5-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 28.6 mW/°C.
5. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
6. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}|$ = 1.

*JEDEC registered value. This data sheet contains all applicable registered data in effect at the time of publication.
†These values are guaranteed by Texas Instruments in addition to the JEDEC registered values which are also shown.

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***thermal characteristics**

PARAMETER		MAX	UNIT
$R_{\theta JC}$	Junction-to-Case Thermal Resistance	35	°C/W
$R_{\theta JA}$	Junction-to-Free-Air Thermal Resistance	175	°C/W

***operating characteristics at 25°C case temperature**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
F	Spot Noise Figure	V_{CE} = 10 V, I_C = 0.3 mA, R_G = 1 kΩ, f = 1 kHz		10	dB

***switching characteristics at 25°C case temperature**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_T	Total Switching Time	See Figure 1		30	ns

PARAMETER MEASUREMENT INFORMATION

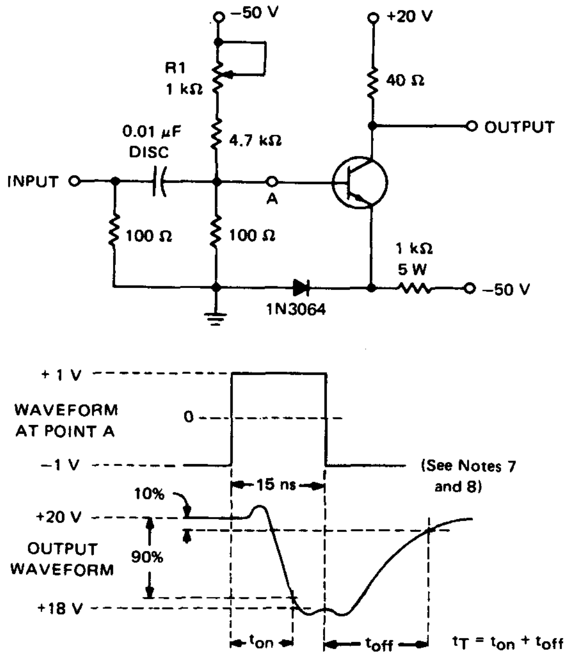

FIGURE 1–SWITCHING TIME MEASUREMENT CIRCUIT

NOTES: 7. The input waveform is supplied by a mercury relay pulse generator with the following characteristics: $t_r \leq 1$ ns, $t_f \leq 1$ ns, t_w = 15 ns, Z_{out} = 50 Ω. Adjust R1 and the input pulse amplitude to obtain the specified voltage levels at Point A.

8. Waveforms are monitored on a sampling oscilloscope ($t_r \leq 0.4$ ns) using a 2-kΩ probe.

*JEDEC registered data

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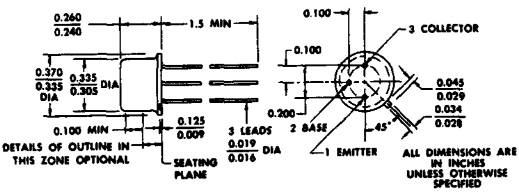
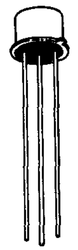
*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-5 DIMENSIONS AND NOTES ARE APPLICABLE.



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−50 V
Collector-Emitter Voltage (See Note 1)	−50 V
Collector-Emitter Voltage (See Note 2)	−35 V
Emitter-Base Voltage	−5 V
Continuous Collector Current	−500 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	0.6 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	2 W
Storage Temperature Range	−65°C to 200°C

NOTES: 1. This value applies when the base-emitter resistance $R_{BE} \leq 10\ \Omega$.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 4 mW/deg.
4. Derate linearly to 175°C case temperature at the rate of 13.3 mW/deg.

*Indicates JEDEC registered data.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−50		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ mA, $I_B = 0$, See Note 5	−35		V
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ mA, $R_{BE} = 10\ \Omega$, See Note 5	−50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V, $I_E = 0$		−1	μA
		$V_{CB} = -30$ V, $I_E = 0$, $T_A = 150°C$		−100	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -2$ V, $I_C = 0$		−100	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -5$ mA, See Note 5	75		
		$V_{CE} = -10$ V, $I_C = -150$ mA, See Note 5	75	200	
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 5		−1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 5		−1.5	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = -5$ V, $I_C = -1$ mA, f = 1 kHz	25	35	Ω
		$V_{CB} = -10$ V, $I_C = -5$ mA, f = 1 kHz		10	Ω
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz	75	300	
		$V_{CE} = -10$ V, $I_C = -5$ mA, f = 1 kHz	75		
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = -5$ V, $I_C = -1$ mA, f = 1 kHz		8×10^{-4}	
		$V_{CB} = -10$ V, $I_C = -5$ mA, f = 1 kHz		8×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = -5$ V, $I_C = -1$ mA, f = 1 kHz		1	μmho
		$V_{CB} = -10$ V, $I_C = -5$ mA, f = 1 kHz		5	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -50$ mA, f = 20 MHz	3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 140 kHz		45	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 140 kHz		80	pF

NOTE 5: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 1\%$.

*Indicates JEDEC registered data

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TEXAS INSTRUMENTS
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TYPES 2N2386, 2N2386A
P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

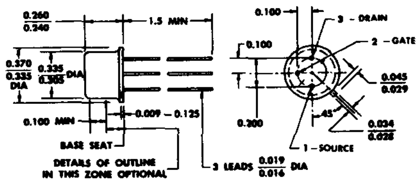
BULLETIN NO. DL-S 6810916, SEPTEMBER 1968

AUDIO- TO HIGH-FREQUENCY SMALL-SIGNAL AMPLIFIERS

2N2386A offers the following improvements resulting from process innovation:

- **$|y_{fs}|$ Min Raised from 1 mmho to 2.2 mmho**
- **C_{iss} Max Lowered from 50 pF to 10 pF**

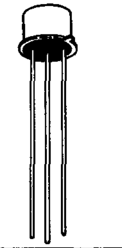
*mechanical data



THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE.

ALL JEDEC TO-5 DIMENSIONS AND NOTES ARE APPLICABLE.

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Continuous Forward Gate Current	−10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	0.5 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	1.5 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2386		2N2386A		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)DGO}$	Drain-Gate Breakdown Voltage (See Note 3)	$I_D = -10\ \mu A$, $I_S = 0$	−20		−20		V
I_{GSS}	Gate Reverse Current	$V_{GS} = 10\ V$, $V_{DS} = 0$		10		10	nA
		$V_{GS} = 10\ V$, $V_{DS} = 0$, $T_A = 100°C$		1		1	µA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = -12\ V$, $V_{GS} = 8\ V$		−10		−0.01	µA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -10\ V$, $V_{GS} = 0$			−1	−15	mA
$\|y_{is}\|$	Small-Signal Common-Source Input Admittance	$V_{DS} = -10\ V$, $V_{GS} = 0$, $f = 1\ kHz$		0.3		0.1	µmho
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10\ V$, $V_{GS} = 0$, $f = 1\ kHz$	1		2.2	5	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -10\ V$, $V_{GS} = 0$, $f = 0.1\ MHz$ to $1\ MHz$		50		10	pF

NOTES: 1. Derate linearly to 175°C free-air temperature at the rate of 3.3 mW/deg.
2. Derate linearly to 175°C case temperature at the rate of 10 mW/deg.
3. This parameter corresponds closely to $V_{(BR)DSS}$ (the Drain-Source Breakdown Voltage for $V_{GS} = 0$). $V_{(BR)DSV}$ (the Drain-Source Breakdown Voltage for other values of V_{GS}) may be calculated from: $|V_{(BR)DSV}| \cong |V_{(BR)DGO}| - |V_{GS}|$.

*Indicates JEDEC registered data

USES CHIP JP71

TEXAS INSTRUMENTS
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BULLETIN NO. DL-S 646026, SEPTEMBER 1964

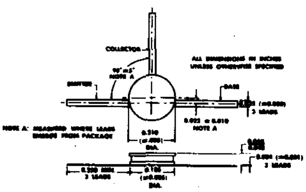
FOR EXTREMELY LOW-LEVEL, LOW-NOISE, HIGH-GAIN, AMPLIFIER APPLICATIONS
Formerly TI 420 and TI 421

- **Guaranteed h_{FE} at 10 μa, $T_A = -55°C$ and $+25°C$**
- **Guaranteed Low-Noise Characteristics at 10 μa**
- **Usable at Collector Currents as Low as 1 μa**
- **Electrically Similar to 2N929 and 2N930**
- **Compatible Package for Interfacing with Integrated Circuits and Thin-Film Modules**

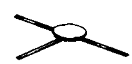
mechanical data

The transistors are in a hermetically sealed welded package meeting the JEDEC TO-50 outline.

*CASE OUTLINE



ALL LEADS INSULATED FROM CASE



4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	45 v
Collector-Emitter Voltage (See Note 1)	45 v
Emitter-Base Voltage	5 v
Collector Current	30 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	300 mw
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1 w
Operating Collector Junction Temperature	175°C
Storage Temperature Range	−65°C to +200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 2 mw/C°.
3. Derate linearly to 175°C case temperature at the rate of 6.66 mw/C°.

*Indicates JEDEC registered data.

TEXAS INSTRUMENTS
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TYPES 2N2387, 2N2388
N-P-N SILICON TRANSISTORS

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2387 MIN	2N2387 MAX	2N2388 MIN	2N2388 MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$, See Note 4	45		45		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10$ na, $I_C = 0$	5		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ v, $I_E = 0$		10		10	na
I_{CES}	Collector Cutoff Current	$V_{CE} = 45$ v, $V_{BE} = 0$		10		10	na
		$V_{CE} = 45$ v, $V_{BE} = 0$, $T_A = 170°C$		10		10	μa
I_{CEO}	Collector Cutoff Current	$V_{CE} = 5$ v, $I_B = 0$		2		2	na
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		10		10	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 10\ \mu a$	40	120	100	300	
		$V_{CE} = 5$ v, $I_C = 10\ \mu a$, $T_A = -55°C$	10		20		
		$V_{CE} = 5$ v, $I_C = 500\ \mu a$	60		150		
		$V_{CE} = 5$ v, $I_C = 10$ ma, See Note 4		350		600	
V_{BE}	Base Emitter Voltage	$I_B = 0.5$ ma, $I_C = 10$ ma, See Note 4	0.6	1.0	0.6	1.0	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ ma, $I_C = 10$ ma, See Note 4		1.0		1.0	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_E = -1$ ma, $f = 1$ kc	25	32	25	32	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio		0	6×10^{-4}	0	6×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance		0	1	0	1	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	60	350	150	600	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 500\ \mu a$, $f = 30$ Mc	1		1		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$, $f = 1$ Mc		8		8	pf

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2387 MAX	2N2388 MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CB} = 5$ v, $I_E = -10\ \mu a$, $R_G = 10\ k\Omega$ Noise Bandwidth 10 cps to 15.7 kc	4	3	db

NOTE: 4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle $\leq$ 2%.

*Indicates JEDEC registered data.

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BULLETIN NO. DL-S 646027, OCTOBER 1964

FOR GENERAL PURPOSE AMPLIFIER AND SWITCHING APPLICATIONS

FROM <0.1 ma to >150 ma, dc to 30 Mc

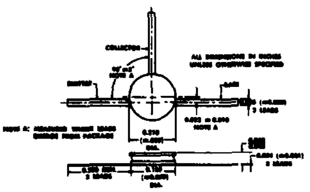
Formerly TI 424 and TI 425

- **Electrically Similar to 2N1613 and 2N1711**
- **Compatible Package for Interfacing with Integrated Circuits and Thin-Film Modules**

mechanical data

The transistors are in a hermetically sealed welded package meeting the JEDEC TO-50 outline.

* CASE OUTLINE



ALL LEADS INSULATED FROM CASE

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	75 v
Collector-Emitter Voltage (See Note 1)	50 v
Emitter-Base Voltage	7 v
Collector Current	500 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	450 mw
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.5 w
Operating Collector Junction Temperature	200°C
Storage Temperature Range	−65°C to +200°C
Lead Temperature 1/16 Inch from Case For 10 Seconds	230°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2389		2N2390		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	75		75		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, See Note 4	50		50		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	7		7		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$		10		10	na
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		10		10	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		10		5	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10\ \mu a$			20		
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$	20		35		
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 4	35		75		
		$V_{CE} = 10$ v, $I_C = 10$ ma, $T_A = -55°C$, See Note 4	20		35		
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 4	40	120	100	300	
		$V_{CE} = 10$ v, $I_C = 500$ ma, See Note 4	20		40		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 4	0.6	1.3	0.6	1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 4		1.5		1.5	v

NOTES: 1. This value applies when the base-emitter resistance $R_{BE} \leq 10\ \Omega$.
2. Derate linearly to 200°C free-air temperature at the rate of 2.57 mw/C°.
3. Derate linearly to 200°C case temperature at the rate of 8.57 mw/C°.
4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

*Indicates JEDEC registered data.

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TYPES 2N2389, 2N2390
N-P-N SILICON TRANSISTORS

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2389 MIN	2N2389 MAX	2N2390 MIN	2N2390 MAX	UNIT
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ v, $I_E = -1$ ma, $f = 1$ kc	24	34	24	34	Ω
		$V_{CB} = 10$ v, $I_E = -5$ ma, $f = 1$ kc	4	8	4	8	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = 5$ v, $I_E = -1$ ma, $f = 1$ kc		3×10^{-4}		5×10^{-4}	
		$V_{CB} = 10$ v, $I_E = -5$ ma, $f = 1$ kc		3×10^{-4}		5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ v, $I_E = -1$ ma, $f = 1$ kc	0.1	0.5	0.1	0.5	µmho
		$V_{CB} = 10$ v, $I_E = -5$ ma, $f = 1$ kc	0.1	1.0	0.1	1.0	µmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	30	100	50	200	
		$V_{CE} = 10$ v, $I_C = 5$ ma, $f = 1$ kc	35	150	70	300	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 20$ ma, $f = 20$ Mc	3.0		3.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ Mc		25		25	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ Mc		80		80	pf

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2389 TYP	2N2389 MAX	2N2390 TYP	2N2390 MAX	UNIT
NF	Spot Noise Figure	$V_{CE} = 10$ v, $I_C = 300$ µa, $R_G = 510$ Ω, $f = 1$ kc	6	12	5	8	db

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2389 TYP	2N2389 MAX	UNIT
t_T	Total Switching Time	See Figure 1	20	30	nsec

*PARAMETER MEASUREMENT INFORMATION

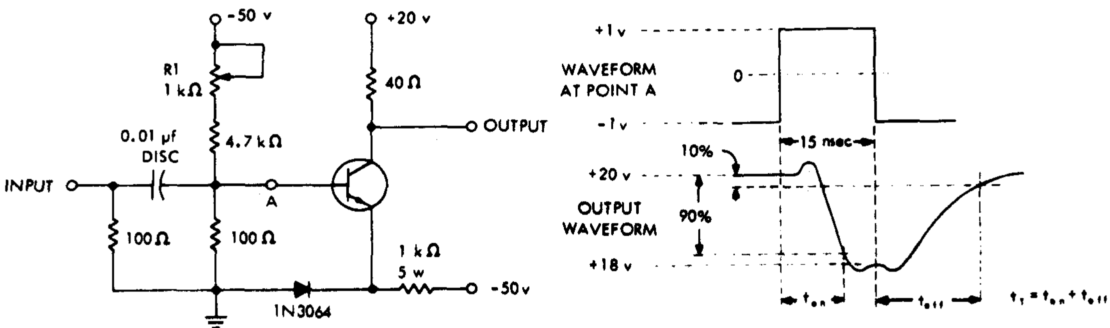

FIGURE 1 — NONSATURATED SWITCHING TIME MEASUREMENT CIRCUIT

NOTES: a. The input waveform, is supplied by a mercury-relay-pulse generator with the following characteristics: $t_r \leq 1$ nsec, $t_f \leq 1$ nsec, PW = 15 nsec. Adjust R1 and the input pulse amplitude to obtain the specified voltage levels at Point A.
b. Waveforms are monitored on a sampling oscilloscope ($t_r \leq 0.4$ nsec, $C_{in} \leq 1$ pf) using a 2000 Ω probe.

*Indicates JEDEC registered data (typical data excluded).

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BULLETIN NO. DL-S 646063, OCTOBER 1964

FOR GENERAL PURPOSE AMPLIFIER AND SWITCHING APPLICATIONS
Formerly TI 428 and TI 429

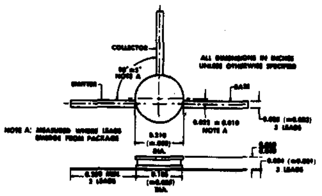
- **Electrically Similar to 2N1131 and 2N1132**
- **Compatible Package For Interfacing With Integrated Circuits and Thin-Film Modules**

4

mechanical data

The transistors are in a hermetically sealed welded package meeting the JEDEC TO-50 outline.

*CASE OUTLINE



ALL LEADS INSULATED FROM CASE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−50 v
Collector-Emitter Voltage (See Note 1)	−35 v
Emitter-Base Voltage	− 5 v
Collector Current	−300 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	450 mw
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.5 w
Operating Collector Junction Temperature	175°C
Storage Temperature Range	−65°C to +200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

NOTES: 1. This value applies when base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 3 mw/C°.
3. Derate linearly to 175°C case temperature at the rate of 10 mw/C°.

*Indicates JEDEC registered data.

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

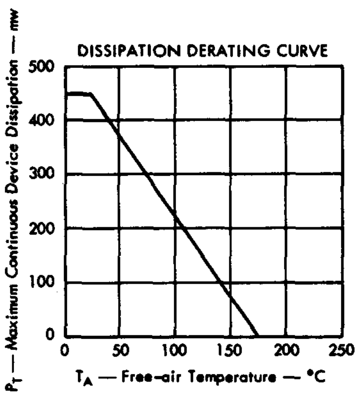
PARAMETER		TEST CONDITIONS	2N2393 MIN	2N2393 MAX	2N2394 MIN	2N2394 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu a$, $I_E = 0$	−50		−50		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ ma, $I_B = 0$, See Note 4	−35		−35		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = -100$ ma, $R_{BE} = 10\ \Omega$, See Note 4	−50		−50		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ v, $I_E = 0$		−1		−1	μa
		$V_{CB} = -30$ v, $I_E = 0$, $T_A = 150°C$		−100		−100	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ v, $I_C = 0$		−100		−100	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -5$ ma, See Note 4	15		25		
		$V_{CE} = -10$ v, $I_C = -150$ ma, See Note 4	20	45	30	90	
V_{BE}	Base-Emitter Voltage	$I_B = -15$ ma, $I_C = -150$ ma, See Note 4		−1.3		−1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ ma, $I_C = -150$ ma, See Note 4		−1.5		−1.5	v
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = -5$ v, $I_E = 1$ ma, f = 1 kc	25	35	25	35	Ω
		$V_{CB} = -10$ v, $I_E = 5$ ma, f = 1 kc		10		10	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = -5$ v, $I_E = 1$ ma, f = 1 kc	0	8×10^{-4}	0	8×10^{-4}	
		$V_{CB} = -10$ v, $I_E = 5$ ma, f = 1 kc	0	8×10^{-4}	0	8×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = -5$ v, $I_E = 1$ ma, f = 1 kc	0	1	0	1	μmho
		$V_{CB} = -10$ v, $I_E = 5$ ma, f = 1 kc	0	5	0	5	μmho
h_{fe}	Small-Signal Forward Current Transfer Ratio	$V_{CE} = -5$ v, $I_C = -1$ ma, f = 1 kc	15	50	25	100	
		$V_{CE} = -10$ v, $I_C = -5$ ma, f = 1 kc	20		30		
$\lvert h_{fe} \rvert$	Small-Signal Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -20$ ma, f = 20 Mc	2.5		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ v, $I_E = 0$, f = 1 Mc		45		45	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ v, $I_C = 0$, f = 1 Mc		80		80	pf

Note 4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

*indicates JEDEC registered data.

4

THERMAL CHARACTERISTICS



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TYPES 2N2395, 2N2396
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 646083, OCTOBER 1964

FOR GENERAL PURPOSE
AMPLIFIER AND SWITCHING APPLICATIONS
Formerly TI 432, TI 433

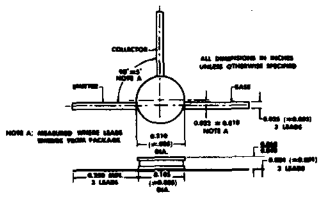
- **Electrically Similar To 2N696 and 2N697**
- **Compatible Package For Interfacing with Integrated Circuits and Thin-Film Modules**

4

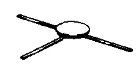
mechanical data

These transistors are in a hermetically sealed welded package meeting the JEDEC TO-50 outline.

* CASE OUTLINE



ALL LEADS INSULATED FROM CASE



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	60 v
Collector-Emitter Voltage (See Note 1)	40 v
Emitter-Base Voltage	5 v
Collector Current	300 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	450 mw
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.5 w
Operating Collector Junction Temperature	200°C
Storage Temperature Range	−65°C to +200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

NOTES: 1. This value applies when base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.57 mw/C°.
3. Derate linearly to 200°C case temperature at the rate of 8.57 mw/C°.

* Indicates JEDEC registered data.

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

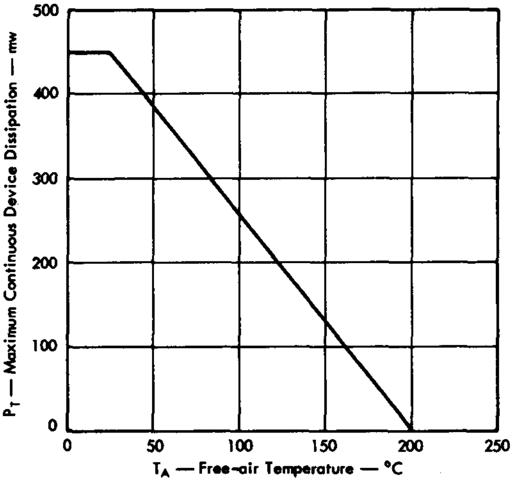
PARAMETER		TEST CONDITIONS	2N2395 MIN	2N2395 MAX	2N2396 MIN	2N2396 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu a$, $I_E = 0$	60		60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $I_B = 0$, See Note 4	40		40		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$		10		10	na
		$V_{CB} = 30$ v, $I_E = 0$, $T_A = 150°C$		10		10	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		1		1	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 4	20	60	40	120	
		$V_{CE} = 10$ v, $I_C = 150$ ma, $T_A = -55°C$, See Note 4	10		20		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 4	0.6	1.3	0.6	1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 4		1		1	v
$\|h_{fe}\|$	Small-Signal Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 20$ ma, f = 20 Mc	2		2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, f = 1 Mc		30		30	pf

4

NOTE 4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle $\leq$ 2%.

THERMAL CHARACTERISTICS

DISSIPATION DERATING CURVE



*Indicates JEDEC registered data.

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TYPES 2N2432, 2N2432A, 2N4138
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 689079, OCTOBER 1966—REVISED JANUARY 1968

FOR LOW-LEVEL, HIGH-SPEED CHOPPER APPLICATIONS IN INVERTED CONNECTION

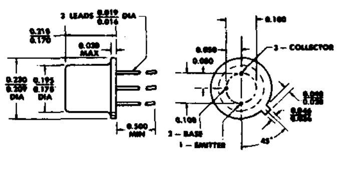
- **Low Offset Voltage . . . 0.4 mV Max (2N2432A)**
- **Low I_{ECS} . . . 2 nA Max**
- **High Rated V_{ECO} for Inverted Connection**

ALSO USEFUL FOR LOW-LEVEL AMPLIFIER APPLICATIONS

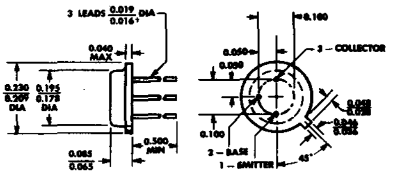
- **h_{FE} . . . 30 Min at 10 μA**

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

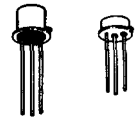


2N2432 AND 2N2432A
ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE.



2N4138
ALL JEDEC TO-46 DIMENSIONS AND NOTES ARE APPLICABLE.

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



†TI guaranteed minimum. The JEDEC registered minimum lead diameter for the TO-46 is 0.012.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2432 2N4138	2N2432A
Collector-Base Voltage	30 V	45 V
Collector-Emitter Voltage (See Note 1)	30 V	45 V
Emitter-Collector Voltage (See Note 2)	15 V	18 V
Emitter-Base Voltage	15 V	18 V
Continuous Collector Current	←100 mA→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	←300 mW→	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	←600 mW→	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTES: 1. This value applies between 0 and 10 mA collector current when the emitter-base diode is open-circuited.
2. This value applies between 0 and 100 μA emitter current when the collector-base diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 2 mW/deg.
4. Derate linearly to 175°C case temperature at the rate of 4 mW/deg.

*Indicates JEDEC registered data.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	2N2432 2N4138 MIN	2N2432 2N4138 MAX	2N2432A MIN	2N2432A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A, I_E = 0$	30		45		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 5	30		45		V
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	$I_E = 100\ \mu A, I_B = 0$	15		18		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 25$ V, $I_E = 0$		10			nA
		$V_{CB} = 40$ V, $I_E = 0$				10	nA
I_{CES}	Collector Cutoff Current	$V_{CE} = 25$ V, $V_{BE} = 0$		10			nA
		$V_{CE} = 25$ V, $V_{BE} = 0$, $T_A = 125°C$		250			nA
		$V_{CE} = 40$ V, $V_{BE} = 0$				10	nA
		$V_{CE} = 40$ V, $V_{BE} = 0$, $T_A = 125°C$				250	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 15$ V, $I_C = 0$		2		2	nA
I_{ECS}	Emitter Cutoff Current	$V_{EC} = 15$ V, $V_{BC} = 0$		2		2	nA
		$V_{EC} = 15$ V, $V_{BC} = 0$, $T_A = 125°C$		200		200	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 10\ \mu A$	30		30		
		$V_{CE} = 5$ V, $I_C = 1$ mA	50		50		
$h_{FE(inv)}$	Static Forward Current Transfer Ratio (Inverted Connection)	$V_{EC} = 5$ V, $I_E = 0.2$ mA	2		3		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ mA, $I_C = 10$ mA		0.15		0.15	V
$V_{EC(ofs)}$	Offset Voltage (Inverted Connection)	$I_B = 200\ \mu A$, $I_E = 0$, See Figure 1		0.5		0.4	mV
		$I_B = 1$ mA, $I_E = 0$, See Figure 1		1		0.7	mV
$r_{ec(on)}$	Small-Signal Emitter-Collector On-State Resistance	$I_B = 1$ mA, $I_E = 0$, $I_e = 100\ \mu A$, f = 1 kHz, See Figure 2		20		15	Ω
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ mA, f = 20 MHz	1		1		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 0$, $I_E = 0$, f = 140 kHz		12		12	pF
C_{cb}	Collector-Base Capacitance	$V_{CB} = 0$, $I_E = 0$, f = 1 MHz, See Note 6		12		12	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0$, $I_C = 0$, f = 140 kHz		12		12	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0$, $I_C = 0$, f = 1 MHz, See Note 6		12		12	pF

NOTES: 5. This parameter must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.
6. C_{cb} and C_{eb} are measured using three-terminal measurement techniques with the third electrode (emitter or collector respectively) guarded.

PARAMETER MEASUREMENT INFORMATION

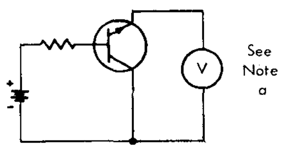

FIGURE 1

MEASUREMENT CIRCUIT FOR OFFSET VOLTAGE

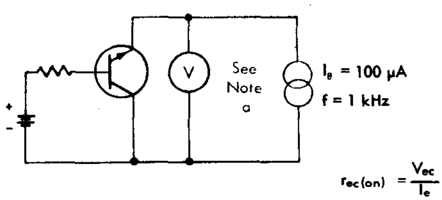

FIGURE 2

MEASUREMENT CIRCUIT FOR EMITTER-COLLECTOR ON-STATE RESISTANCE

NOTE a: The voltmeter must have high enough impedance that halving the value of the voltmeter impedance does not change the measured value.

*Indicates JEDEC registered data.

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PRINTED IN U.S.A.

TYPE 2N2453
DUAL N-P-N SILICON TRANSISTOR

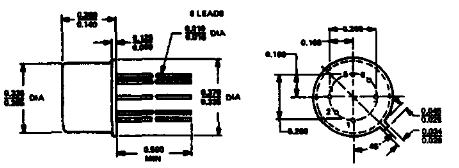
BULLETIN NO. DL-S 7211682, MARCH 1972

TWO TRANSISTORS IN ONE PACKAGE
RECOMMENDED FOR

- **Differential Amplifiers**
- **Low-Level, Low-Noise Audio Amplifiers**
- **Low-Level Flip-Flops**

*mechanical data

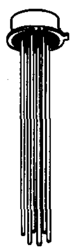
ALL LEADS INSULATED FROM CASE



Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	60 V	
Collector-Emitter Voltage (See Note 1)	30 V	
Emitter-Base Voltage	7 V	
Continuous Collector Current	50 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.2 W	0.3 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.6 W	1.2 W
Continuous Device Dissipation at 100°C Case Temperature	0.35 W	0.7 W
Operating Collector Junction Temperature	200°C	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←300°C→	

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rates of 1.14 mW/°C for each triode and 1.71 mW/°C for total device.
3. Derate linearly to 200°C case temperature at the rates of 3.43 mW/°C for each triode and 6.86 mW/°C for total device.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$, See Note 5	30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 0.1\ \mu A$, $I_C = 0$	7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50\ V$, $I_E = 0$		5	nA
		$V_{CB} = 50\ V$, $I_E = 0$, $T_A = 150°C$		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5\ V$, $I_C = 0$		2	nA
h_{FE}	Static Forward Current Transfer Ratio	$I_C = 10\ \mu A$, $V_{CE} = 5\ V$	80		
		$I_C = 10\ \mu A$, $V_{CE} = 5\ V$, $T_A = -55°C$	40		
		$I_C = 1\ mA$, $V_{CE} = 5\ V$	150	600	
		$I_C = 1\ mA$, $V_{CE} = 5\ V$, $T_A = -55°C$	75		
V_{BE}	Base-Emitter Voltage	$I_C = 5\ mA$, $I_B = 0.5\ mA$		0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 5\ mA$, $I_B = 0.5\ mA$		1	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	20	30	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio			5×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance			0.2	μmho
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	5		kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		150	600	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			6×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance		5	30	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 5\ mA$, $f = 30\ MHz$	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$, $f = 140\ kHz$		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$, $f = 140\ kHz$		10	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current-Gain Balance Ratio	$V_{CE} = 5\ V$, $I_C = 1\ mA$, See Note 6	0.9	1	
		$V_{CE} = 5\ V$, $I_C = 1\ mA$, See Note 6, $T_A = -55°C$ to $125°C$	0.85	1	
$\lvert V_{BE1} - V_{BE2} \rvert$	Base-Emitter-Voltage Differential	$V_{CE} = 5\ V$, $I_C = 10\ \mu A$		3	mV
		$V_{CE} = 5\ V$, $I_C = 1\ mA$		5	mV
$\left\lvert \frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A} \right\rvert$	Base-Emitter-Voltage-Differential Temperature Gradient	$V_{CE} = 5\ V$, $I_C = 10\ \mu A$, $\Delta T_A = [25°C-(-55°)]$ and $[125°C-25°C]$		10	μV/°C

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 5\ V$, $I_C = 10\ \mu A$, $R_G = 10\ k\Omega$, $f = 1\ kHz$		7	dB

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. *This parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.*
6. The lower of the two h_{FE} readings is taken as h_{FE1}.

*JEDEC registered data

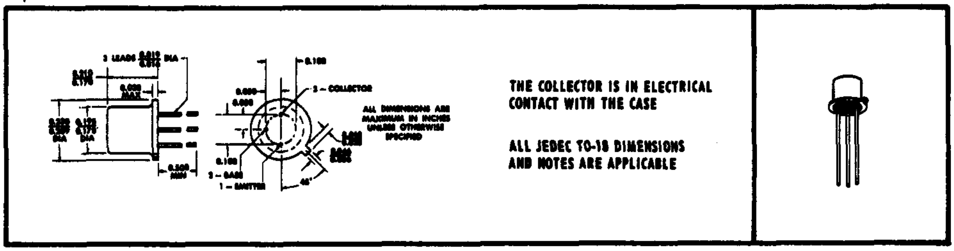
PRINTED IN U.S.A. 372

BULLETIN NO. DL-S 6710300, SEPTEMBER 1967

FOR LOW-LEVEL, LOW-NOISE, HIGH-GAIN, AMPLIFIER APPLICATIONS

- **Guaranteed Low-Noise Characteristics at 100 Hz, 1 kHz, and 10 kHz**
- **High $V_{(BR)CEO}$ . . . 60 V Min**
- **D-C Beta Guaranteed at $I_C = 1\ \mu A$ (2N2484)**

*mechanical data



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	60 V
Collector-Emitter Voltage (See Note 1)	60 V
Emitter-Base Voltage	6 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.36 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 W
Continuous Device Dissipation at 100°C Case Temperature	0.68 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.06 mW/deg.
3. Derate linearly to 200°C case temperature at the rate of 6.85 mW/deg.

*Indicates JEDEC registered data

USES CHIP N11

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2483 MIN	2N2483 MAX	2N2484 MIN	2N2484 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 4	60		60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ V, $I_E = 0$		10		10	nA
		$V_{CB} = 45$ V, $I_E = 0$, $T_A = 150°C$		10		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1\ \mu A$			30		
		$V_{CE} = 5$ V, $I_C = 10\ \mu A$	40	120	100	500	
		$V_{CE} = 5$ V, $I_C = 10\ \mu A$, $T_A = -55°C$	10		20		
		$V_{CE} = 5$ V, $I_C = 100\ \mu A$	75		175		
		$V_{CE} = 5$ V, $I_C = 500\ \mu A$	100		200		
		$V_{CE} = 5$ V, $I_C = 1$ mA	175		250		
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 4		500		800	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 100\ \mu A$	0.5	0.7	0.5	0.7	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 100\ \mu A$, $I_C = 1$ mA		0.35		0.35	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz	1.5	13	3.5	24	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		80	450	150	900	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			8×10^{-4}		8×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance			30		40	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 50\ \mu A$, $f = 5$ MHz	2.4		3		
		$V_{CE} = 5$ V, $I_C = 500\ \mu A$, $f = 30$ MHz	2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_E = 0$, $f = 140$ kHz		6		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 140$ kHz		6		6	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2483 MAX	2N2484 MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 10\ \mu A$, $R_G = 10$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 5	4	3	dB
NF	Spot Noise Figure	$V_{CE} = 5$ V, $I_C = 10\ \mu A$, $R_G = 10$ kΩ, $f = 100$ Hz, Noise Bandwidth = 20 Hz	15	10	dB
		$V_{CE} = 5$ V, $I_C = 10\ \mu A$, $R_G = 10$ kΩ, $f = 1$ kHz, Noise Bandwidth = 200 Hz	4	3	dB
		$V_{CE} = 5$ V, $I_C = 10\ \mu A$, $R_G = 10$ kΩ, $f = 10$ kHz, Noise Bandwidth = 2 kHz	3	2	dB

NOTES: 4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 1\%$.

5. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*Indicates JEDEC registered data

4

TEXAS INSTRUMENTS
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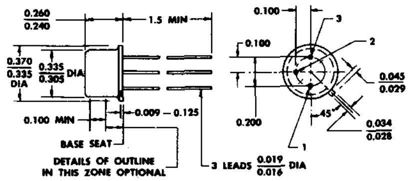
TYPES 2N2497 THRU 2N2500
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 683519, MAY 1963–REVISED MAY 1968

FOR SMALL-SIGNAL, LOW-NOISE APPLICATIONS

- **Guaranteed 10 cps Noise Figure (2N2500)**
- **High Input Impedance (>5 megohms at 1 kc)**

*mechanical data

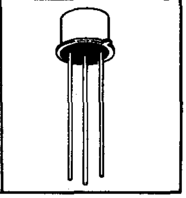


THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-5 DIMENSIONS AND NOTES ARE APPLICABLE

1 — SOURCE 2 — GATE
3 — DRAIN

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Continuous Forward Gate Current . . . . −10 ma
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1) . . . . . 0.5 w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 2) . . . . . . 1.5 w
Storage Temperature Range . . . . −195°C to + 200°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	2N2497 MIN	2N2497 MAX	2N2498 MIN	2N2498 MAX	2N2499 MIN	2N2499 MAX	2N2500 MIN	2N2500 MAX	UNIT
$V_{(BR)DGO}$	Drain-Gate Breakdown Voltage (See Note 3)	$I_D = -10\ \mu a$, $I_S = 0$	−20		−20		−20		−20		v
I_{GSS}	Gate Cutoff Current	$V_{GS} = 10$ v, $V_{DS} = 0$		0.01		0.01		0.01		0.01	µa
I_{GSS}	Gate Cutoff Current	$V_{GS} = 10$ v, $V_{DS} = 0$, $T_A = 150°C$		10		10		10		10	µa
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -10$ v, $V_{GS} = 0$	−1	−3	−2	−6	−5	−15	−1	−6	ma
$I_{D(off)}$	Pinch-Off Drain Current	$V_{DS} = -15$ v, V_{GS}: See Note 4		−10		−10		−10		−10	µa
r_{DS}	Static Drain-Source Resistance	$I_D = -100\ \mu a$, $V_{GS} = 0$		1000		800		600			ohm
$\lvert y_{is}\rvert$	Small-Signal Common-Source Input Admittance	$V_{DS} = -10$ v, I_D: See Note 5, f = 1 kc		0.2		0.2		0.2		0.2	µmho
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance		1000	2000	1500	3000	2000	4000	1000	2200	µmho
$\lvert y_{rs}\rvert$	Small-Signal Common-Source Reverse Transfer Admittance			0.1		0.1		0.1		0.1	µmho
$\lvert y_{os}\rvert$	Small-Signal Common-Source Output Admittance			20		40		100		20	µmho
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ v, I_D: See Note 5, f = 10 mc	900		1350		1800		900		µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{GS} = 0$, $V_{DS} = -10$ v, f = 140 kc		32		32		32		32	pf

*operating characteristics at 25°C free-air temperature

		TEST CONDITIONS	2N2497	2N2498	2N2499	2N2500	UNIT
NF	Spot Noise Figure	$V_{DS} = -5$ v, $I_D = -1$ ma, f = 1 kc, $R_G = 1\ M\Omega$	3	3	4	1	db
		$V_{DS} = -5$ v, $I_D = -1$ ma, f = 10 cps, $R_G = 10\ M\Omega$				5	db

NOTES: 1. Derate linearly to 175°C free-air temperature at the rate of 3.3 mw/°C.
2. Derate linearly to 175°C case temperature at the rate of 10 mw/°C.
3. This parameter corresponds closely to $V_{(BR)DSS}$ (the Drain-Source Breakdown Voltage for $V_{GS} = 0$). $V_{(BR)DSV}$ (the Drain-Source Breakdown Voltage for other values of V_{GS}) may be calculated from:
$\lvert V_{(BR)DSV}\rvert \approx \lvert V_{(BR)DGO}\rvert - \lvert V_{GS}\rvert$.

	2N2497	2N2498	2N2499	2N2500
NOTE 4: V_{GS} =	5 v	6 v	8 v	6 v
NOTE 5: I_D =	−1 ma	−2 ma	−5 ma	−1 ma

*Indicates JEDEC registered data.

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TYPES 2N2537 THRU 2N2540
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 694130, AUGUST 1963—REVISED JANUARY 1969

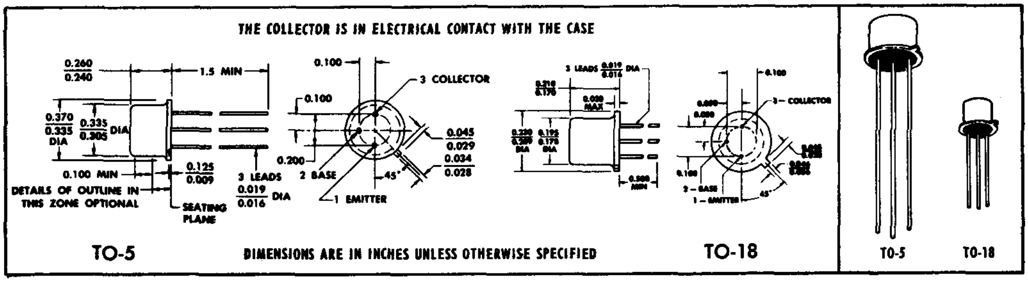
DESIGNED FOR MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **Total Switching Time . . . 80 nsec max at 150 ma**
- **High f_T . . . 250 Mc min at 20 v, 20 ma**
- **h_{FE} Guaranteed from 1 ma to 500 ma**

4

*mechanical data

Device types 2N2537 and 2N2538 are in JEDEC TO-5 packages.
Device types 2N2539 and 2N2540 are in JEDEC TO-18 packages.



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2537 2N2538	2N2539 2N2540
Collector-Base Voltage	60 v	60 v
Collector-Emitter Voltage (See Note 1)	40 v	40 v
Collector-Emitter Voltage (See Note 2)	30 v	30 v
Emitter-Base Voltage	5 v	5 v
Collector Current	0.8 a	0.8 a
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 3 and 4)	0.8 w	0.5 w
Total Device Dissipation at (or below) 25°C Case Temperature (See Notes 5 and 6)	3 w	1.8 w
Storage Temperature Range	−65°C to + 200°C	

NOTES: 1. This value applies when the base-emitter resistance (R_{BE}) is equal to or less than 10 ohms.
2. This value applies when the base-emitter diode is open-circuited.
3. Derate 2N2537 and 2N2538 linearly to 200°C free-air temperature at the rate of 4.57 mw/C°.
4. Derate 2N2539 and 2N2540 linearly to 200°C free-air temperature at the rate of 2.86 mw/C°.
5. Derate 2N2537 and 2N2538 linearly to 200°C case temperature at the rate of 17.2 mw/C°.
6. Derate 2N2539 and 2N2540 linearly to 200°C case temperature at the rate of 10.3 mw/C°.

*Indicates JEDEC registered data

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TO-5 → 2N2537 / TO-18 → 2N2539 MIN	TO-5 → 2N2537 / TO-18 → 2N2539 MAX	TO-5 → 2N2538 / TO-18 → 2N2540 MIN	TO-5 → 2N2538 / TO-18 → 2N2540 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu a$, $I_E = 0$	60		60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $I_B = 0$, (See Note 7)	30		30		v
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ ma, $R_{BE} = 10\ \Omega$, (See Note 7)	40		40		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$	5		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40$ v, $I_E = 0$,		250		250	na
		$V_{CB} = 40$ v, $I_E = 0$, $T_A = 150°C$		200		200	μa
I_{CEX}	Collector Cutoff Current	$V_{CE} = 20$ v, $V_{BE} = 0.2$ v		250		250	na
I_{BEX}	Base Cutoff Current	$V_{CE} = 20$ v, $V_{BE} = 0.2$ v		250		250	na
		$V_{CE} = 20$ v, $V_{BE} = 0.2$ v, $T_A = 150°C$		200		200	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ v, $I_C = 0$		50		50	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 1$ ma	20		35		
		$V_{CE} = 10$ v, $I_C = 10$ ma	30		50		
		$V_{CE} = 10$ v, $I_C = 150$ ma, (See Note 7)	50	150	100	300	
		$V_{CE} = 10$ v, $I_C = 500$ ma, (See Note 7)	20		30		
		$V_{CE} = 1$ v, $I_C = 150$ ma	20		40		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, (See Note 7)		1.3		1.3	v
		$I_B = 50$ ma, $I_C = 500$ ma, (See Note 7)		2.6		2.6	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, (See Note 7)		0.45		0.45	v
		$I_B = 50$ ma, $I_C = 500$ ma, (See Note 7)		1.6		1.6	v
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 20$ v, $I_C = 20$ ma, f = 100 mc	2.5		2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, f = 100 kc		8		8	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, f = 100 kc		25		25	pf

NOTE 7: These parameters must be measured using pulse techniques. PW ≤ 300 μsec, Duty Cycle ≤ 2%.

*Indicates JEDEC registered data

4

***switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	TO-5 → 2N2537 MIN	TO-18 → 2N2539 MAX	2N2538 MIN	2N2540 MAX	UNIT
t_{on}	Turn-on Time	$I_C = 150$ ma, $I_{B(1)} = 15$ ma, $I_{B(2)} = -15$ ma		40		40	nsec
t_{off}	Turn-off Time	$V_{BE(off)} = -1$ v, $V_{CC} = 7$ v, (See Figure 1)		40		40	nsec
t_s	Storage Time	$I_C = I_{B(1)} = -I_{B(2)} = 20$ ma, (See Figure 2)		20		20	nsec
Q_T	Total Control Charge	$I_C = 150$ ma, $I_{B(1)} = 15$ ma, (See Figure 3)		750		750	pcb
τ_A	Active-Region Time Constant	$V_{CC} = 15.2$ v, $I_C = 150$ ma, $I_{B(1)} = 15$ ma, (See Figure 4)		2.0		2.0	nsec

PARAMETER MEASUREMENT INFORMATION

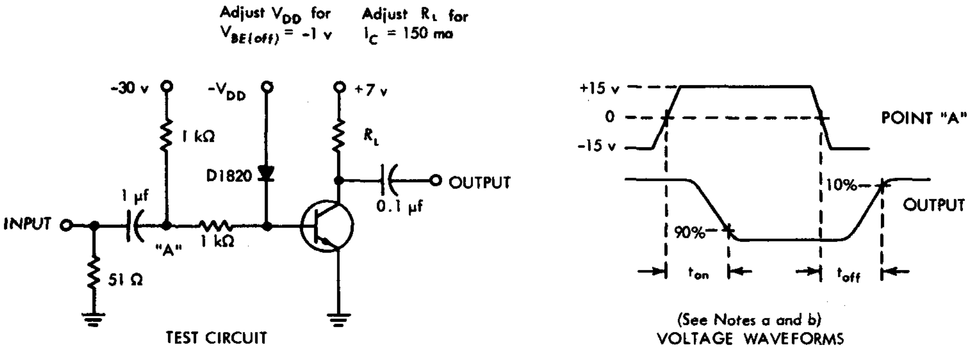


***FIGURE 1 — TURN-ON AND TURN-OFF TIMES**

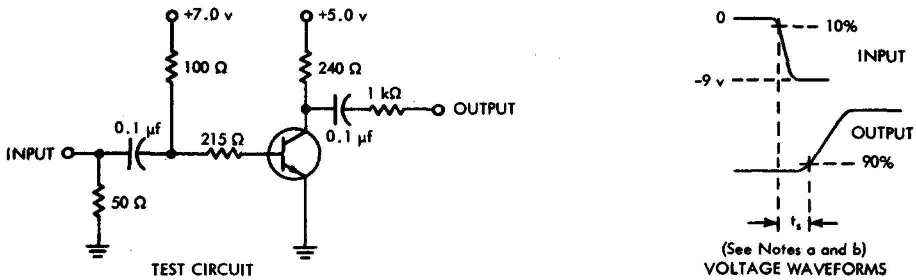
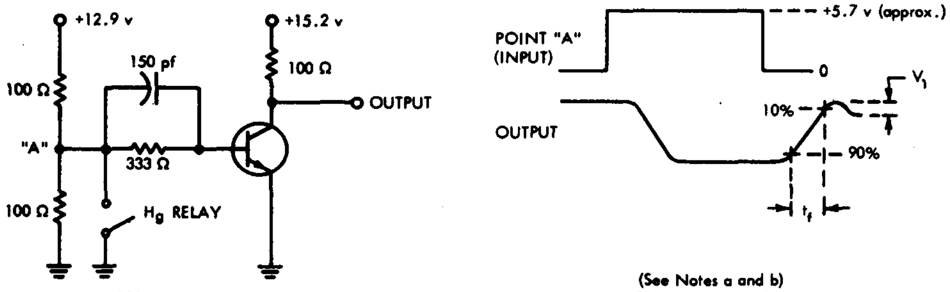


***FIGURE 2 — STORAGE TIME**

*Indicates JEDEC registered data

PARAMETER MEASUREMENT INFORMATION

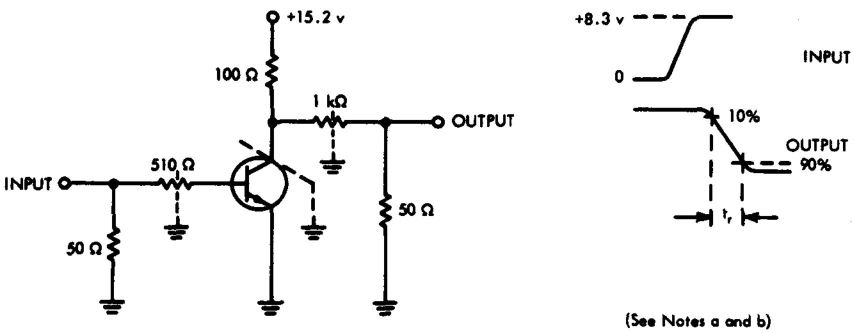


TEST CIRCUIT

(See Notes a and b)
VOLTAGE WAVEFORMS

Note: $Q_T \leq 750$ pcb when $V_1 \leq 50$ mv and $t_f \leq 10$ nsec.

*** FIGURE 3 — TOTAL CONTROL CHARGE**



TEST CIRCUIT

(See Notes a and b)
VOLTAGE WAVEFORMS

Note: In this circuit, $\tau_A = \frac{t_r}{10}$

***FIGURE 4 — ACTIVE-REGION TIME CONSTANT**

NOTE a: The input waveforms are supplied by generators with the following characteristics:

FIGURE	t_r*	t_f*	PW*	Z_{out}*
1	≤ 2 nsec	≤ 2 nsec	1 μsec	50 Ω
2	≤ 2 nsec	≤ 2 nsec		50 Ω
3		≤ 2 nsec		
4	≤ 2 nsec	≤ 2 nsec		50 Ω

NOTE b: Waveforms are monitored on oscilloscopes with the following characteristics:

FIGURE	t_r*	R_{in}*	C_{in}
1	≤ 1 nsec	10 M Ω	≤ 5 pf
2	≤ 5 nsec	10 M Ω	≤ 10 pf
3	≤ 1 nsec	10 M Ω	≤ 5 pf*
4	≤ 5 nsec	10 M Ω	≤ 10 pf

*Indicates JEDEC registered data.

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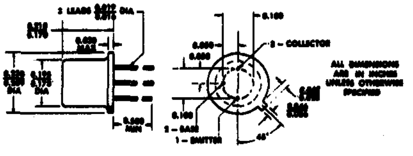
BULLETIN NO. DL-S 652987, AUGUST 1962—REVISED SEPTEMBER 1965

FOR EXTREMELY LOW-LEVEL, LOW-NOISE, AMPLIFIER APPLICATIONS

- Guaranteed Very-Low-Current h_{FE} . . . 80 min at 1 μA
- Guaranteed Low-Temperature h_{FE} . . . 40 min at 10 μA, −55°C
- Complete Noise Characterization at 1 μA and 10 μA

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	60 v
Collector-Emitter Voltage (See Note 1)	45 v
Emitter-Base Voltage	6 v
Collector Current	30 ma
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.3 w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.6 w
Operating Collector Junction Temperature	175°C
Storage Temperature Range	−65°C to + 200°C

NOTES: 1. This value applies when the emitter-base diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 2.0 mw/C°.
3. Derate linearly to 175°C case temperature at the rate of 4.0 mw/C°.
4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle $\leq$ 2%.

*Indicates JEDEC registered data

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu a$, $I_E = 0$	60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$ (See Note 4)	45		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$	6		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ v, $I_E = 0$		2	na
I_{CEO}	Collector Cutoff Current	$V_{CE} = 5$ v, $I_B = 0$		2	na
I_{CES}	Collector Cutoff Current	$V_{CE} = 45$ v, $V_{BE} = 0$		2	na
		$V_{CE} = 45$ v, $V_{BE} = 0$, $T_A = 170°C$		10	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		2	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1\ \mu a$	80		
		$V_{CE} = 5$ v, $I_C = 10\ \mu a$	120	360	
		$V_{CE} = 5$ v, $I_C = 10\ \mu a$, $T_A = -55°C$	40		
		$V_{CE} = 5$ v, $I_C = 500\ \mu a$	150		
		$V_{CE} = 5$ v, $I_C = 10$ ma (See Note 4)		600	
V_{BE}	Base-Emitter Voltage	$I_B = 0.5$ ma, $I_C = 10$ ma	0.7	0.9	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ ma, $I_C = 10$ ma		0.5	v
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	4.5	18	kohm
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		100	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	150	600	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 500\ \mu a$, $f = 30$ mc	1.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$, $f = 1$ mc		7.0	pf

***operating characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	MAX	UNIT
NF	Spot Noise Figure	$V_{CE} = 5$ v, $I_C = 10\ \mu a$, $R_G = 10\ k\Omega$, $f = 10$ kc	2.0	db
		$V_{CE} = 5$ v, $I_C = 10\ \mu a$, $R_G = 10\ k\Omega$, $f = 1$ kc	3.0	db
		$V_{CE} = 5$ v, $I_C = 1\ \mu a$, $R_G = 1\ M\Omega$, $f = 10$ kc	2.0	db
		$V_{CE} = 5$ v, $I_C = 1\ \mu a$, $R_G = 1\ M\Omega$, $f = 1$ kc	3.5	db

*Indicates JEDEC registered data

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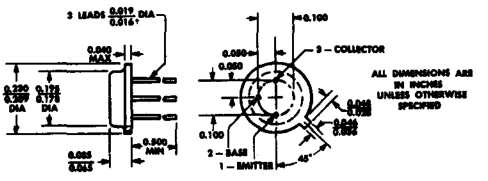
BULLETIN NO. DL-S 7311966, MARCH 1973

FOR LOW-LEVEL, LOW-NOISE, HIGH-GAIN AMPLIFIER APPLICATIONS

- For Complementary Use with 2N929, 2N930, 2N2483, 2N2484, and 2N2586
- Guaranteed h_{FE} at 10 μA, –55°C and 25°C
- Low Noise Characteristics
- Usable at Collector Currents as Low as 1 μA

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-46 DIMENSIONS AND NOTES ARE APPLICABLE

†TI guaranteed minimum. The JEDEC registered minimum lead diameter for the TO-46 is 0.012.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	–60 V
Collector-Emitter Voltage (See Note 1)	–45 V
Emitter-Base Voltage	–6 V
Continuous Collector Current	–30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	400 mW
Storage Temperature Range	–65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

NOTES: 1. This value applies between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.28 mW/°C.

*JEDEC registered. This data sheet contains all applicable registered data in effect at the time of publication.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2604		2N2605		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−60		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 3	−45		−45		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−6		−6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -45$ V, $I_E = 0$		−10		−10	nA
I_{CES}	Collector Cutoff Current	$V_{CE} = -45$ V, $V_{BE} = 0$		−10		−10	nA
		$V_{CE} = -45$ V, $V_{BE} = 0$, $T_A = 170°C$		−10		−10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−2		−2	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -10\ \mu A$	40	120	100	300	
		$V_{CE} = -5$ V, $I_C = -10\ \mu A$, $T_A = -55°C$	10		20		
		$V_{CE} = -5$ V, $I_C = -500\ \mu A$	60		150		
		$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 3		350		600	
V_{BE}	Base-Emitter Voltage	$I_B = -0.5$ mA, $I_C = -10$ mA, See Note 3	−0.7	−0.9	−0.7	−0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.5$ mA, $I_C = -10$ mA, See Note 3		−0.5		−0.5	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = -5$ V, $I_E = 1$ mA, f = 1 kHz	25	35	25	35	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio	$V_{CB} = -5$ V, $I_E = 1$ mA, f = 1 kHz		10×10^{-4}		10×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = -5$ V, $I_E = 1$ mA, f = 1 kHz		1		1	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CB} = -5$ V, $I_E = 1$ mA, f = 1 kHz	60	350	150	600	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -500\ \mu A$, f = 30 MHz	1		1		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 1 MHz		6		6	pF
$h_{ie(real)}$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 100 MHz		200		200	Ω

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2604		2N2605		UNIT
			MIN	MAX	MIN	MAX	
$\overline{F}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -10\ \mu A$, $R_G = 10\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 4		4		3	dB

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

*JEDEC registered data

BULLETIN NO. DL-S 7311948, MARCH 1973

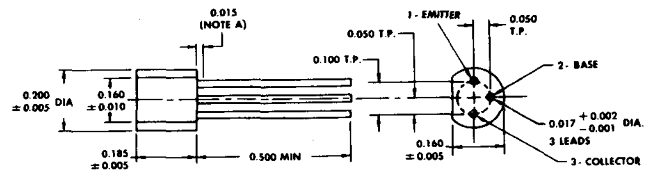
SILECT† TRANSISTORS‡
FOR LOW-LEVEL, LOW-NOISE, HIGH-GAIN AMPLIFIER APPLICATIONS

- **Minimum h_{FE} at 10 μA . . . 100 (A5T2605)**
- **Low Average Noise Figure . . . 3 dB, Max (A5T2605)**
- **Usable at Collector Currents as Low as 1 μA**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

4



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−60 V
Collector-Emitter Voltage (See Note 1)	−45 V
Emitter-Base Voltage	−6 V
Continuous Collector Current	−30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP P19

TEXAS INSTRUMENTS
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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	A5T2604 MIN	A5T2604 MAX	A5T2605 MIN	A5T2605 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−60		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ mA$, $I_B = 0$, See Note 3	−45		−45		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−6		−6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -45\ V$, $I_E = 0$		−10		−10	nA
I_{CES}	Collector Cutoff Current	$V_{CE} = -45\ V$, $V_{BE} = 0$		−10		−10	nA
		$V_{CE} = -45\ V$, $V_{BE} = 0$, $T_A = 85°C$		−200		−200	
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5\ V$, $I_C = 0$		−2		−2	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5\ V$, $I_C = -10\ \mu A$	40	120	100	300	
		$V_{CE} = -5\ V$, $I_C = -500\ \mu A$	60		150		
		$V_{CE} = -5\ V$, $I_C = -10\ mA$, See Note 3		350		600	
V_{BE}	Base-Emitter Voltage	$I_B = -0.5\ mA$, $I_C = -10\ mA$, See Note 3	−0.7	−0.9	−0.7	−0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.5\ mA$, $I_C = -10\ mA$, See Note 3		−0.5		−0.5	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = -5\ V$, $I_E = 1\ mA$, $f = 1\ kHz$	25	35	25	35	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio			10×10^{-4}		10×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance			1		1	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		60	350	150	600	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5\ V$, $I_C = -500\ \mu A$, $f = 30\ MHz$	1		1		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5\ V$, $I_E = 0$, $f = 1\ MHz$		6		6	pF
$h_{ie(real)}$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5\ V$, $I_C = -1\ mA$, $f = 100\ MHz$		200		200	Ω

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T2604 MIN	A5T2604 MAX	A5T2605 MIN	A5T2605 MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{CE} = -5\ V$, $I_C = -10\ \mu A$, $R_G = 10\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 4		4		3	dB

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

4

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TYPES 2N2608, 2N2609
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

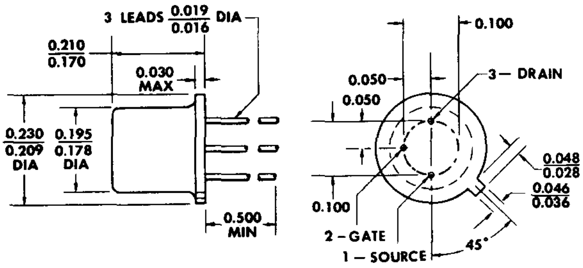
BULLETIN NO. DL-S 7011341, AUGUST 1970

FOR SMALL-SIGNAL, LOW-NOISE APPLICATIONS

- High Input Impedance

*mechanical data

THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Continuous Forward Gate Current	−10 mA
*Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
*Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2608 MIN	2N2608 MAX	2N2609 MIN	2N2609 MAX	UNIT
*$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 1\ \mu A$, $V_{DS} = 0$	30		30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = 30\ V$, $V_{DS} = 0$		10		30	nA
*I_{GSS}	Gate Reverse Current	$V_{GS} = 5\ V$, $V_{DS} = 0$		10		30	nA
		$V_{GS} = 5\ V$, $V_{DS} = 0$, $T_A = 150°C$		10		30	μA
*$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = -5\ V$, $I_D = -1\ \mu A$	1	4	1	4	V
*I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -5\ V$, $V_{GS} = 0$	−0.9	−4.5	−2	−10	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{DS} = 0$, $V_{GS} = 0$, $f = 1\ kHz$		1000		600	Ω
*$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -5\ V$, $V_{GS} = 0$, $f = 1\ kHz$	1		2.5		mmho
*C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -5\ V$, $V_{GS} = 1\ V$, $f = 140\ kHz$		17		30	pF

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	BOTH MIN	BOTH MAX	UNIT
*NF	Common-Source Spot Noise Figure	$V_{DS} = -5\ V$, $V_{GS} = 0$, $f = 1\ kHz$, $R_G = 1\ M\Omega$		3	dB

NOTE 1: Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JP71

TEXAS INSTRUMENTS INCORPORATED
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TYPES 2N2639 THRU 2N2644
DUAL N-P-N SILICON TRANSISTORS

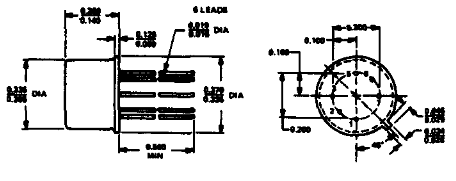
BULLETIN NO. DL-S 7211679, MARCH 1972

TWO TRANSISTORS IN ONE PACKAGE
RECOMMENDED FOR

- Differential Amplifiers
- High-Gain, Low-Noise Audio Amplifiers
- Transducer Signal-Conditioner Amplifiers
- Low-Level Flip-Flops

*mechanical data

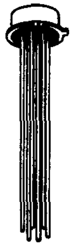
ALL LEADS INSULATED FROM CASE



ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED

Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	45 V	
Collector-Emitter Voltage (See Note 1)	45 V	
Emitter-Base Voltage	5 V	
Continuous Collector Current	30 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.3 W	0.6 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.6 W	1.2 W
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTES: 1. This value applies when the emitter-base diode is open-circuited.
2. For each triode derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.
3. For each triode derate linearly to 175°C case temperature at the rate of 4 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP N11

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS			2N2639 2N2640 2N2641 MIN	MAX	2N2642 2N2643 2N2644 MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA,	$I_B = 0$,	See Note 5	45		45		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ V,	$I_E = 0$			10		10	nA
		$V_{CB} = 45$ V,	$I_E = 0$,	$T_A = 150°C$		10		10	μA
I_{CEO}	Collector Cutoff Current	$V_{CE} = 5$ V,	$I_B = 0$			10		10	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V,	$I_C = 0$			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V,	$I_C = 10$ μA		50	300	100	300	
		$V_{CE} = 5$ V,	$I_C = 10$ μA,	$T_A = -55°C$	10		20		
		$V_{CE} = 5$ V,	$I_C = 100$ μA		55		110		
		$V_{CE} = 5$ V,	$I_C = 1$ mA		65		130		
V_{BE}	Base-Emitter Voltage	$I_B = 0.5$ mA,	$I_C = 10$ mA,		0.6	1	0.6	1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ mA,	$I_C = 10$ mA			1		1	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ V,	$I_E = -1$ mA,	$f = 1$ kHz	25	32	25	32	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio					6×10^{-4}		6×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance					1		1	μmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V,	$I_C = 1$ mA,	$f = 1$ kHz	65	600	130	600	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V,	$I_C = 1$ mA,	$f = 20$ MHz	4		4		dB
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V,	$I_E = 0$,	$f = 1$ MHz		8		8	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N2639 2N2642 MIN	MAX	2N2640 2N2643 MIN	MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current-Gain Balance Ratio	$V_{CE} = 5$ V, $I_C = 10$ μA, See Note 6	0.9	1	0.8	1	
$\|V_{BE1} - V_{BE2}\|$	Base-Emitter-Voltage Differential	$V_{CE} = 5$ V, $I_C = 10$ μA		5		10	mV
$\left\|\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}\right\|$	Base-Emitter-Voltage-Differential Temperature Gradient	$V_{CE} = 5$ V, $I_C = 10$ μA, $\Delta T_A = [25°C - (-55°C)]$ and $[125°C - 25°C]$		10		20	μV/°C

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	ALL TYPES MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{CB} = 5$ V, $I_E = -10$ μA, $R_G = 10$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 7	4	dB

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. This parameter must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
6. The lower of the two h_{FE} readings is taken as h_{FE1}.
7. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data

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BULLETIN NO. DL-S 7311959, MARCH 1973

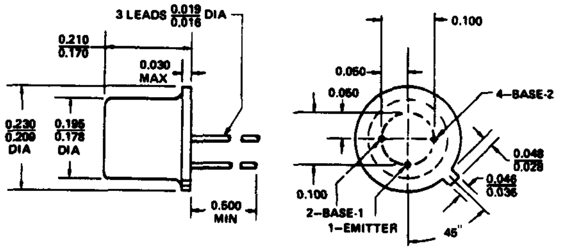
PLANAR UNIJUNCTION TRANSISTORS SPECIFICALLY CHARACTERIZED FOR A WIDE RANGE OF MILITARY AND INDUSTRIAL APPLICATIONS

- **Planar Process Ensures Low Leakage, Low Drive-Current Requirement, and Improved Reliability**

*mechanical data

Package outline is the same as JEDEC TO-18 except for lead position. All TO-18 registration notes also apply to this outline.

BASE-2 IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Emitter–Base-Two Reverse Voltage	−30 V
Interbase Voltage (See Note 1)	35 V
Continuous Emitter Current	50 mA
Peak Emitter Current (See Note 2)	2 A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	300 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This rating is based upon allowable power dissipation: $V_{B2B1} = \sqrt{r_{BB} \cdot P_T}$.
2. This value applies for a capacitor discharge through the emitter–base-one diode. Current must fall to 0.74 A within 1.5 ms and pulse-repetition rate must not exceed 10 pps.
3. Derate linearly to 125°C free-air temperature at the rate of 3 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP U42

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TYPES 2N2646, 2N2647
P-N PLANAR SILICON UNIJUNCTION TRANSISTORS

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		2N2646 MIN	2N2646 MAX	2N2647 MIN	2N2647 MAX	UNIT
r_{BB}	Static Interbase Resistance	$V_{B2B1} = 3$ V,	$I_E = 0$	4.7	9.1	4.7	9.1	kΩ
α_{rBB}	Interbase Resistance Temperature Coefficient	$V_{B2B1} = 3$ V, $T_A = -55°C$ to 125°C,	$I_E = 0$, See Note 4	0.1	0.9	0.1	0.9	%/°C
η	Intrinsic Standoff Ratio	$V_{B2B1} = 10$ V,	See Figure 1	0.56	0.75	0.68	0.82	
I_{EB2O}	Emitter Reverse Current	$V_{EB2} = -30$ V,	$I_{B1} = 0$		−12		−0.2	μA
I_P	Peak-Point Emitter Current	$V_{B2B1} = 25$ V			5		2	μA
I_V	Valley-Point Emitter Current	$V_{B2B1} = 20$ V		4		8	18	mA
V_{OB1}	Base-One Peak Pulse Voltage	See Figure 2		3		6		V

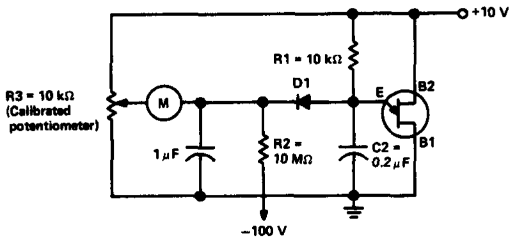
NOTE 4: Temperature coefficient α_{rBB} is determined by the following formula:

$$\alpha_{rBB} = \left[\frac{(r_{BB} @ 125°C)-(r_{BB} @ -55°C)}{r_{BB} @ 25°C}\right]\frac{100\%}{180\%}.$$

To obtain r_{BB} for a given temperature $T_{A(2)}$, use the following formula:

$$r_{BB(2)} = [r_{BB} @ 25°C]\,[1 + (\alpha_{rBB}/100\%)(T_{A(2)}-25°C)].$$

*PARAMETER MEASUREMENT INFORMATION



η—Intrinsic Standoff Ratio—This parameter is defined by the equation: $V_P = \eta V_{BB} + V_F$, where V_F is about 0.67 volts at 25°C and decreases with temperature at about 2 millivolts/°C.

A circuit which may be used to measure η is shown in this figure. In this circuit, R1, C1, and the unijunction transistor form a relaxation oscillator. The remainder of the circuit serves as a peak-voltage detector with the diode D1 automatically subtracting the voltage V_F. To use the circuit, the calibrated potentiometer R3 is adjusted to null the meter M. The potentiometer is then read directly for η, e.g., 6 kΩ represents $\eta = 0.6$.

D1: Silicon diode with the following characteristics:
$V_F = 0.672$ V at $I_F = 0.5$ mA
$I_R \leq 2$ nA at $V_R = 20$ V.

FIGURE 1—η TEST CIRCUIT

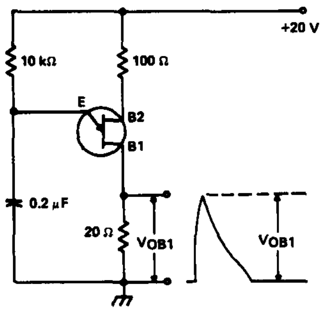


FIGURE 2—V_{OB1} TEST CIRCUIT

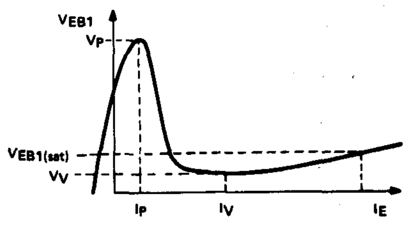


FIGURE 3—GENERAL STATIC EMITTER CHARACTERISTIC CURVE

*JEDEC registered data

TYPES 2N2802 THRU 2N2807
DUAL P-N-P SILICON TRANSISTORS

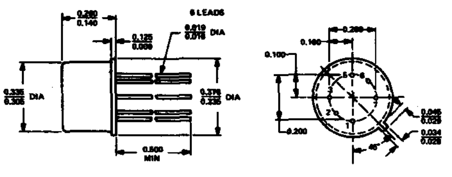
BULLETIN NO. DL-S 7211680, MARCH 1972

TWO P-N-P TRANSISTORS IN ONE PACKAGE
RECOMMENDED FOR

- **Differential Amplifiers**
- **Low-Noise, Low-Level Amplifiers**
- **Low-Level Flip-Flops**
- **Complementary Use With 2N2639 Through 2N2644 Dual N-P-N Transistors**

*meachanical data

ALL LEADS INSULATED FROM CASE



ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED

Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	−25 V	
Collector-Emitter Voltage (See Note 1)	−20 V	
Emitter-Base Voltage	−5 V	
Continuous Collector Current	−30 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.25 W	0.5 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.5 W	1 W
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 230°C →	

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. For each triode derate linearly to 175°C free-air temperature at the rate of 1.67 mW/°C.
3. For each triode derate linearly to 175°C case temperature at the rate of 3.33 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP P19

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INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	2N2802 2N2803 2N2804 MIN	MAX	2N2805 2N2806 2N2807 MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 5	−20		−20		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -25$ V, $I_E = 0$		−10		−10	nA
		$V_{CB} = -25$ V, $I_E = 0$, $T_A = 150°C$		−10		−10	µA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−10		−10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -10\ \mu A$	15		30		
		$V_{CE} = -5$ V, $I_C = -100\ \mu A$	20	120	40	120	
		$V_{CE} = -5$ V, $I_C = -100\ \mu A$, $T_A = -55°C$	10		20		
		$V_{CE} = -5$ V, $I_C = -1$ mA	20		40		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA, $I_C = -10$ mA	−0.7	−0.9	−0.7	−0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA		−0.5		−0.5	V
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = -5$ V, $I_E = 1$ mA, f = 1 kHz	25	32	25	32	Ω
h_{rb}	Small-Signal Common-Base Reverse Voltage Transfer Ratio			12×10^{-4}		12×10^{-4}	
h_{ob}	Small-Signal Common-Base Output Admittance			1		1	µmho
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz	20	200	40	200	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 20 MHz	3		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 1 MHz		8		8	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N2802 2N2805 MIN	MAX	2N2803 2N2806 MIN	MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current-Gain Balance Ratio	$V_{CE} = -5$ V, $I_C = -100\ \mu A$, See Note 6	0.9	1	0.8	1	
$\lvert V_{BE1} - V_{BE2} \rvert$	Base-Emitter-Voltage Differential	$V_{CE} = -5$ V, $I_C = -100\ \mu A$		5		10	mV
$\left\lvert \frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A} \right\rvert$	Base-Emitter-Voltage-Differential Temperature Gradient	$V_{CE} = -5$ V, $I_C = -100\ \mu A$, ΔT_A = [25°C−(−55°C)] and [125°C−25°C]		10		20	µV/°C

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	ALL TYPES MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{CB} = -5$ V, $I_E = 10\ \mu A$, $R_G = 10\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 7	4	dB

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. This parameter must be measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%.
6. The lower of the two h_{FE} readings is taken as h_{FE1}.
7. Average Noise Figure is measured in an amplifier with low-frequency response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data

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TEXAS INSTRUMENTS
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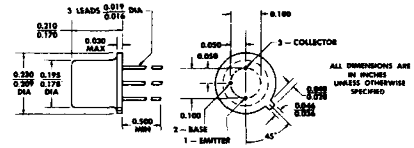
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 645051, AUGUST 1964

DESIGNED FOR HIGH-SPEED SWITCHING APPLICATIONS

- **Guaranteed $V_{CE(sat)}$ ... 0.5 v Max at 100 ma**
- **High f_T ... 400 Mc Min**

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE.

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−12 v
Collector-Emitter Voltage (See Note 1)	−12 v
Emitter-Base Voltage	−4 v
Collector Current	−200 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.36 w
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 w
Operating Collector Junction Temperature	200°C
Storage Temperature Range	−65°C to +200°C
Lead Temperature 1/16 Inch from Case For 60 Seconds	300°C

4

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2894 MIN	2N2894 MAX	2N3012 MIN	2N3012 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu a$, $I_E = 0$	−12		−12		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ ma, $I_B = 0$, See Note 4	−12		−12		v
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ \mu a$, $V_{BE} = 0$	−12		−12		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu a$, $I_C = 0$	−4		−4		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = -6$ v, $I_E = 0$, $T_A = 125°C$		−10			μa
I_{CES}	Collector Cutoff Current	$V_{CE} = -6$ v, $V_{BE} = 0$		−80		−80	na
		$V_{CE} = -6$ v, $V_{BE} = 0$, $T_A = 85°C$				−5	μa
I_B	Base Current	$V_{CE} = -6$ v, $V_{BE} = 0$		80		30	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.3$ v, $I_C = -10$ ma, See Note 4	30		25		
		$V_{CE} = -0.5$ v, $I_C = -30$ ma, See Note 4	40	150	30	120	
		$V_{CE} = -1$ v, $I_C = -100$ ma, See Note 4	25		20		
		$V_{CE} = -0.5$ v, $I_C = -30$ ma, $T_A = -55°C$, See Note 4	17				
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ ma, $I_C = -10$ ma, See Note 4		−0.15		−0.15	v
		$I_B = -3$ ma, $I_C = -30$ ma, See Note 4		−0.20		−0.20	v
		$I_B = -10$ ma, $I_C = -100$ ma, See Note 4		−0.50		−0.50	v
		$I_B = -3$ ma, $I_C = -30$ ma, $T_A = 85°C$, See Note 4				−0.40	v
V_{BE}	Base-Emitter Voltage	$I_B = -1$ ma, $I_C = -10$ ma, See Note 4	−0.78	−0.98	−0.78	−0.98	v
		$I_B = -3$ ma, $I_C = -30$ ma, See Note 4	−0.85	−1.2	−0.85	−1.2	v
		$I_B = -10$ ma, $I_C = -100$ ma, See Note 4		−1.7		−1.7	v

NOTES: 1. This value applies between 10 μa and 10 ma collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.06 mw/C°.
3. Derate linearly to 200°C case temperature at the rate of 6.85 mw/C°.
4. This parameter must be measured using pulse techniques. PW = 300 μsec, Duty Cycle = 1%.

*Indicates JEDEC registered data.

USES CHIP P11

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2894 MIN	2N2894 MAX	2N3012 MIN	2N3012 MAX	UNIT
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -30$ ma, f = 100 Mc	4		4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ v, $I_E = 0$, f = 140 kc		6		6	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ v, $I_C = 0$, f = 140 kc		6		6	pf

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N2894 MAX	2N3012 MAX	UNIT
t_{on}	Turn-On Time	$I_C = -30$ ma, $I_{B(1)} = -1.5$ ma, $V_{BE(off)} = 3$ v, $R_L = 62\ \Omega$, See Figure 1	60	60	nsec
t_{off}	Turn-Off Time	$I_C = -30$ ma, $I_{B(1)} = -1.5$ ma, $I_{B(2)} = 1.5$ ma, $R_L = 62\ \Omega$, See Figure 1	90	75	nsec

4

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION

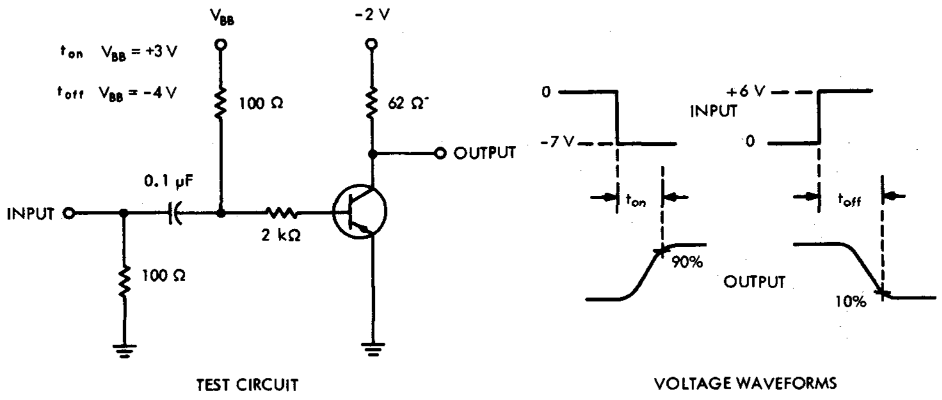


FIGURE 1 — TURN-ON AND TURN-OFF TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 1$ nsec, PW > 200 nsec.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec, $R_{in} \geq 100\ k\Omega$.

*Indicates JEDEC registered data.

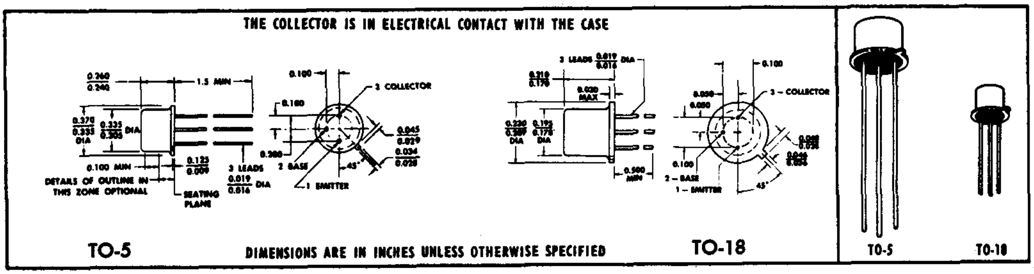
BULLETIN NO. DL-S 7311915, MARCH 1973

DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- High Breakdown Voltage Combined with Very Low Saturation Voltage
- h_{FE} Guaranteed from 100 μA to 500 mA
- 2N2904, 2N2906 for Complementary Use with 2N2218, 2N2221
- 2N2905, 2N2907 for Complementary Use with 2N2219, 2N2222

*mechanical data

Device types 2N2904, 2N2904A, 2N2905, and 2N2905A are in JEDEC TO-5 packages.
Device types 2N2906, 2N2906A, 2N2907, and 2N2907A are in JEDEC TO-18 packages.



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2904 2N2905	2N2904A 2N2905A	2N2906 2N2907	2N2906A 2N2907A	UNIT
Collector-Base Voltage	−60	−60	−60	−60	V
Collector-Emitter Voltage (See Note 1)	−40	−60	−40	−60	V
Emitter-Base Voltage	−5	−5	−5	−5	V
Continuous Collector Current	−0.6	−0.6	−0.6	−0.6	A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 2 and 3)	0.6	0.6	0.4	0.4	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Notes 4 and 5)	3	3	1.8	1.8	W
Storage Temperature Range	−65 to 200				°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230				°C

NOTES: 1. These values apply between 0 and 100 mA collector current when the base-emitter diode is open-circuited.
2. Derate 2N2904, 2N2904A, 2N2905, and 2N2905A linearly to 200°C free-air temperature at the rate of 3.43 mW/°C.
3. Derate 2N2906, 2N2906A, 2N2907, and 2N2907A linearly to 200°C free-air temperature at the rate of 2.28 mW/°C.
4. Derate 2N2904, 2N2904A, 2N2905, and 2N2905A linearly to 200°C case temperature at the rate of 17.3 mW/°C.
5. Derate 2N2906, 2N2906A, 2N2907, and 2N2907A linearly to 200°C case temperature at the rate of 10.3 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP P20

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	TO-5→ 2N2904 MIN	TO-18→ 2N2906 MAX	2N2904A 2N2906A MIN	MAX	2N2905 2N2907 MIN	MAX	2N2905A 2N2907A MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−60		−60		−60		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 6	−40		−60		−40		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−5		−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V, $I_E = 0$		−20		−10		−20		−10	nA
		$V_{CB} = -50$ V, $I_E = 0$, $T_A = 150°C$		−20		−10		−20		−10	μA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 0.5$ V		−50		−50		−50		−50	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 0.5$ V		50		50		50		50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -100\ \mu A$	20		40		35		75		
		$V_{CE} = -10$ V, $I_C = -1$ mA	25		40		50		100		
		$V_{CE} = -10$ V, $I_C = -10$ mA	35		40		75		100		
		$V_{CE} = -10$ V, $I_C = -150$ mA, See Note 6	40	120	40	120	100	300	100	300	
		$V_{CE} = -10$ V, $I_C = -500$ mA, See Note 6	20		40		30		50		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 6		−1.3		−1.3		−1.3		−1.3	V
		$I_B = -50$ mA, $I_C = -500$ mA, See Note 6		−2.6		−2.6		−2.6		−2.6	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 6		−0.4		−0.4		−0.4		−0.4	V
		$I_B = -50$ mA, $I_C = -500$ mA, See Note 6		−1.6		−1.6		−1.6		−1.6	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -20$ V, $I_C = -50$ mA, f = 100 MHz	2		2		2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 100 kHz		8		8		8		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -2$ V, $I_C = 0$, f = 100 kHz		30		30		30		30	pF

NOTE 6: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

*JEDEC registered data

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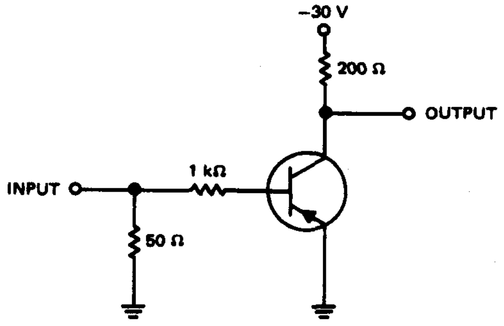
***switching characteristics at 25°C free-air temperature**

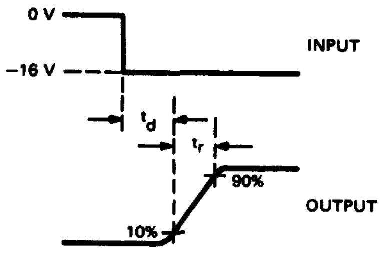
PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$V_{CC} = -30$ V, $I_C = -150$ mA, $I_{B(1)} = -15$ mA, $V_{BE(off)} = 0$, See Figure 1	10	ns
t_r	Rise Time		40	ns
t_{on}	Turn-On Time		45	ns
t_s	Storage Time	$V_{CC} = -6$ V, $I_C = -150$ mA, $I_{B(1)} = -13$ mA, $I_{B(2)} = 17$ mA, See Figure 2	80	ns
t_f	Fall Time		30	ns
t_{off}	Turn-Off Time		100	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION

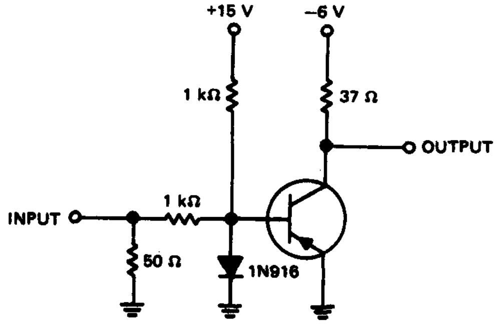


TEST CIRCUIT

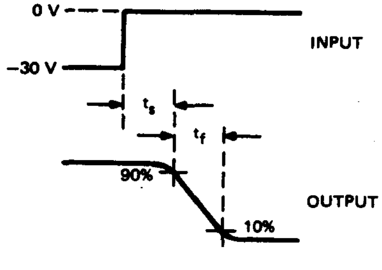


(See Notes A and B)
VOLTAGE WAVEFORMS

FIGURE 1



TEST CIRCUIT



(See Notes A and B)
VOLTAGE WAVEFORMS

FIGURE 2

NOTES: A. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 2$ ns, $t_f \leq 2$ ns, $t_w = 200$ ns, PRR = 150 Hz.
B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} = 10$ MΩ.

*JEDEC registered data

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TYPES D2T2904, D2T2904A, D2T2905, D2T2905A
DUAL P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 7311971, MARCH 1973

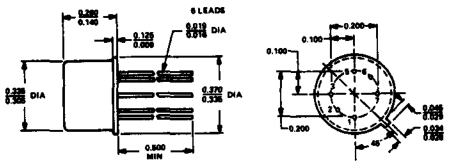
TWO GENERAL PURPOSE TRANSISTORS IN ONE PACKAGE

- Each Triode Electrically Similar to 2N2904, 2N2904A, 2N2905, 2N2905A Transistors
- For Complementary Use with D2T2218, D2T2218A, D2T2219, D2T2219A Dual N-P-N Transistors

4

mechanical data

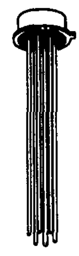
ALL LEADS INSULATED FROM CASE



ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED

Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		D2T2904 / D2T2905	D2T2904A / D2T2905A	UNIT
Collector-Base Voltage		−60	−60	V
Collector-Emitter Voltage (See Note 1)		−40	−60	V
Emitter-Base Voltage		−5	−5	V
Continuous Collector Current		−600		mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	Each Triode	400		mW
	Total Device	600		mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3	Each Triode	1		W
	Total Device	2		W
Storage Temperature Range		−65 to 200		°C
Lead Temperature 1/16 Inch from Case for 10 Seconds		300		°C

NOTES:
1. These values apply between 0 and 100 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rates of 2.28 mW/°C for each triode and 3.43 mW/°C for the total device.
3. Derate linearly to 200°C case temperature at the rates of 5.7 mW/°C for each triode and 11.4 mW/°C for the total device.

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	D2T2904		D2T2904A		D2T2905		D2T2905A		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\,\mu A$, $I_E = 0$	−60		−60		−60		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10\,mA$, $I_B = 0$, See Note 4	−40		−60		−40		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\,\mu A$, $I_C = 0$	−5		−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50\,V$, $I_E = 0$		−20		−10		−20		−10	nA
		$V_{CB} = -50\,V$, $I_E = 0$, $T_A = 150°C$		−20		−10		−20		−10	µA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30\,V$, $V_{BE} = 0.5\,V$		−50		−50		−50		−50	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30\,V$, $V_{BE} = 0.5\,V$		50		50		50		50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10\,V$, $I_C = -100\,\mu A$	20		40		35		75		
		$V_{CE} = -10\,V$, $I_C = -1\,mA$	25		40		50		100		
		$V_{CE} = -10\,V$, $I_C = -10\,mA$	35		40		75		100		
		$V_{CE} = -10\,V$, $I_C = -150\,mA$, See Note 4	40	120	40	120	100	300	100	300	
		$V_{CE} = -10\,V$, $I_C = -500\,mA$, See Note 4	20		40		30		50		
V_{BE}	Base-Emitter Voltage	$I_B = -15\,mA$, $I_C = -150\,mA$, See Note 4		−1.3		−1.3		−1.3		−1.3	V
		$I_B = -50\,mA$, $I_C = -500\,mA$, See Note 4		−2.6		−2.6		−2.6		−2.6	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15\,mA$, $I_C = -150\,mA$, See Note 4		−0.4		−0.4		−0.4		−0.4	V
		$I_B = -50\,mA$, $I_C = -500\,mA$, See Note 4		−1.6		−1.6		−1.6		−1.6	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10\,V$, $I_C = -30\,mA$, $f = 100\,MHz$	2		2		2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10\,V$, $I_E = 0$, $f = 1\,MHz$		8		8		8		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -2\,V$, $I_C = 0$, $f = 1\,MHz$		30		30		30		30	pF

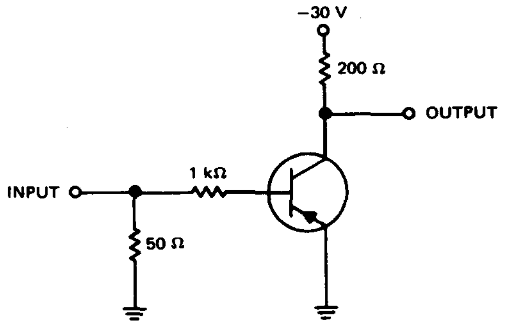
NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\,\mu s$, duty cycle ≤ 2%.

switching characteristics at 25°C free-air temperature

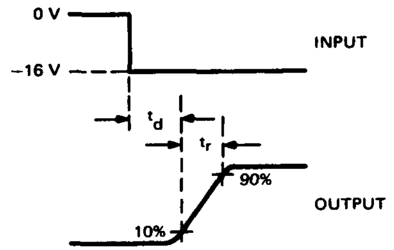
PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$V_{CC} = -30$ V, $I_C = -150$ mA, $I_{B(1)} = -15$ mA, $V_{BE(off)} = 0$, See Figure 1	10	ns
t_r	Rise Time		40	ns
t_{on}	Turn-On Time		45	ns
t_s	Storage Time	$V_{CC} = -30$ V, $I_C = -150$ mA, $I_{B(1)} = -13$ mA, $I_{B(2)} = 17$ mA, See Figure 2	80	ns
t_f	Fall Time		30	ns
t_{off}	Turn-Off Time		100	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

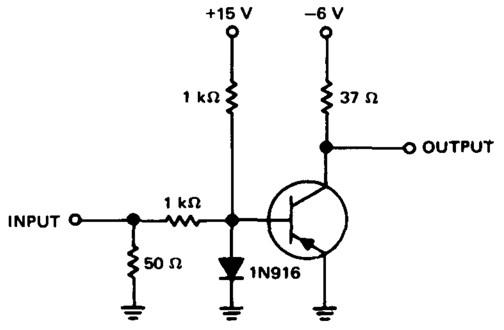


TEST CIRCUIT

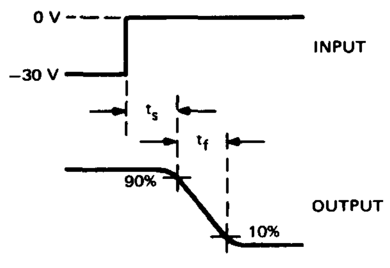


(See Notes A and B)
VOLTAGE WAVEFORMS

FIGURE 1



TEST CIRCUIT



(See Notes A and B)
VOLTAGE WAVEFORMS

FIGURE 2

NOTES: A. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 2$ ns, $t_f \leq 2$ ns, $t_w = 200$ ns, PRR = 150 Hz.
B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} = 10\ M\Omega$.

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PRINTED IN U.S.A.

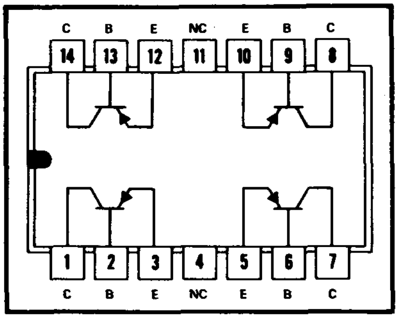
QUAD P-N-P SILICON TRANSISTOR

BULLETIN NO. DL-S 7311702, APRIL 1972—REVISED MARCH 1973

DESIGNED FOR MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- High Breakdown Voltage Combined with Very Low Saturation Voltage
- h_{FE} . . . Guaranteed from 100 μA to 500 mA
- High f_T . . . 200 MHz Min at 20 V, 20 mA

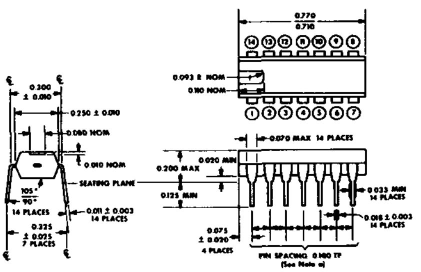
(TOP VIEW)



NC—No internal connection

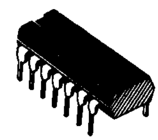
mechanical data

14-PIN PLASTIC DUAL-IN-LINE PACKAGE



NOTES:
a. The true-position pin spacing is 0.100 between centerlines. Each pin centerline is located within 0.010 of its true longitudinal position relative to pins 4 and 11.
b. All dimensions are in inches unless otherwise noted.

Falls Within JEDEC TO-116 and MO-001AA Dimensions



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	−60 V	
Collector-Emitter Voltage (See Note 1)	−40 V	
Emitter-Base Voltage	−5 V	
Continuous Collector Current	−0.6 A	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.5 W†	1.5 W†
Storage Temperature Range	−55°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←260°C→	

NOTES: 1. This value applies between 0 and 100 mA collector current when the emitter-base diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rates of 4 mW/°C for each triode and 12 mW/°C for the total device.

†Previous editions of this data sheet showed higher power dissipation ratings which have been found to be in error. The new ratings correct these errors and do not represent product changes.

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA,	$I_B = 0$,	See Note 3	−40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V,	$I_E = 0$			−20	nA
		$V_{CB} = -50$ V,	$I_E = 0$,	$T_A = 125°C$		−10	μA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30$ V,	$V_{BE} = 0.5$ V			−50	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30$ V,	$V_{BE} = 0.5$ V			50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -100\ \mu A$		35		
		$V_{CE} = -10$ V,	$I_C = -1$ mA		50		
		$V_{CE} = -10$ V,	$I_C = -10$ mA	See Note 3	75		
		$V_{CE} = -10$ V,	$I_C = -150$ mA		100	300	
		$V_{CE} = -10$ V,	$I_C = -500$ mA		30		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA,	$I_C = -150$ mA	See Note 3		−1.3	V
		$I_B = -50$ mA,	$I_C = -500$ mA			−2.6	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA,	$I_C = -150$ mA	See Note 3		−0.4	V
		$I_B = -50$ mA,	$I_C = -500$ mA			−1.6	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -30$ mA,	f = 100 MHz	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V,	$I_E = 0$,	f = 1 MHz		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -2$ V,	$I_C = 0$,	f = 1 MHz		30	pF

NOTE 3: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$I_C = -150$ mA, $I_{B(1)} = -15$ mA, $V_{BE(off)} = 0$, $R_L = 200\ \Omega$, See Figure 1	10	ns
t_r	Rise Time		40	ns
t_{on}	Turn-On Time		45	ns
t_s	Storage Time	$I_C = -150$ mA, $I_{B(1)} = -13$ mA, $I_{B(2)} = 17$ mA, $R_L = 37\ \Omega$, See Figure 2	80	ns
t_f	Fall Time		30	ns
t_{off}	Turn-Off Time		100	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

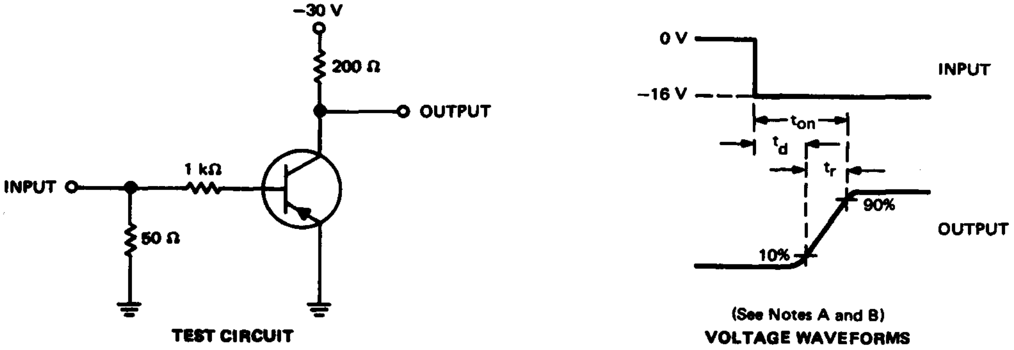

FIGURE 1—TURN-ON TIME

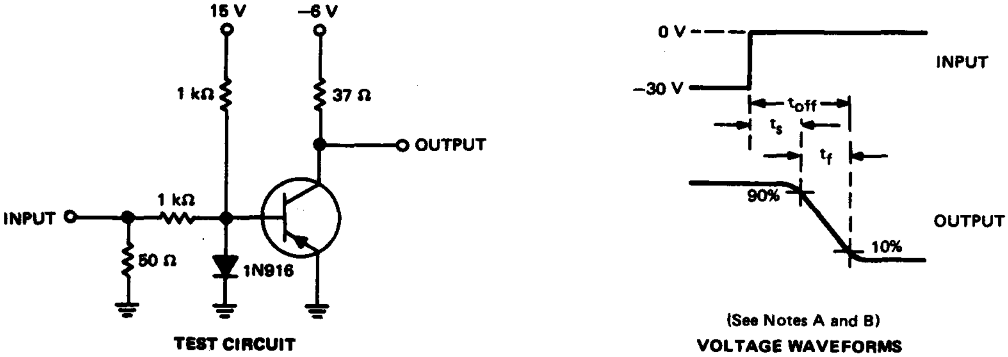

FIGURE 2—TURN-OFF TIME

NOTES: A. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, t_r < 2 ns, t_f < 2 ns, t_w = 200 ns, PRR = 150 pps.

B. Waveforms are monitored on an oscilloscope with the following characteristics: t_r < 5 ns, R_{in} = MΩ, C_{in} < 12 pF.

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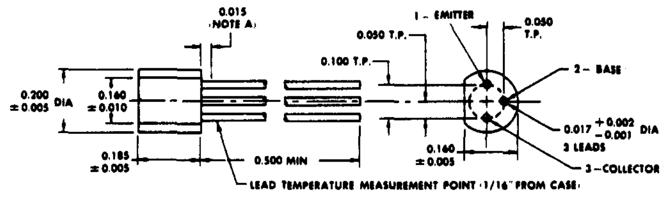
BULLETIN NO. DL-S 7311318, MARCH 1970—REVISED MARCH 1973

SILECT† TRANSISTORS‡
DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- A5T2907, A5T3644, and A5T3645 Electrically Similar to 2N2907, 2N3644, and 2N3645
- TIS112 Processing Includes Operational Aging at 300 mW for 24 Hours

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T2907 TIS112	A5T3644	A5T3645
Collector-Base Voltage	−60 V	−45 V	−60 V
Collector-Emitter Voltage (See Note 1)	−40 V	−45 V	−60 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	←—	−600 mA	—→
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←—	625 mW	—→
Continuous Device Dissipation at (or below) 25°C Case and Lead Temperature (See Note 3)	←—	1.6 W	—→
Storage Temperature Range	←—	−65°C to 150°C	—→
Lead Temperature 1/16 Inch from Case for 10 Seconds	←—	260°C	—→

NOTES: 1. This value applies between 0 and 600 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			A5T2907 TIS112 MIN	A5T2907 TIS112 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA,	$I_B = 0$,	See Note 4	−40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V,	$I_E = 0$			−20	nA
		$V_{CB} = -50$ V,	$I_E = 0$,	$T_A = 125°C$		−10	μA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30$ V,	$V_{BE} = 0.5$ V			−50	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30$ V,	$V_{BE} = 0.5$ V			50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -100\ \mu A$		35		
		$V_{CE} = -10$ V,	$I_C = -1$ mA		50		
		$V_{CE} = -10$ V,	$I_C = -10$ mA	See Note 4	75		
		$V_{CE} = -10$ V,	$I_C = -150$ mA		100	300	
		$V_{CE} = -10$ V,	$I_C = -500$ mA		30		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA,	$I_C = -150$ mA	See Note 4		−1.3	V
		$I_B = -50$ mA,	$I_C = -500$ mA			−2.6	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA,	$I_C = -150$ mA	See Note 4		−0.4	V
		$I_B = -50$ mA,	$I_C = -500$ mA			−1.6	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -30$ mA,	f = 100 MHz	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V,	$I_E = 0$,	f = 1 MHz		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -2$ V,	$I_C = 0$,	f = 1 MHz		30	pF

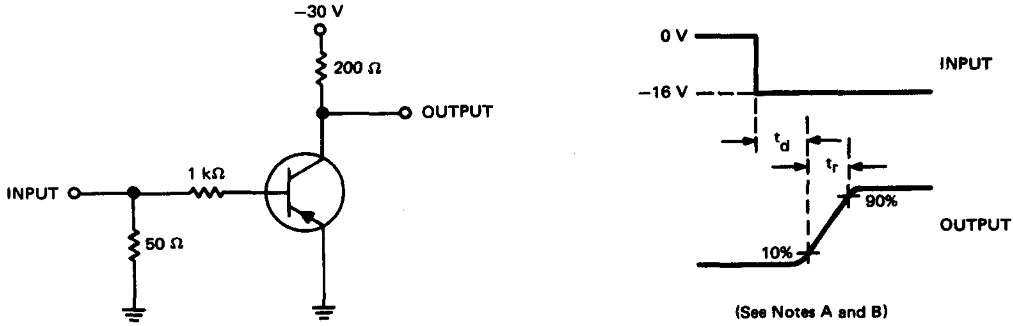
NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	A5T2907 MAX	TIS112 MAX	UNIT
t_d	Delay Time	$I_C = -150$ mA, $I_{B(1)} = -15$ mA, $V_{BE(off)} = 0$, $R_L = 200\ \Omega$, See Figure 1	10	10	ns
t_r	Rise Time		40	40	ns
t_{on}	Turn-On Time		45	45	ns
t_s	Storage Time	$I_C = -150$ mA, $I_{B(1)} = -13$ mA, $I_{B(2)} = 17$ mA, $R_L = 37\ \Omega$, See Figure 2	80	80	ns
t_f	Fall Time		30	70	ns
t_{off}	Turn-Off Time		100	140	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

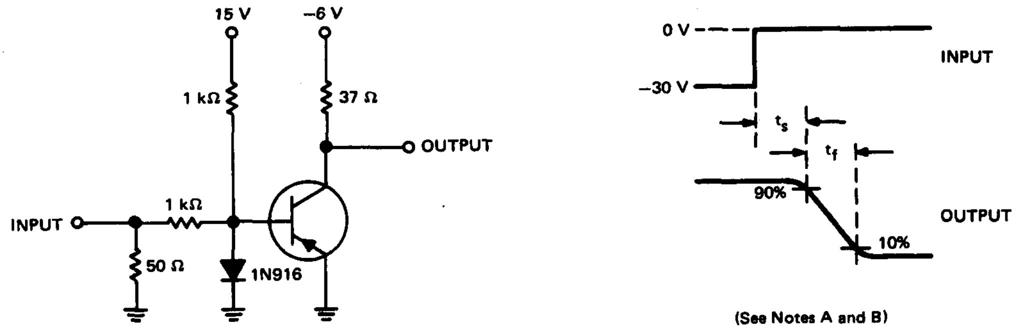
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 1—A5T2907 and TIS112



TEST CIRCUIT

VOLTAGE WAVEFORMS

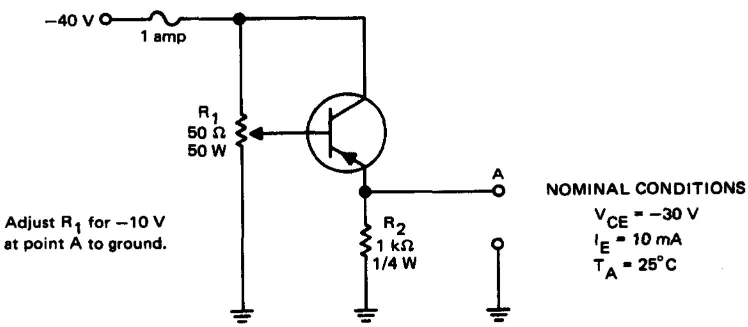
FIGURE 2—A5T2907 and TIS112

NOTES: A. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 2$ ns, $t_f \leq 2$ ns, $t_w = 200$ ns, PRR = 150 pps.

B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} = 10\ M\Omega$, $C_{in} \leq 12$ pF.

TIS112 OPERATIONAL AGING

All TIS112 transistors are aged for a minimum of 24 hours in the circuit shown below. Total device dissipation is approximately 300 mW. All static characteristics are tested prior to and after aging. Dynamic characteristics are tested as necessary to guarantee the specified limits after aging.



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BULLETIN NO. DL-S 6911165, MARCH 1969

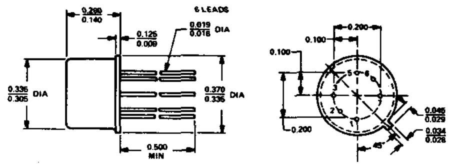
A BROAD FAMILY OF DUAL TRANSISTORS RECOMMENDED FOR

- **Differential Amplifiers**
- **High-Gain, Low-Noise, Audio Amplifiers**
- **Transducer Signal-Conditioner Amplifiers**
- **Low-Level Flip-Flops**

4

*mechanical data

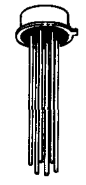
ALL LEADS INSULATED FROM CASE



Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

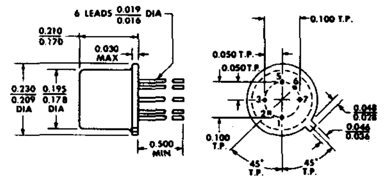
1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



OUTLINE A — TYPES 2N2913 THRU 2N2920, 2N2915A, 2N2916A, 2N2919A, 2N2920A

ALL LEADS INSULATED FROM CASE



FALLS WITHIN TO-71 DIMENSIONS

1. EMITTER 1
2. BASE 1
3. COLLECTOR 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

OUTLINE B — TYPES 2N2972 THRU 2N2979

quick-selection guide (for details see characteristics on the following pages)

TYPE		MIN $V_{(BR)CEO}$		MIN-MAX h_{FE} (I_C = 10 μA)		MIN $\frac{h_{FE1}}{h_{FE2}}$		$\lvert V_{BE1}-V_{BE2}\rvert$ (I_C = 100 μA)			$\lvert\Delta(V_{BE1}-V_{BE2})/\Delta T_A\rvert$ ($T_{A(1)}$ = 25°C, $T_{A(2)}$ = 125°C)		
OUTLINE A	OUTLINE B	60 V	45 V	60–240	150–600	0.9	0.8	1.5 mV	3 mV	5 mV	0.5 mV	1 mV	2 mV
2N2913	2N2972		•	•									
2N2914	2N2973		•		•								
2N2915	2N2974		•	•		•			•			•	
2N2915A			•	•		•		•			•		
2N2916	2N2975		•		•	•			•			•	
2N2916A			•		•	•		•			•		
2N2917	2N2976		•	•			•			•			•
2N2918	2N2977		•		•		•			•			•
2N2919	2N2978	•		•		•			•			•	
2N2919A		•		•		•		•			•		
2N2920	2N2979	•			•	•			•			•	
2N2920A		•			•	•		•			•		

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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TYPES 2N2913 THRU 2N2920, 2N2915A, 2N2916A, 2N2919A, 2N2920A, 2N2972 THRU 2N2979
DUAL N-P-N SILICON TRANSISTORS

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2913 thru 2N2918, 2N2915A, 2N2916A		2N2972 thru 2N2977		2N2919, 2N2919A, 2N2920, 2N2920A		2N2978, 2N2979		UNIT
	EACH TRIODE	TOTAL DEVICE	EACH TRIODE	TOTAL DEVICE	EACH TRIODE	TOTAL DEVICE	EACH TRIODE	TOTAL DEVICE	
Collector-Base Voltage	45		45		60		60		V
Collector-Emitter Voltage (See Note 1)	45		45		60		60		V
Emitter-Base Voltage	6		6		6		6		V
Collector-1 — Collector-2 Voltage		(±200)†				(±200)†			V
Continuous Collector Current	30		30		30		30		mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.3	0.5	0.25	0.3	0.3	0.5	0.25	0.3	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.75	1.5	0.5	0.75	0.75	1.5	0.5	0.75	W
Storage Temperature Range	-65 to 200		-65 to 200		-65 to 200		-65 to 200		°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300		300		300		300		°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	2N2913, 2N2915, 2N2915A, 2N2917, 2N2972, 2N2974, 2N2976		2N2914, 2N2916, 2N2916A, 2N2918, 2N2973, 2N2975, 2N2977		2N2919, 2N2919A, 2N2978		2N2920, 2N2920A, 2N2979		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	45		45		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 5	45		45		60		60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	6		6		6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ V, $I_E = 0$		10		10		2		2	nA
		$V_{CB} = 45$ V, $I_E = 0$, $T_A = 150°C$		10		10		10		10	μA
I_{CEO}	Collector Cutoff Current	$V_{CE} = 5$ V, $I_B = 0$		2		2		2		2	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		2		2		2		2	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 10\ \mu A$	60	240	150	600	60	240	150	600	
		$V_{CE} = 5$ V, $I_C = 100\ \mu A$	100		225		100		225		
		$V_{CE} = 5$ V, $I_C = 1$ mA	150		300		150		300		
		$V_{CE} = 5$ V, $I_C = 10\ \mu A$, $T_A = -55°C$	15		30 (40)‡		15		40		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 100\ \mu A$		0.7		0.7		0.7		0.7	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 100\ \mu A$, $I_C = 1$ mA		0.35		0.35		0.35		0.35	V

NOTES:
1. These values apply when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the following rates: 1.72 mW/°C for each triode and 2.86 mW/°C for total device (2N2913 thru 2N2920, 2N2915A, 2N2916A, 2N2919A, 2N2920A); 1.43 mW/°C for each triode and 1.72 mW/°C for total device (2N2972 thru 2N2979).
3. Derate linearly to 200°C case temperature at the following rates: 4.3 mW/°C for each triode and 8.6 mW/°C for total device (2N2913 thru 2N2920, 2N2915A, 2N2916A, 2N2919A, 2N2920A); 2.96 mW/°C for each triode and 4.3 mW/°C for total device (2N2972 thru 2N2979).
4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 1%.

*JEDEC registered data

†These values apply to types 2N2915A, 2N2916A, 2N2919A, and 2N2920A only.

‡This value applies to type 2N2916A only.

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*electrical characteristics at 25°C free-air temperature (continued)

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	2N2913 thru 2N2920 — 2N2972 thru 2N2979 MIN	MAX	2N2915A 2N2916A 2N2919A 2N2920A MIN	MAX	UNIT
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz	25	32	25	32	Ω
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz		1		1	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 0.5$ mA, $f = 20$ MHz	3		3	8	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_E = 0$, $f = 140$ kHz to 1 MHz		6		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 140$ kHz to 1 MHz				10	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N2915 2N2916 2N2919 2N2920 2N2974 2N2975 2N2978 2N2979 MIN	MAX	2N2915A 2N2916A 2N2919A 2N2920A MIN	MAX	2N2917 2N2918 2N2976 2N2977 MIN	MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current-Gain Balance Ratio	$V_{CE} = 5$ V, $I_C = 100$ μA, See Note 6	0.9	1	0.9	1	0.8	1	
		$V_{CE} = 5$ V, $I_C = 100$ μA to 1 mA, $T_A = -55°C$ to 125°C, See Note 6			0.85	1			
$\|V_{BE1}-V_{BE2}\|$	Base-Emitter-Voltage Differential	$V_{CE} = 5$ V, $I_C = 100$ μA		3		1.5		5	mV
		$V_{CE} = 5$ V, $I_C = 10$ μA to 1 mA		5		2		10	mV
$\|\Delta(V_{BE1}-V_{BE2})_{\Delta T_A}\|$	Base-Emitter-Voltage-Differential Change With Temperature	$V_{CE} = 5$ V, $I_C = 100$ μA, $T_{A(1)} = 25°C$, $T_{A(2)} = -55°C$		0.8		0.4		1.6	mV
		$V_{CE} = 5$ V, $I_C = 100$ μA, $T_{A(1)} = 25°C$, $T_{A(2)} = 125°C$		1		0.5		2	mV

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	2N2913 2N2915 2N2915A 2N2917 2N2919 2N2919A 2N2972 2N2974 2N2976 2N2978 MAX	2N2914 2N2916 2N2916A 2N2918 2N2920 2N2920A 2N2973 2N2975 2N2977 2N2979 MAX	UNIT
$\bar{F}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 10$ μA, $R_G = 10$ kΩ, $f = 1$ kHz, Noise bandwidth = 200 Hz	4	3	dB
		$V_{CE} = 5$ V, $I_C = 10$ μA, $R_G = 10$ kΩ, Noise bandwidth = 15.7 kHz, See Note 7	4	3	dB

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.

6. The lower of the two h_{FE} readings is taken as h_{FE1}.

7. This parameter is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data

TYPICAL MATCHING CHARACTERISTICS†

FOR TYPES 2N2915, 2N2915A, 2N2916, 2N2916A, 2N2919, 2N2919A, 2N2920, 2N2920A, 2N2974, 2N2975, 2N2978, 2N2979

STATIC FORWARD-CURRENT-GAIN BALANCE RATIO
vs
COLLECTOR CURRENT

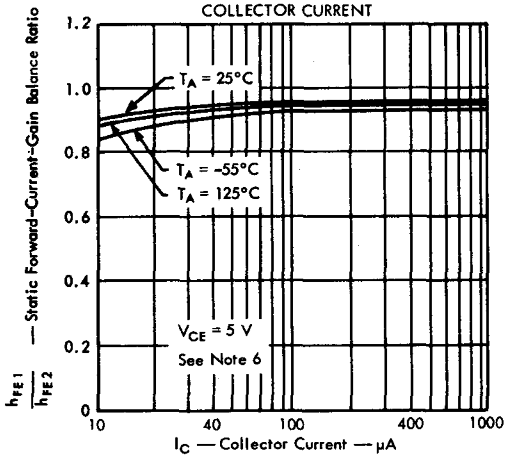

FIGURE 1

BASE-EMITTER-VOLTAGE DIFFERENTIAL
vs
COLLECTOR CURRENT

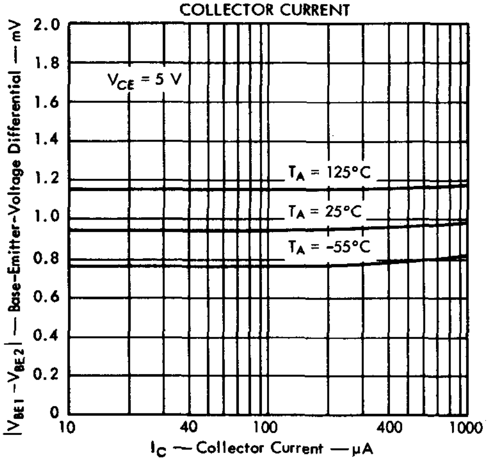

FIGURE 2

BASE-EMITTER-VOLTAGE DIFFERENTIAL
vs
FREE-AIR TEMPERATURE

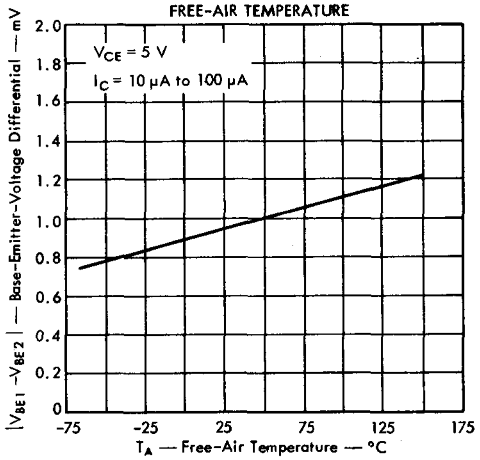

FIGURE 3

NOTE 6: The lower of the two h_{FE} readings is taken as h_{FE1}.

†These curves represent the average behavior of groups of dual transistors. Unlike normal single-triode characteristics, matching characteristics of dual transistors may differ considerably in behavior from the typical. For example, a minority of devices have been observed with smaller V_{BE} mismatch at 150°C than at -65°C, as opposed to the average behavior as shown in figures 2 and 3.

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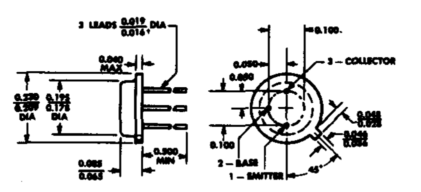
TYPES 2N2944, 2N2945, 2N2946, 2N2944A, 2N2945A, 2N2946A
P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 679561, MARCH 1967

FOR LOW-LEVEL, HIGH-SPEED CHOPPER APPLICATIONS IN INVERTED CONNECTION

- **Low Guaranteed Offset Voltage**
- **High Emitter-Base Breakdown Voltage**
- **Greatly Improved $h_{FE(inv)}$ . . . 50 Min at $I_B = 200\ \mu A$ (2N2944A)**
- **Extremely Low $r_{ec(on)}$ . . . 4 Ω Max (2N2944A)**
- **Recommended For Complementary Use with 2N2432A**

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-46 DIMENSIONS AND NOTES ARE APPLICABLE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

†TI guaranteed minimum. The JEDEC registered minimum lead diameter for the TO-46 is 0.012.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2944 2N2944A	2N2945 2N2945A	2N2946 2N2946A
Collector-Base Voltage, V_{CB}	−15 V	−25 V	−40 V
Emitter-Collector Voltage, V_{ECO} (See Note 1)	−10 V	−20 V	−35 V
Emitter-Base Voltage, V_{EB}	−15 V	−25 V	−40 V
Continuous Collector Current	←	−100 mA	→
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←	0.4 W	→
Storage Temperature Range	←	−65°C to 200°C	→
Lead Temperature 1/16 Inch from Case for 10 Seconds	←	240°C	→

NOTES: 1. This value applies when the collector-base diode is open-circuited.

2. Derate linearly to 200°C free-air temperature at the rate of 2.3 mW/deg.

*Indicates JEDEC registered data

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TYPES 2N2944, 2N2945, 2N2946, 2N2944A, 2N2945A, 2N2946A
P-N-P SILICON TRANSISTORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2944 MIN	2N2944 MAX	2N2945 MIN	2N2945 MAX	2N2946 MIN	2N2946 MAX	UNIT
I_{CBO}	Collector Cutoff Current	V_{CB} = Rated V_{CB}, $I_E = 0$		−0.1*		−0.2*		−0.5*	nA
		V_{CB} = Rated V_{CB}, $I_E = 0$, $T_A = 100°C$		−10		−20		−25	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = Rated V_{EB}, $I_C = 0$		−0.1*		−0.2*		−0.5*	nA
		V_{EB} = Rated V_{EB}, $I_C = 0$, $T_A = 100°C$		−10		−15		−20	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.5$ V, $I_C = -1$ mA	80*		40*		30*		
$h_{FE(inv)}$	Static Forward Current Transfer Ratio (Inverted Connection)	$V_{EC} = -0.5$ V, $I_B = -200$ µA	6		4		3		
$V_{EC(ofs)}$	Emitter-Collector Offset Voltage	$I_B = -200$ µA, $I_E = 0$, See Figure 1		−0.3		−0.5		−0.8	mV
		$I_B = -1$ mA, $I_E = 0$, See Figure 1		−0.6*		−1*		−2*	mV
		$I_B = -2$ mA, $I_E = 0$, See Figure 1		−1		−1.6		−2.5	mV
$r_{ec(on)}$	Small-Signal Emitter-Collector On-State Resistance	$I_B = -1$ mA, $I_E = 0$, $I_e = 100$ µA, $f = 1$ kHz, See Figure 2		20*		35*		45*	Ω
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -6$ V, $I_C = -1$ mA, $f = 1$ MHz	10*		5*		3*		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -6$ V, $I_E = 0$, $f = 500$ kHz		10*		10*		10*	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -6$ V, $I_C = 0$, $f = 500$ kHz		6*		6*		6*	pF

4

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2944A MIN	2N2944A MAX	2N2945A MIN	2N2945A MAX	2N2946A MIN	2N2946A MAX	UNIT
I_{CBO}	Collector Cutoff Current	V_{CB} = Rated V_{CB}, $I_E = 0$		−0.1*		−0.2*		−0.5*	nA
		V_{CB} = Rated V_{CB}, $I_E = 0$, $T_A = 100°C$		−10*		−20*		−25*	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = Rated V_{EB}, $I_C = 0$		−0.1*		−0.2*		−0.5*	nA
		V_{EB} = Rated V_{EB}, $I_C = 0$, $T_A = 100°C$		−10*		−15*		−20*	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.5$ V, $I_C = -1$ mA	100*		70*		50*		
$h_{FE(inv)}$	Static Forward Current Transfer Ratio (Inverted Connection)	$V_{EC} = -0.5$ V, $I_B = -200$ µA	50*		30*		20*		
$V_{EC(ofs)}$	Emitter-Collector Offset Voltage	$I_B = -200$ µA, $I_E = 0$, See Figure 1		−0.3*		−0.5*		−0.8*	mV
		$I_B = -1$ mA, $I_E = 0$, See Figure 1		−0.6*		−1*		−2*	mV
		$I_B = -2$ mA, $I_E = 0$, See Figure 1		−1*		−1.6*		−2.5*	mV
$r_{ec(on)}$	Small-Signal Emitter-Collector On-State Resistance	$I_B = -1$ mA, $I_E = 0$, $I_e = 100$ µA, $f = 1$ kHz, See Figure 2		4*		6*		8*	Ω
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -6$ V, $I_C = -1$ mA, $f = 1$ MHz	15*		10*		5*		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -6$ V, $I_E = 0$, $f = 0.1$ MHz to 1 MHz		10*		10*		10*	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -6$ V, $I_C = 0$, $f = 0.1$ MHz to 1 MHz		6*		6*		6*	pF

PARAMETER MEASUREMENT INFORMATION

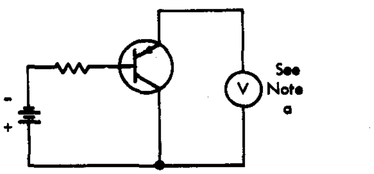


FIGURE 1

MEASUREMENT CIRCUIT FOR OFFSET VOLTAGE

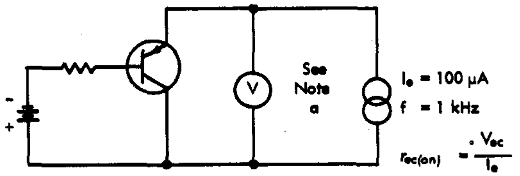


FIGURE 2

MEASUREMENT CIRCUIT FOR EMITTER-COLLECTOR ON-STATE RESISTANCE

NOTE a: The voltmeter must have high enough impedance that halving the value of the voltmeter impedance does not change the measured value.

*Indicates JEDEC registered data

TYPES 2N2913 THRU 2N2920, 2N2915A, 2N2916A, 2N2919A, 2N2920A, 2N2972 THRU 2N2979
DUAL N-P-N SILICON TRANSISTORS

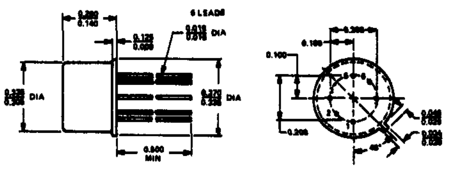
BULLETIN NO. DL-S 6911165, MARCH 1969

A BROAD FAMILY OF DUAL TRANSISTORS RECOMMENDED FOR

- **Differential Amplifiers**
- **High-Gain, Low-Noise, Audio Amplifiers**
- **Transducer Signal-Conditioner Amplifiers**
- **Low-Level Flip-Flops**

*mechanical data

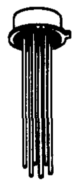
ALL LEADS INSULATED FROM CASE



Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

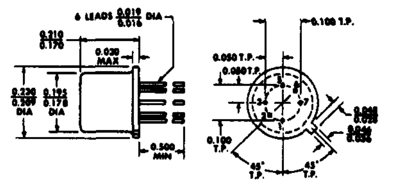
1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



OUTLINE A — TYPES 2N2913 THRU 2N2920, 2N2915A, 2N2916A, 2N2919A, 2N2920A

ALL LEADS INSULATED FROM CASE



FALLS WITHIN TO-71 DIMENSIONS

1. EMITTER 1
2. BASE 1
3. COLLECTOR 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

OUTLINE B — TYPES 2N2972 THRU 2N2979

quick-selection guide (for details see characteristics on the following pages)

TYPE		MIN $V_{(BR)CEO}$		MIN-MAX h_{FE} (I_C = 10 μA)		MIN $\frac{h_{FE1}}{h_{FE2}}$		$\lvert V_{BE1}-V_{BE2}\rvert$ (I_C = 100 μA)			$\lvert \Delta(V_{BE1}-V_{BE2})/\Delta T_A\rvert$ ($T_{A(1)}$ = 25°C, $T_{A(2)}$ = 125°C)		
OUTLINE A	OUTLINE B	60 V	45 V	60–240	150–600	0.9	0.8	1.5 mV	3 mV	5 mV	0.5 mV	1 mV	2 mV
2N2913	2N2972		•	•									
2N2914	2N2973		•		•								
2N2915	2N2974		•	•		•			•			•	
2N2915A			•	•		•		•			•		
2N2916	2N2975		•		•	•			•			•	
2N2916A			•		•	•		•			•		
2N2917	2N2976		•	•			•			•			•
2N2918	2N2977		•		•		•			•			•
2N2919	2N2978	•		•		•			•			•	
2N2919A		•		•		•		•			•		
2N2920	2N2979	•			•	•			•			•	
2N2920A		•			•	•		•			•		

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2913 thru 2N2918, 2N2915A, 2N2916A		2N2972 thru 2N2977		2N2919, 2N2919A, 2N2920, 2N2920A		2N2978, 2N2979		UNIT
	EACH TRIODE	TOTAL DEVICE	EACH TRIODE	TOTAL DEVICE	EACH TRIODE	TOTAL DEVICE	EACH TRIODE	TOTAL DEVICE	
Collector-Base Voltage	45		45		60		60		V
Collector-Emitter Voltage (See Note 1)	45		45		60		60		V
Emitter-Base Voltage	6		6		6		6		V
Collector-1 — Collector-2 Voltage		(±200)†				(±200)†			V
Continuous Collector Current	30		30		30		30		mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.3	0.5	0.25	0.3	0.3	0.5	0.25	0.3	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.75	1.5	0.5	0.75	0.75	1.5	0.5	0.75	W
Storage Temperature Range	−65 to 200		−65 to 200		−65 to 200		−65 to 200		°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300		300		300		300		°C

4

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

*individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	2N2913, 2N2915, 2N2915A, 2N2917, 2N2972, 2N2974, 2N2976		2N2914, 2N2916, 2N2916A, 2N2918, 2N2973, 2N2975, 2N2977		2N2919, 2N2919A, 2N2978		2N2920, 2N2920A, 2N2979		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	45		45		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$, See Note 5	45		45		60		60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	6		6		6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45\ V$, $I_E = 0$		10		10		2		2	nA
		$V_{CB} = 45\ V$, $I_E = 0$, $T_A = 150°C$		10		10		10		10	μA
I_{CEO}	Collector Cutoff Current	$V_{CE} = 5\ V$, $I_B = 0$		2		2		2		2	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5\ V$, $I_C = 0$		2		2		2		2	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 10\ \mu A$	60	240	150	600	60	240	150	600	
		$V_{CE} = 5\ V$, $I_C = 100\ \mu A$	100		225		100		225		
		$V_{CE} = 5\ V$, $I_C = 1\ mA$	150		300		150		300		
		$V_{CE} = 5\ V$, $I_C = 10\ \mu A$, $T_A = -55°C$	15		30 (40)‡		15		40		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5\ V$, $I_C = 100\ \mu A$		0.7		0.7		0.7		0.7	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 100\ \mu A$, $I_C = 1\ mA$		0.35		0.35		0.35		0.35	V

NOTES: 1. These values apply when the base-emitter diode is open-circuited.

2. Derate linearly to 200°C free-air temperature at the following rates: 1.72 mW/deg for each triode and 2.86 mW/deg for total device (2N2913 thru 2N2920, 2N2915A, 2N2916A, 2N2919A, 2N2920A); 1.43 mW/deg for each triode and 1.72 mW/deg for total device (2N2972 thru 2N2979).

3. Derate linearly to 200°C case temperature at the following rates: 4.3 mW/deg for each triode and 8.6 mW/deg for total device (2N2913 thru 2N2920, 2N2915A, 2N2916A, 2N2919A, 2N2920A); 2.86 mW/deg for each triode and 4.3 mW/deg for total device (2N2972 thru 2N2979).

4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.

5. This parameter must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 1\%$.

* JEDEC registered data

†These values apply to types 2N2915A, 2N2916A, 2N2919A, and 2N2920A only.

‡This value applies to type 2N2916A only.

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*electrical characteristics at 25°C free-air temperature (continued)

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	2N2913 thru 2N2920 — 2N2972 thru 2N2979 MIN	MAX	2N2915A 2N2916A 2N2919A 2N2920A MIN	MAX	UNIT
h_{ib}	Small-Signal Common-Base Input Impedance	$V_{CB} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz	25	32	25	32	Ω
h_{ob}	Small-Signal Common-Base Output Admittance	$V_{CB} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz		1		1	µmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 0.5$ mA, $f = 20$ MHz	3		3	8	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_E = 0$, $f = 140$ kHz to 1 MHz		6		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 140$ kHz to 1 MHz				10	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N2915 2N2916 2N2919 2N2920 2N2974 2N2975 2N2978 2N2979 MIN	MAX	2N2915A 2N2916A 2N2919A 2N2920A MIN	MAX	2N2917 2N2918 2N2976 2N2977 MIN	MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current-Gain Balance Ratio	$V_{CE} = 5$ V, $I_C = 100$ µA, See Note 6	0.9	1	0.9	1	0.8	1	
		$V_{CE} = 5$ V, $I_C = 100$ µA to 1 mA, $T_A = -55°C$ to 125°C, See Note 6			0.85	1			
$\lvert V_{BE1} - V_{BE2} \rvert$	Base-Emitter-Voltage Differential	$V_{CE} = 5$ V, $I_C = 100$ µA		3		1.5		5	mV
		$V_{CE} = 5$ V, $I_C = 10$ µA to 1 mA		5		2		10	
$\lvert \Delta(V_{BE1} - V_{BE2})_{\Delta T_A} \rvert$	Base-Emitter-Voltage-Differential Change With Temperature	$V_{CE} = 5$ V, $I_C = 100$ µA, $T_{A(1)} = 25°C$, $T_{A(2)} = -55°C$		0.8		0.4		1.6	mV
		$V_{CE} = 5$ V, $I_C = 100$ µA, $T_{A(1)} = 25°C$, $T_{A(2)} = 125°C$		1		0.5		2	

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 4)

PARAMETER	TEST CONDITIONS	2N2913 2N2915 2N2915A 2N2917 2N2919 2N2919A 2N2972 2N2974 2N2976 2N2978 MAX	2N2914 2N2916 2N2916A 2N2918 2N2920 2N2920A 2N2973 2N2975 2N2977 2N2979 MAX	UNIT
$\bar{F}$ Average Noise Figure	$V_{CE} = 5$ V, $I_C = 10$ µA, $R_G = 10$ kΩ, $f = 1$ kHz, Noise bandwidth = 200 Hz	4	3	dB
	$V_{CE} = 5$ V, $I_C = 10$ µA, $R_G = 10$ kΩ, Noise bandwidth = 15.7 kHz, See Note 7	4	3	

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.

6. The lower of the two h_{FE} readings is taken as h_{FE1}.

7. This parameter is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data

4

TYPICAL MATCHING CHARACTERISTICS†

FOR TYPES 2N2915, 2N2915A, 2N2916, 2N2916A, 2N2919, 2N2919A, 2N2920, 2N2920A, 2N2974, 2N2975, 2N2978, 2N2979

STATIC FORWARD-CURRENT-GAIN BALANCE RATIO
vs
COLLECTOR CURRENT

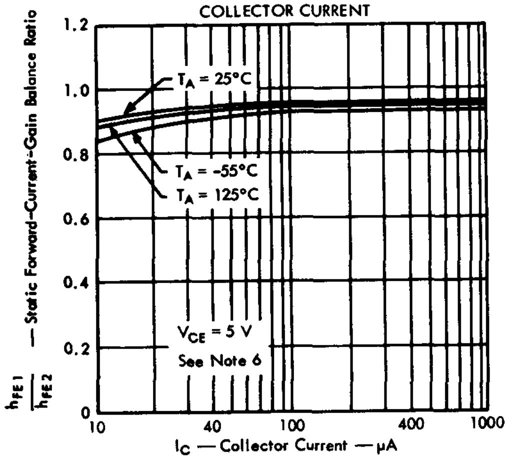

FIGURE 1

BASE-EMITTER-VOLTAGE DIFFERENTIAL
vs
COLLECTOR CURRENT

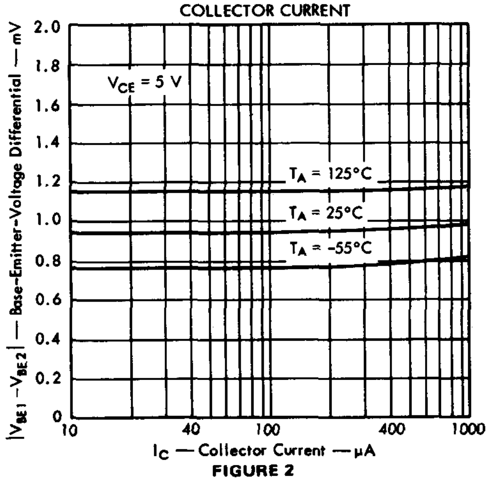

FIGURE 2

BASE-EMITTER-VOLTAGE DIFFERENTIAL
vs
FREE-AIR TEMPERATURE

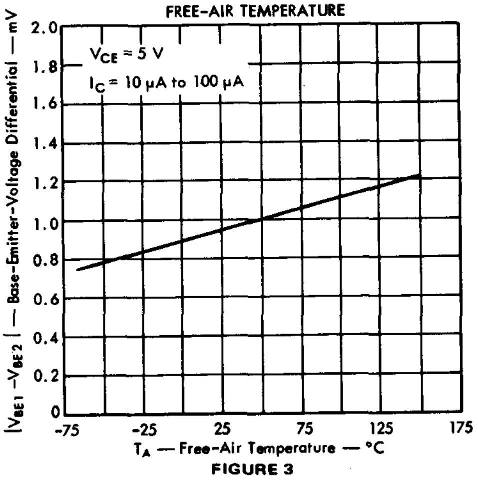

FIGURE 3

NOTE 6: The lower of the two h_{FE} readings is taken as h_{FE1}.

†These curves represent the average behavior of groups of dual transistors. *Unlike normal single-triode characteristics,* matching characteristics of dual transistors may differ considerably in behavior from the typical. For example, a minority of devices have been observed with smaller V_{BE} mismatch at 150°C than at -65°C, as opposed to the average behavior as shown in figures 2 and 3.

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TYPES 2N2894, 2N3012
P-N-P SILICON TRANSISTORS

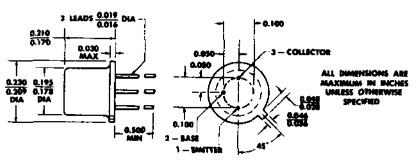
BULLETIN NO. DL-S 645051, AUGUST 1964

DESIGNED FOR HIGH-SPEED SWITCHING APPLICATIONS

- **Guaranteed $V_{CE(sat)}$ ··· 0.5 v Max at 100 ma**
- **High f_T ··· 400 Mc Min**

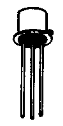
4

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE.

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE.



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−12 v
Collector-Emitter Voltage (See Note 1)	−12 v
Emitter-Base Voltage	−4 v
Collector Current	−200 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.36 w
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 w
Operating Collector Junction Temperature	200°C
Storage Temperature Range	−65°C to +200°C
Lead Temperature 1/16 Inch from Case For 60 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N2894 MIN	2N2894 MAX	2N3012 MIN	2N3012 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu a$, $I_E = 0$	−12		−12		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ ma, $I_B = 0$, See Note 4	−12		−12		v
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ \mu a$, $V_{BE} = 0$	−12		−12		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu a$, $I_C = 0$	−4		−4		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = -6$ v, $I_E = 0$, $T_A = 125°C$		−10			μa
I_{CES}	Collector Cutoff Current	$V_{CE} = -6$ v, $V_{BE} = 0$		−80		−80	na
		$V_{CE} = -6$ v, $V_{BE} = 0$, $T_A = 85°C$				−5	μa
I_B	Base Current	$V_{CE} = -6$ v, $V_{BE} = 0$		80		30	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.3$ v, $I_C = -10$ ma, See Note 4	30		25		
		$V_{CE} = -0.5$ v, $I_C = -30$ ma, See Note 4	40	150	30	120	
		$V_{CE} = -1$ v, $I_C = -100$ ma, See Note 4	25		20		
		$V_{CE} = -0.5$ v, $I_C = -30$ ma, $T_A = -55°C$, See Note 4	17				
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ ma, $I_C = -10$ ma, See Note 4		−0.15		−0.15	v
		$I_B = -3$ ma, $I_C = -30$ ma, See Note 4		−0.20		−0.20	v
		$I_B = -10$ ma, $I_C = -100$ ma, See Note 4		−0.50		−0.50	v
		$I_B = -3$ ma, $I_C = -30$ ma, $T_A = 85°C$, See Note 4				−0.40	v
V_{BE}	Base-Emitter Voltage	$I_B = -1$ ma, $I_C = -10$ ma, See Note 4	−0.78	−0.98	−0.78	−0.98	v
		$I_B = -3$ ma, $I_C = -30$ ma, See Note 4	−0.85	−1.2	−0.85	−1.2	v
		$I_B = -10$ ma, $I_C = -100$ ma, See Note 4		−1.7		−1.7	v

NOTES: 1. This value applies between 10 μa and 10 ma collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.06 mw/C°.
3. Derate linearly to 200°C case temperature at the rate of 6.85 mw/C°.
4. This parameter must be measured using pulse techniques. PW = 300 μsec, Duty Cycle = 1%.

*Indicates JEDEC registered data.

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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N2894 MIN	2N2894 MAX	2N3012 MIN	2N3012 MAX	UNIT
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -30$ ma, $f = 100$ Mc	4		4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ v, $I_E = 0$, $f = 140$ kc		6		6	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ v, $I_C = 0$, $f = 140$ kc		6		6	pf

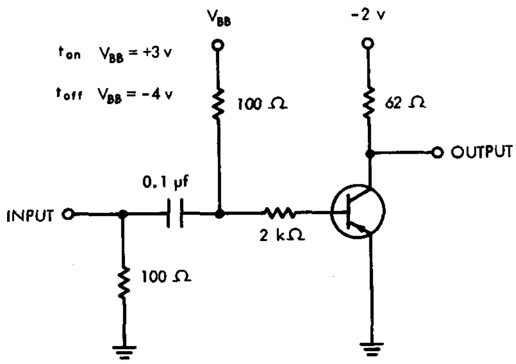
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N2894 MAX	2N3012 MAX	UNIT
t_{on}	Turn-On Time	$I_C = -30$ ma, $I_{B(1)} = -1.5$ ma, $V_{BE(off)} = 3$ v, $R_L = 62\ \Omega$, See Figure 1	60	60	nsec
t_{off}	Turn-Off Time	$I_C = -30$ ma, $I_{B(1)} = -1.5$ ma, $I_{B(2)} = 1.5$ ma, $R_L = 62\ \Omega$, See Figure 1	90	75	nsec

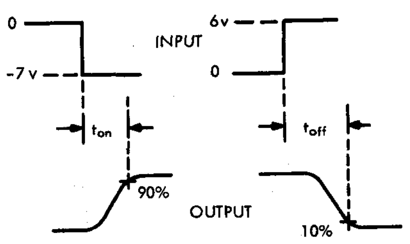
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

4

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

FIGURE 1 – TURN-ON AND TURN-OFF TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 1$ nsec, PW $>$ 200 nsec.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec, $R_{in} \geq 100$ kΩ.

*Indicates JEDEC registered data.

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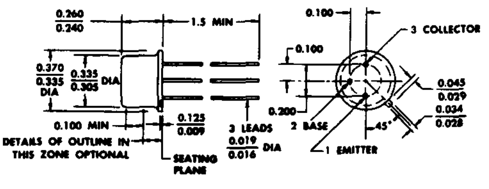
PRINTED IN U.S.A. 373

BULLETIN NO. DL-S 645017, MARCH 1964

DESIGNED FOR HIGH-SPEED, HIGH-CURRENT SWITCHING APPLICATIONS

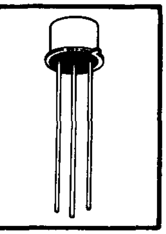
*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE.

ALL JEDEC TO-5 DIMENSIONS AND NOTES ARE APPLICABLE.

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	60 v
Collector-Emitter Voltage (See Note 1)	30 v
Emitter-Base Voltage	5 v
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.8 w
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	3.0 w
Operating Collector Junction Temperature	200°C
Storage Temperature Range	−65°C to +200°C

4

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 4	30		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	5		v
I_{CES}	Collector Cutoff Current	$V_{CE} = 30$ v, $V_{BE} = 0$		0.2	μa
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ v, $I_E = 0$, $T_A = 125°C$		200	μa
I_B	Base Current	$V_{CE} = 20$ v, $V_{BE} = 0$		−0.2	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 4	30	120	
		$V_{CE} = 0.7$ v, $I_C = 300$ ma, See Note 4	10		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 4		1.2	v
		$I_B = 50$ ma, $I_C = 500$ ma, See Note 4		1.6	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 4		0.4	v
		$I_B = 50$ ma, $I_C = 500$ ma, See Note 4		1.0	v
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, $f = 100$ Mc	2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 140$ kc		8.0	pf

NOTES: 1. This value applies between 1 ma and 30 ma collector current when the base-emitter diode is open-circuited.

2. Derate linearly to 200°C free-air temperature at the rate of 4.6 mw/C°.

3. Derate linearly to 200°C case temperature at the rate of 17.2 mw/C°.

4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

*Indicates JEDEC registered data

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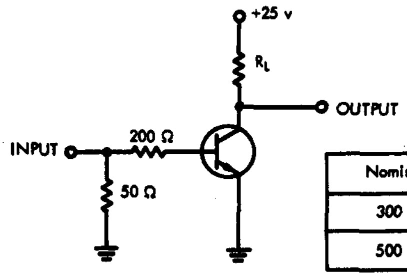
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_{on}	Turn-on Time	$I_C = 300$ ma, $I_{B(1)} = 30$ ma, $V_{BE(off)} = 0$, $R_L = 80\ \Omega$, See Figure 1	40	nsec
		$I_C = 500$ ma, $I_{B(1)} = 50$ ma, $V_{BE(off)} = 0$, $R_L = 48\ \Omega$, See Figure 1	40	nsec
t_{off}	Turn-off Time	$I_C = 300$ ma, $I_{B(1)} = 30$ ma, $I_{B(2)} = -35$ ma, $R_L = 80\ \Omega$, See Figure 2	60	nsec
		$I_C = 500$ ma, $I_{B(1)} = 50$ ma, $I_{B(2)} = -55$ ma, $R_L = 48\ \Omega$, See Figure 2	60	nsec

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

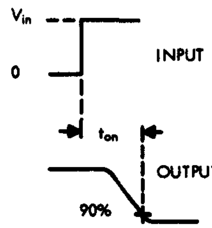
*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

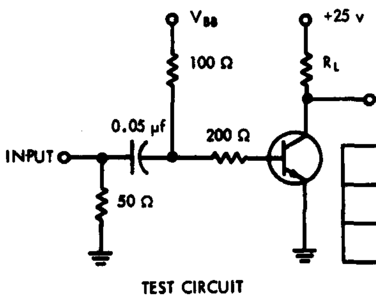
Nominal I_C	R_L	V_{in}
300 ma	80 Ω	+7 v
500 ma	48 Ω	+11 v

CIRCUIT CONDITIONS



VOLTAGE WAVEFORMS

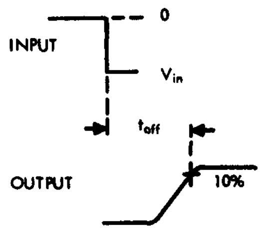
FIGURE 1 — TURN-ON TIMES



TEST CIRCUIT

Nominal I_C	R_L	V_{BB}	V_{in}
300 ma	80 Ω	+10 v	-13 v
500 ma	48 Ω	+16 v	-21 v

CIRCUIT CONDITIONS



VOLTAGE WAVEFORMS

FIGURE 2 — TURN-OFF TIMES

NOTES: a. The input waveforms are supplied by a pulse generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 2$ nsec, PW = 200 nsec.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec, $R_{in} \geq 100$ kΩ.

*Indicates JEDEC registered data

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PRINTED IN U.S.A.

TYPE 2N3036
N-P-N SILICON TRANSISTOR

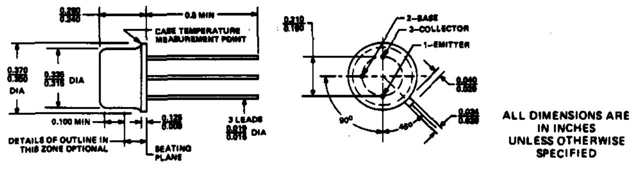
BULLETIN NO. DL-S 734232, AUGUST 1963–REVISED MARCH 1973

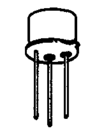
FOR GENERAL PURPOSE, MEDIUM-POWER AMPLIFIER AND SWITCHING APPLICATIONS

- **High Power Dissipation Capability: 10 w at T_C = 25°C**
- **High Breakdown Voltage Combined with Very Low Saturation Voltage**
- **DC Beta Guaranteed From 100 μa to 1 amp**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

4

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	120 v*
Collector-Emitter Voltage (See Note 1)	80 v*
Emitter-Base Voltage	7 v*
Continuous Collector Current	1.2 a*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.8 w*
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	10 w† / 5 w*
Storage Temperature Range	−65°C to 200°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C*

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 μa, I_E = 0	120		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 ma, I_B = 0, (See Note 4)	80		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 100 μa, I_C = 0	7		v
I_{CBO}	Collector Cutoff Current	V_{CB} = 60 v, I_E = 0		10	na
		V_{CB} = 60 v, I_E = 0, T_A = 150°C		10	μa
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 v, I_C = 0		10	na
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 10 v, I_C = 100 μa	20		
		V_{CE} = 10 v, I_C = 10 ma	40		
		V_{CE} = 10 v, I_C = 150 ma, (See Note 4)	50	150	
		V_{CE} = 10 v, I_C = 500 ma, (See Note 4)	25		
		V_{CE} = 10 v, I_C = 1 a, (See Note 4)	15		
		V_{CE} = 1 v, I_C = 150 ma, (See Note 4)	30		
V_{BE}	Base-Emitter Voltage	I_B = 15ma, I_C = 150 ma, (See Note 4)	0.75	1.1	v
		I_B = 50 ma, I_C = 500 ma, (See Note 4)		1.5	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 15 ma, I_C = 150 ma, (See Note 4)		0.25	v
		I_B = 50 ma, I_C = 500 ma, (See Note 4)		1.0	v

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mw/°C.
Derate the 5-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 28.6 mw/°C.
4. These parameters must be measured using pulse techniques. PW = 300 μs, Duty Cycle ≤ 2%.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

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*electrical characteristics at 25°C free-air temperature

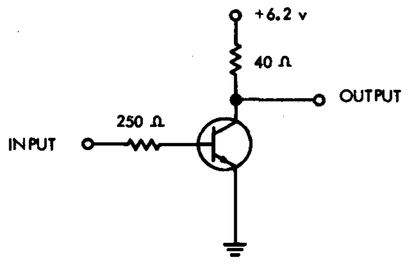
PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 1$ kc	120	900	ohm
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 1$ kc	40	180	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 1$ kc		120	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 20$ mc	2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		15	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc		85	pf

*switching characteristics at 25°C free-air temperature

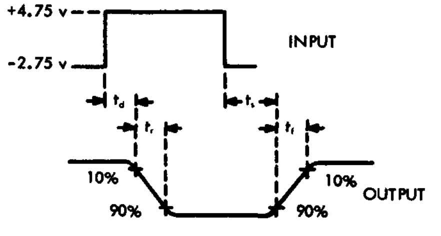
PARAMETER		TEST CONDITIONS †	MIN	MAX	UNIT
t_d	Delay Time	$I_C = 150$ ma, $I_{B(1)} = 15$ ma,		30	nsec
t_r	Rise Time	$I_{B(2)} = -15$ ma,		150	nsec
t_s	Storage Time	$V_{BE(off)} = -2.75$ v, $R_L = 40\ \Omega$,		1	μsec
t_f	Fall Time	(See Figure 1)		200	nsec

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1 —— SWITCHING TIMES

NOTES: a. The input waveform has the following characteristics: $t_r \leq 1$ nsec, $t_f \leq 1$ nsec, PW ≥ 500 nsec, Duty Cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 4$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pf.

*Indicates JEDEC registered data

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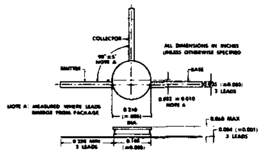
TYPES 2N3037, 2N3038
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 634251, AUGUST 1963

FOR GENERAL PURPOSE AMPLIFIER AND SWITCHING APPLICATIONS

- High Breakdown Voltage Combined With Very Low Saturation Voltage
- DC Beta — Guaranteed From 100 μa to 500 ma
- Electrically Similar to 2N2243
- Recommended for Complementary Use With 2N3039 and 2N3040

*mechanical data



ALL LEADS INSULATED FROM CASE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3037	2N3038
Collector-Base Voltage	120 v	100 v
Collector-Emitter Voltage (See Note 1)	70 v	60 v
Emitter-Base Voltage	7 v	7 v
Collector Current	← 500 ma →	
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 360 mw →	
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 1.0 w →	
Storage Temperature Range	−65°C to +200°C	

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3037 MIN	2N3037 MAX	2N3038 MIN	2N3038 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$, $I_E = 0$	120		100		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, (See Note 4)	70		60		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$, $I_C = 0$	7		7		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$		10		10	na
		$V_{CB} = 60$ v, $I_E = 0$, $T_A = 150°C$		10		10	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ v, $I_C = 0$		10		10	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 100\ \mu a$	15		30		
		$V_{CE} = 10$ v, $I_C = 10$ ma, (See Note 4)	30		60		
		$V_{CE} = 10$ v, $I_C = 150$ ma, (See Note 4)	40	120	80	240	
		$V_{CE} = 10$ v, $I_C = 500$ ma, (See Note 4)	20		40		
		$V_{CE} = 1$ v, $I_C = 150$ ma, (See Note 4)	25		50		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ ma, $I_C = 10$ ma	0.6	0.8	0.6	0.8	v
		$I_B = 15$ ma, $I_C = 150$ ma, (See Note 4)	0.75	1.1	0.75	1.1	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ ma, $I_C = 10$ ma		0.2		0.2	v
		$I_B = 15$ ma, $I_C = 150$ ma, (See Note 4)		0.35		0.35	v

NOTES: 1. This value applies when the base-emitter diode is open-circuited.

2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mw/C°.

3. Derate linearly to 175°C case temperature at the rate of 6.67 mw/C°.

4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle $\leq$ 2%.

*Indicates JEDEC registered data

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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3037 MIN	2N3037 MAX	2N3038 MIN	2N3038 MAX	UNIT
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 1$ kc	90	700	180	1500	ohm
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 1$ kc	30	140	60	300	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 1$ kc		100		200	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 10$ ma, $f = 20$ mc	2.5		2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 1$ mc		15		15	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, $f = 1$ mc		85		85	pf

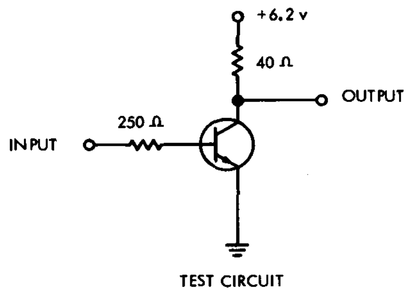
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N3037 MIN	2N3037 MAX	2N3038 MIN	2N3038 MAX	UNIT
t_d	Delay Time	$I_C = 150$ ma, $I_{B(1)} = 15$ ma		30		30	nsec
t_r	Rise Time	$I_{B(2)} = -15$ ma		150		150	nsec
t_s	Storage Time	$V_{BE(off)} = -2.75$ v, $R_L = 40\ \Omega$		1		1	μsec
t_f	Fall Time	(See Figure 1)		200		200	nsec

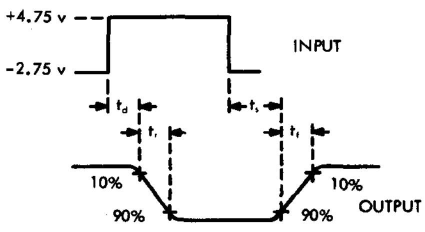
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

4

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

FIGURE 1 — SWITCHING TIMES

NOTES: a. The input waveform has the following characteristics: $t_r \leq 1$ nsec, $t_f \leq 1$ nsec, PW ≥ 500 nsec, Duty Cycle $\leq 2\%$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 4$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pf.

*Indicates JEDEC registered data

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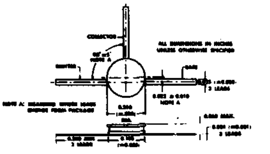
PRINTED IN U.S.A.

BULLETIN NO. DL-S 634231, AUGUST 1963

FOR GENERAL PURPOSE AMPLIFIER AND SWITCHING APPLICATIONS

- **High Breakdown Voltage Combined With Very Low Saturation Voltage**
- **DC Beta — Guaranteed From 100 μa to 500 ma**
- **Recommended for Complementary Use With 2N3037 and 2N3038**

***mechanical data**



ALL LEADS INSULATED FROM CASE

***absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)**

	2N3039	2N3040
Collector-Base Voltage	−50 v	−40 v
Collector-Emitter Voltage (See Note 1)	−35 v	−30 v
Emitter-Base Voltage	−5 v	−5 v
Collector Current	←−500 ma→	
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←360 mw→	
Total Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	←1.0 w→	
Storage Temperature Range	−65°C to +200°C	

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	2N3039 MIN	2N3039 MAX	2N3040 MIN	2N3040 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu a$, $I_E = 0$	−50		−40		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -30$ ma, $I_B = 0$, (See Note 4)	−35		−30		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu a$, $I_C = 0$	−5		−5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ v, $I_E = 0$		−25		−25	na
		$V_{CB} = -30$ v, $I_E = 0$, $T_A = 150°C$		−25		−25	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ v, $I_C = 0$		−10		−10	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -100\ \mu a$	15		30		
		$V_{CE} = -10$ v, $I_C = -10$ ma, (See Note 4)	20		40		
		$V_{CE} = -10$ v, $I_C = -150$ ma, (See Note 4)	20	80	40	160	
		$V_{CE} = -10$ v, $I_C = -500$ ma, (See Note 4)	15		25		
		$V_{CE} = -1$ v, $I_C = -150$ ma, (See Note 4)	15		20		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ ma, $I_C = -10$ ma	−0.6	−1.0	−0.6	−1.0	v
		$I_B = -15$ ma, $I_C = -150$ ma, (See Note 4)	−0.8	−1.3	−0.8	−1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ ma, $I_C = -10$ ma		−0.2		−0.2	v
		$I_B = -15$ ma, $I_C = -150$ ma, (See Note 4)		−0.5		−0.5	v

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mw/C°.
3. Derate linearly to 175°C case temperature at the rate of 6.67 mw/C°.
4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

*Indicates JEDEC registered data

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*electrical characteristics at 25°C free-air temperature

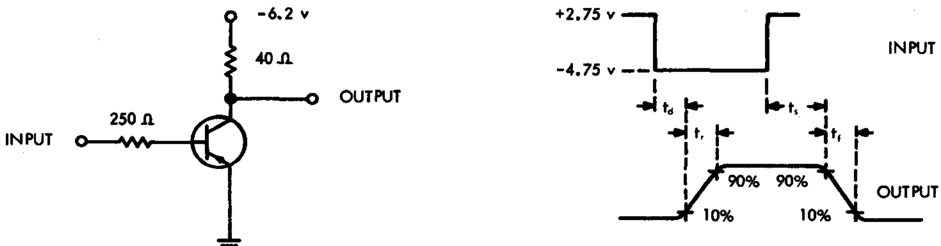
PARAMETER		TEST CONDITIONS	2N3039 MIN	2N3039 MAX	2N3040 MIN	2N3040 MAX	UNIT
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ v, $I_C = -10$ ma, f = 1 kc	60	600	120	1200	ohm
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -10$ ma, f = 1 kc	20	120	40	240	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ v, $I_C = -10$ ma, f = 1 kc		250		500	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -10$ ma, f = 20 mc	2.5		2.5		
C_{ob}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ v, $I_E = 0$, f = 1 mc		40		40	pf
C_{ib}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ v, $I_C = 0$, f = 1 mc		80		80	pf

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N3039 MIN	2N3039 MAX	2N3040 MIN	2N3040 MAX	UNIT
t_d	Delay Time	$I_C = -150$ ma, $I_{B(1)} = -15$ ma, $I_{B(2)} = 15$ ma, $V_{BE(off)} = +2.75$ v, $R_L = 40\,\Omega$ (See Figure 1)		50		50	nsec
t_r	Rise Time			100		100	nsec
t_s	Storage Time			500		500	nsec
t_f	Fall Time			150		150	nsec

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

(See Notes a and b)

VOLTAGE WAVEFORMS

FIGURE 1 — SWITCHING TIMES

NOTES: a. The input waveform has the following characteristics: $t_r \leq 1$ nsec, $t_f \leq 1$ nsec, PW ≥ 500 nsec, Duty Cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 4$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pf.

*Indicates JEDEC registered data

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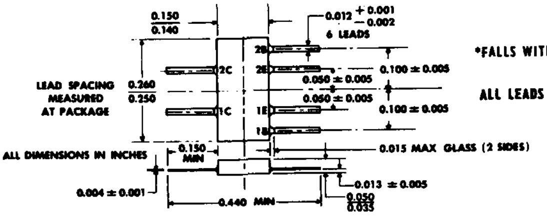
TYPES 2N3043 THRU 2N3048
DUAL N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 674208, AUGUST 1963—REVISED APRIL 1967

DESIGNED FOR DIFFERENTIAL AMPLIFIERS AND HIGH-GAIN LOW-NOISE AUDIO AMPLIFIERS

- **Electrically Similar to 2N2639-2N2644 Series**
- **Individual Triodes are Electrically Similar to 2N929, 2N930**
- **Popular TO-89 Flatpack Facilitates High-Density Packaging**
- **Welded Metal Construction**

mechanical data



*FALLS WITHIN TO-89 DIMENSIONS

ALL LEADS INSULATED FROM CASE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	45 v	
Collector-Emitter Voltage (See Note 1)	45 v	
Emitter-Base Voltage	5 v	
Continuous Collector Current	30 ma	
Continuous Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mw	350 mw
Continuous Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.7 w	1.4 w
Storage Temperature Range	−65°C to +200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds		230°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.

2. Derate linearly to 175°C free-air temperature at the rate of 1.67 mw/C° for each triode and 2.33 mw/C° for total device.

3. Derate linearly to 175°C case temperature at the rate of 4.67 mw/C° for each triode and 9.33 mw/C° for total device.

*Indicates JEDEC registered data

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TYPES 2N3043 THRU 2N3048
DUAL N-P-N SILICON TRANSISTORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

*individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	2N3043 2N3044 2N3045 MIN	MAX	2N3046 2N3047 2N3048 MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$, See Note 5	45		45		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$	5		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ v, $I_E = 0$		10		10	na
		$V_{CB} = 45$ v, $I_E = 0$, $T_A = 150°C$		10		10	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ v, $I_C = 0$		10		10	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 10\ \mu a$	100	300	50	200	
		$V_{CE} = 5$ v, $I_C = 1$ ma	130		65		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ v, $I_C = 10$ ma	0.6	0.8	0.6	0.8	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ ma, $I_C = 10$ ma		1		1	v
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	3.2	19	1.6	13	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc	130	600	65	400	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 1$ kc		100		70	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 1$ ma, $f = 20$ Mc	1.5		1.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$, $f = 1$ Mc		8		8	pf

*triode matching characteristics

PARAMETER		TEST CONDITIONS	2N3043 2N3046 MIN	MAX	2N3044 2N3047 MIN	MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current-Gain Balance Ratio	$V_{CE} = 5$ v, $I_C = 10\ \mu a$, See Note 6	0.9	1	0.8	1	
$\lvert V_{BE1} - V_{BE2} \rvert$	Base-Emitter-Voltage-Differential	$V_{CE} = 5$ v, $I_C = 10\ \mu a$		5		10	mv
$\lvert \Delta(V_{BE1} - V_{BE2})_{\Delta T_A} \rvert$	Base-Emitter-Voltage-Differential Change With Temperature	$V_{CE} = 5$ v, $I_C = 10\ \mu a$, $T_{A(1)} = 25°C$, $T_{A(2)} = -55°C$		0.8		1.6	mv
		$V_{CE} = 5$ v, $I_C = 10\ \mu a$, $T_{A(1)} = 25°C$, $T_{A(2)} = 125°C$		1		2	mv

operating characteristics at 25°C free-air temperature

*individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	ALL TYPES MIN	MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CE} = 5$ v, $I_C = 10\ \mu a$, $R_G = 10\ k\Omega$, Noise Bandwidth = 15.7 kc, See Note 7		5	db

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. This parameter must be measured using pulse techniques. PW = 300 μsec, Duty Cycle $\leq$ 2%.
6. The lower of the two h_{FE} readings is taken as h_{FE1}.
7. Average Noise Figure is measured in an amplifier with low-frequency-response down 3 db at 10 cps.

*Indicates JEDEC registered data

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4

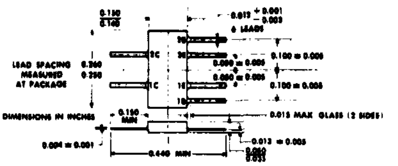
TYPES 2N3049, 2N3050, 2N3051
DUAL P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 674230, AUGUST 1963—REVISED APRIL 1967

DESIGNED FOR DIFFERENTIAL AMPLIFIERS, LOW-NOISE AMPLIFIERS, AND LOW-LEVEL SWITCHING

- **Each Triode Electrically Similar to 2N2411 and 2N2412 Transistors**
- **Popular TO-89 Flatpack Facilitates High-Density Packaging**
- **Welded Metal Construction**

mechanical data



*FALLS WITHIN TO-89 DIMENSIONS

ALL LEADS INSULATED FROM CASE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	−25 v	
Collector-Emitter Voltage (See Note 1)	−20 v	
Emitter-Base Voltage	−5 v	
Continuous Collector Current	−100 ma	
Continuous Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mw	350 mw
Continuous Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.7 w	1.4 w
Storage Temperature Range	−65°C to + 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds		230°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

*individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ ma, $I_B = 0$, See Note 5	−20		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = -25$ v, $I_E = 0$		−10	na
		$V_{CB} = -25$ v, $I_E = 0$, $T_A = 150°C$		−10	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ v, $I_C = 0$		−10	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ v, $I_C = -10$ μa	20	120	
		$V_{CE} = -5$ v, $I_C = -100$ μa	30	120	
		$V_{CE} = -5$ v, $I_C = -1$ ma	30	120	
		$V_{CE} = -5$ v, $I_C = -10$ ma, See Note 5	30	120	
		$V_{CE} = -1$ v, $I_C = -10$ ma	20		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ ma, $I_C = -10$ ma	−0.7	−0.9	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ ma, $I_C = -10$ ma		−0.2	v
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5$ v, $I_C = -1$ ma, f = 1 kc	0.75	4.5	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ v, $I_C = -1$ ma, f = 1 kc	30	130	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -5$ v, $I_C = -1$ ma, f = 1 kc		50	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ v, $I_C = -1$ ma, f = 20 Mc	3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ v, $I_E = 0$, f = 1 Mc		8	pf

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 1.67 mw/C° for each triode and 2.33 mw/C° for total device.
3. Derate linearly to 175°C case temperature at the rate of 4.67 mw/C° for each triode and 9.33 mw/C° for total device.
4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

*Indicates JEDEC registered data

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

*triode matching characteristics

PARAMETER		TEST CONDITIONS	2N3049		2N3050		UNIT
			MIN	MAX	MIN	MAX	
$\frac{h_{FE1}}{h_{FE2}}$	Static-Forward-Current-Gain Balance Ratio	$V_{CE} = -5$ v, $I_C = -100$ μa, See Note 6	0.9	1	0.8	1	
$\|V_{BE1} - V_{BE2}\|$	Base-Emitter-Voltage-Differential	$V_{CE} = -5$ v, $I_C = -100$ μa		5		10	mv
$\|\Delta (V_{BE1} - V_{BE2})_{\Delta T_A}\|$	Base-Emitter-Voltage-Differential Change With Temperature	$V_{CE} = -5$ v, $I_C = -100$ μa, $T_{A(1)} = 25°C$, $T_{A(2)} = -55°C$		0.8		1.6	mv
		$V_{CE} = -5$ v, $I_C = -100$ μa, $T_{A(1)} = 25°C$, $T_{A(2)} = 125°C$		1		2	mv

NOTE 6: The lower of the two h_{FE} readings is taken as h_{FE1}.

operating characteristics at 25°C free-air temperature

*individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	ALL TYPES		UNIT
			MIN	MAX	
$\overline{NF}$	Average Noise Figure	$V_{CE} = -5$ v, $I_C = -100$ μa, $R_G = 1$ kΩ, Noise Bandwidth = 15.7 kc, See Note 7		6	db

NOTE 7: Average Noise Figure is measured in an amplifier with low-frequency-response down 3 db at 10 cps.

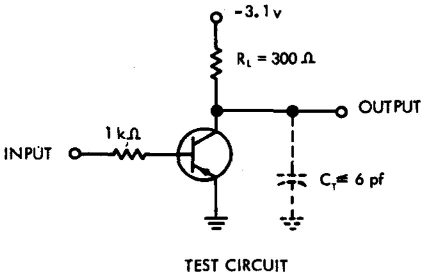
switching characteristics at 25°C free-air temperature

*individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS†	2N3051		UNIT
			MIN	MAX	
t_d	Delay Time	$I_C = -10$ ma, $I_{B(1)} = -2.5$ ma, $I_{B(2)} = 2$ ma, $V_{BE(off)} = +1.2$ v, $R_L = 300\ \Omega$, See Figure 1		15	nsec
t_r	Rise Time			20	nsec
t_s	Storage Time			120	nsec
t_f	Fall Time			30	nsec

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



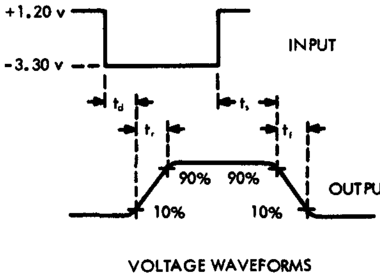


FIGURE 1 — SWITCHING TIMES

NOTES: a. The input waveform has the following characteristics: $t_r \leq 1$ nsec, $t_f \leq 1$ nsec, PW ≥ 200 nsec, Duty Cycle ≤ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 3$ pf. The input impedance of the oscilloscope is included in the values shown for R_L, Total Collector Load Resistance, and C_T, Total Collector Shunt Capacitance.

*Indicates JEDEC registered data

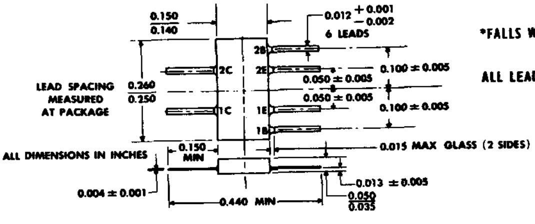
BULLETIN NO. DL-S 674236, AUGUST 1963—REVISED APRIL 1967

TYPE 2N3052
DUAL N-P-N SILICON TRANSISTOR

DESIGNED FOR MINIATURIZED APPLICATIONS REQUIRING DEVICES SIMILAR TO 2N706, 2N708, 2N744, 2N753, 2N834, 2N914, ETC.

- **Popular TO-89 Flatpack Facilitates High-Density Packaging**
- **Welded Metal Construction**

mechanical data



*FALLS WITHIN TO-89 DIMENSIONS

ALL LEADS INSULATED FROM CASE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	35 v	
Collector-Emitter Voltage (See Note 1)	15 v	
Emitter-Base Voltage	5 v	
Continuous Collector Current	200 ma	
Continuous Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mw	350 mw
Continuous Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.7 w	1.4 w
Storage Temperature Range	−65°C to + 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds		230°C

NOTES: 1. This value applies between 0 and 100 ma collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 1.67 mw/C° for each triode and 2.33 mw/C° for total device.
3. Derate linearly to 175°C case temperature at the rate of 4.67 mw/C° for each triode and 9.33 mw/C° for total device.
4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

*Indicates JEDEC registered data.

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TYPE 2N3052
DUAL N-P-N SILICON TRANSISTOR

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

***individual triode characteristics (see note 4)**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu a$, $I_E = 0$	35		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$, See Note 5	15		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$	5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20$ v, $I_E = 0$		25	na
		$V_{CB} = 20$ v, $I_E = 0$, $T_A = 150°C$		25	μa
I_{CES}	Collector Cutoff Current	$V_{CE} = 20$ v, $V_{BE} = 0$		25	na
I_B	Base Current	$V_{CE} = 20$ v, $V_{BE} = 0$		−25	na
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ v, $I_C = 0$		100	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ v, $I_C = 10$ ma	25	130	
		$V_{CE} = 1$ v, $I_C = 100$ ma, See Note 5	20		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ ma, $I_C = 10$ ma	0.65	0.8	v
		$I_B = 10$ ma, $I_C = 100$ ma, See Note 5	0.8	1.2	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ ma, $I_C = 10$ ma		0.25	v
		$I_B = 10$ ma, $I_C = 100$ ma, See Note 5		0.6	v
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v, $I_C = 10$ ma, f = 100 Mc	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ v, $I_E = 0$, f = 1 Mc		8	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$, f = 1 Mc		12	pf

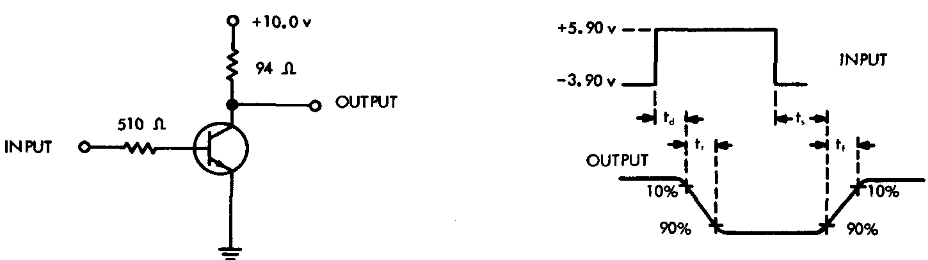
switching characteristics at 25°C free-air temperature

***individual triode characteristics (see note 4)**

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_d	Delay Time	$I_C = 100$ ma, $I_{B(1)} = 10$ ma, $I_{B(2)} = -10$ ma, $V_{BE(off)} = -3.9$ v, $R_L = 94\ \Omega$, See Figure 1		12	nsec
t_r	Rise Time			50	nsec
t_s	Storage Time			35	nsec
t_f	Fall Time			20	nsec

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 1 — SWITCHING TIMES

NOTES: a. The input waveform has the following characteristics: $t_r \leq 1$ nsec, $t_f \leq 1$ nsec, PW ≥ 300 nsec, Duty Cycle $\leq 2\%$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 5$ pf.

*Indicates JEDEC registered data

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TYPE 2N3053
N-P-N SILICON TRANSISTOR

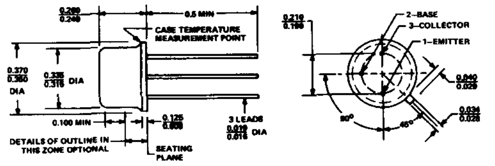
BULLETIN NO. DL-S 7311957, MARCH 1973

FOR HIGH-CURRENT, HIGH-DISSIPATION, GENERAL PURPOSE APPLICATIONS

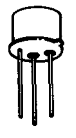
- High Current Capability . . . 700 mA
- High Dissipation Capability . . . 10 W
- f_T . . . 100 MHz Min

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



CASE TEMPERATURE MEASUREMENT POINT IS CENTER OF SEATING SURFACE



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C case temperature (unless otherwise noted)

Collector-Base Voltage	60 V*
Collector-Emitter Voltage (See Note 1)	40 V*
Collector-Emitter Voltage (See Note 2)	50 V
Emitter-Base Voltage	5 V*
Continuous Collector Current	700 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	1 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	10 W† / 5 W*
Storage Temperature Range	−65°C to 200°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C† / 235°C*

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 100\ \mu A$, $I_B = 0$		40		V
$V_{(BR)CER}$	Collector-Emitter Breakdown Voltage	$I_C = 100$ mA, $R_{BE} = 10\ \Omega$,	See Note 5	50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$		5		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = 30$ V, $V_{BE} = -1.5$ V			250	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ V, $I_C = 0$			250	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2.5$ V, $I_C = 150$ mA	See Note 5	25		
		$V_{CE} = 10$ V, $I_C = 150$ mA		50	250	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 2.5$ V, $I_C = 150$ mA	See Note 5		1.7	V
		$I_B = 15$ mA, $I_C = 150$ mA			1.7	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ mA, $I_C = 150$ mA,	See Note 5		1.4	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 50$ mA, $f = 20$ MHz		5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 140$ kHz			15	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 140$ kHz			80	pF

NOTES:
1. This value applies between 0 and 700 mA collector current when the base-emitter diode is open-circuited. The instantaneous product of collector-emitter voltage and collector current must not exceed 5 W for longer than 300 µs at a 2% duty cycle.
2. This value applies when the base-emitter resistance $R_{BE} \leq 10\ \Omega$.
3. Derate linearly to 200°C free-air temperature at the rate of 5.71 mW/°C.
4. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mW/°C. Derate the 5-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 28.6 mW/°C.
5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

♦The JEDEC registered outline for this device is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†These values are guaranteed by Texas Instruments in addition to the JEDEC registered values which are also shown.

USES CHIP N13

4

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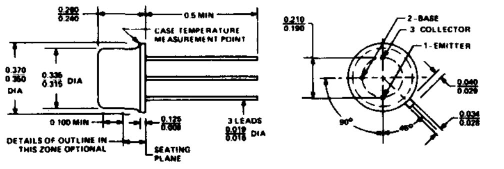
BULLETIN NO. DL-S 737397, MARCH 1965—REVISED MARCH 1973

DESIGNED FOR USE AS HIGH VOLTAGE VHF AMPLIFIER

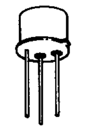
• Featuring 150-Volt $V_{(BR)CEO}$

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE ♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	150 v *
Collector-Emitter Voltage (See Note 1)	150 v *
Emitter-Base Voltage	5 v *
Collector Current	200 ma *
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.8 w *
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	10 w † / 5 w *
Storage Temperature Range	−65°C to +200°C *
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C *

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu a$,	$I_E = 0$		150		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma,	$I_B = 0$,	See Note 4	150		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu a$,	$I_C = 0$		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 100$ v,	$I_E = 0$			10	na
		$V_{CB} = 100$ v,	$I_E = 0$,	$T_A = 150°C$		10	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ v,	$I_C = 0$			100	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ v,	$I_C = 100\ \mu a$,	See Note 4	15		
		$V_{CE} = 10$ v,	$I_C = 30$ ma,	See Note 4	30	120	
		$V_{CE} = 10$ v,	$I_C = 30$ ma,	$T_A = -55°C$ See Note 4	12		
V_{BE}	Base-Emitter Voltage	$I_B = 5$ ma,	$I_C = 50$ ma			0.9	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ ma,	$I_C = 50$ ma			1	v

NOTES:
1. This value applies between 1 ma and 30 ma collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mw/°C. Derate the 5-watt (JEDEC registered) rating linearly to 200°C *case temperature* at the rate of 28.6 mw/°C.
4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 1%.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

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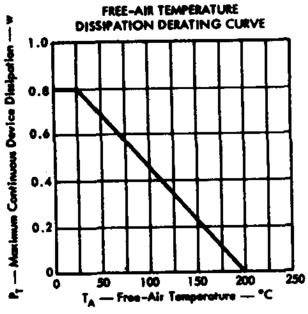
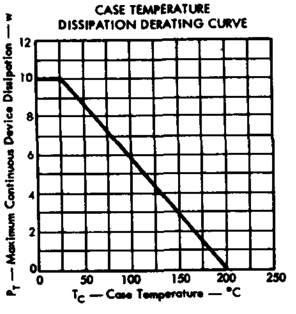
***electrical characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ v,	$I_C = 1$ ma,	f = 1 kc	25		
$\lvert h_{fe}\rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v,	$I_C = 30$ ma,	f = 20 Mc	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 20$ v,	$I_E = 0$,	f = 140 kc		9	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v,	$I_C = 0$,	f = 140 kc		80	pf
$Re(h_{ie})$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ v,	$I_C = 10$ ma,	f = 100 Mc		30	Ω

4

THERMAL INFORMATION





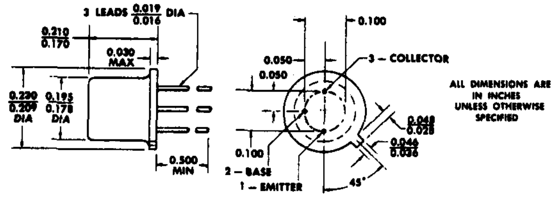
*Indicates JEDEC registered data

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

DESIGNED FOR USE IN LOW-LEVEL, LOW-NOISE AMPLIFIERS

- **Guaranteed Low-Noise Characteristics at 10 Hz, 100 Hz, 1 kHz and 10 kHz**
- **High Guaranteed h_{FE} at $I_C = 10\ \mu A \ldots 250$ Minimum**

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	60 V
Collector-Emitter Voltage (See Note 1)	60 V
Emitter-Base Voltage	6 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.36 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 W
Continuous Device Dissipation at 100°C Case Temperature	0.68 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.06 mW/deg.
3. Derate linearly to 200°C case temperature at the rate of 6.85 mW/deg.

*Indicates JEDEC registered data

USES CHIP N11

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 4	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ V, $I_E = 0$		10	nA
		$V_{CB} = 45$ V, $I_E = 0$, $T_A = 150°C$		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1\ \mu A$	100		
		$V_{CE} = 5$ V, $I_C = 10\ \mu A$	250	500	
		$V_{CE} = 5$ V, $I_C = 100\ \mu A$	300		
		$V_{CE} = 5$ V, $I_C = 1$ mA	400		
		$V_{CE} = 5$ V, $I_C = 10\ \mu A$, $T_A = -55°C$	50		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 100\ \mu A$		0.7	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.1$ mA, $I_C = 1$ mA		0.35	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz	10	24	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		400	900	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			8×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance			40	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 0.5$ mA, $f = 30$ MHz	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_E = 0$, $f = 140$ kHz		4.5	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 140$ kHz		6	pF

***operating characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 30\ \mu A$, $R_G = 10$ kΩ, $f = 10$ Hz, Noise Bandwidth = 2 Hz		15	dB
		$V_{CE} = 5$ V, $I_C = 30\ \mu A$, $R_G = 10$ kΩ, $f = 100$ Hz, Noise Bandwidth = 20 Hz		4	dB
		$V_{CE} = 5$ V, $I_C = 5\ \mu A$, $R_G = 50$ kΩ, $f = 1$ kHz, Noise Bandwidth = 200 Hz		1	dB
NF	Spot Noise Figure	$V_{CE} = 5$ V, $I_C = 5\ \mu A$, $R_G = 50$ kΩ, $f = 10$ kHz		1	dB

NOTE 4: This parameter must be measured using pulse techniques: $t_p = 300\ \mu s$, duty cycle $\leq 1\%$.

*Indicates JEDEC registered data

4

TEXAS INSTRUMENTS
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TYPES 2N3244, 2N3245, 2N3467, 2N3468
P-N-P SILICON TRANSISTORS

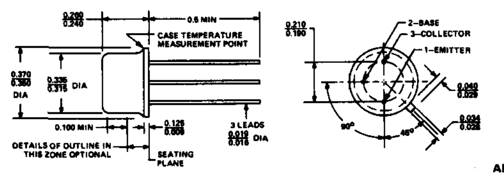
BULLETIN NO. DL-S 7310576, MAY 1968—REVISED MARCH 1973

DESIGNED FOR HIGH-SPEED CORE-DRIVER APPLICATIONS

- **High Dissipation Capability . . . 10 Watts at 25°C Case Temperature**
- **High $V_{(BR)CEO}$ . . . 50 V Min (2N3245, 2N3468)**
- **High Speed . . . 60 ns Max t_s at 500 mA (2N3467, 2N3468)**
- **High Collector Current Rating . . . 1 A**

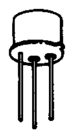
mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3244	2N3245	2N3467	2N3468	UNIT
Collector-Base Voltage	−40*	−50*	−40*	−50*	V
Collector-Emitter Voltage (See Note 1)	−40*	−50*	−40*	−50*	V
Emitter-Base Voltage	−5*	−5*	−5*	−5*	V
Continuous Collector Current	−1*	−1*	−1*	−1*	A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	1*	1*	1*	1*	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	10† 5*	10† 5*	10	10	W
Storage Temperature Range	−65 to 200*				°C
Lead Temperature 1/16 Inch from Case for 10 Seconds			230*		°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300*		300†		°C

NOTES: 1. These values apply between 0 and 1 A collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 5.71 mW/°C.
3. Derate the 10-watt TI value linearly to 200°C case temperature at the rate of 57.1 mW/°C.
Derate the 5-watt JEDEC value linearly to 200°C case temperature at the rate of 28.6 mW/°C.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable data in effect at the time of publication.
†These values are guaranteed by Texas Instruments in addition to the JEDEC registered values which are also shown.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N3244 MIN	2N3244 MAX	2N3245 MIN	2N3245 MAX	2N3467 MIN	2N3467 MAX	2N3468 MIN	2N3468 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−40		−50		−40		−50		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 4	−40		−50		−40		−50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−5		−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V, $I_E = 0$			−50				−100		−100	nA
		$V_{CB} = -30$ V, $I_E = 0$,	$T_A = 100°C$						−15		−15	μA
		$V_{CB} = -50$ V, $I_E = 0$					−50					nA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 3$ V			−50		−50		−100		−100	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 3$ V			80		80		120		120	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$			−30		−30					nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -150$ mA	See Note 4	60		35		40		25		
		$V_{CE} = -1$ V, $I_C = -500$ mA		50	150	30	90	40	120	25	75	
		$V_{CE} = -5$ V, $I_C = -750$ mA		25								
		$V_{CE} = -5$ V, $I_C = -1$ A				20		40		20		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA, $I_C = -150$ mA	See Note 4		−1.1		−1.1		−1		−1	V
		$I_B = -50$ mA, $I_C = -500$ mA		−0.75	−1.5	−0.75	−1.5	−0.8	−1.2	−0.8	−1.2	V
		$I_B = -75$ mA, $I_C = -750$ mA			−2							V
		$I_B = -100$ mA, $I_C = -1$ A					−2		−1.6		−1.6	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA, $I_C = -150$ mA	See Note 4		−0.3		−0.35		−0.3		−0.35	V
		$I_B = -50$ mA, $I_C = -500$ mA			−0.5		−0.6		−0.5		−0.6	V
		$I_B = -100$ mA, $I_C = -1$ A			−1		−1.2		−1		−1.2	V
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -50$ mA,	See Note 5	175		150		175		150		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$,	f = 100 kHz		25		25		25		25	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$,	f = 100 kHz		100		100		100		100	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

*Indicates JEDEC registered data

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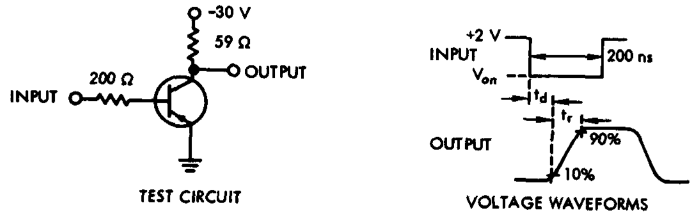
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N3244 MAX	2N3245 MAX	2N3467 MAX	2N3468 MAX	UNIT
t_d	Delay Time	$I_C = -500$ mA, $I_{B(1)} = -50$ mA, $V_{BE(off)} = 2$ V,	15	15	10	10	ns
t_r	Rise Time	$R_L = 59\ \Omega$, See Figure 1	35	40	30	30	ns
t_s	Storage Time	$I_C = -500$ mA, $I_{B(1)} = -50$ mA, $I_{B(2)} = 50$ mA,	140	120	60	60	ns
t_f	Fall Time	$R_L = 59\ \Omega$, See Figure 2	45	45	30	30	ns
Q_T	Total Control Charge	$I_C = -500$ mA, $I_B = -50$ mA, See Figure 3	14	12	6	6	nC

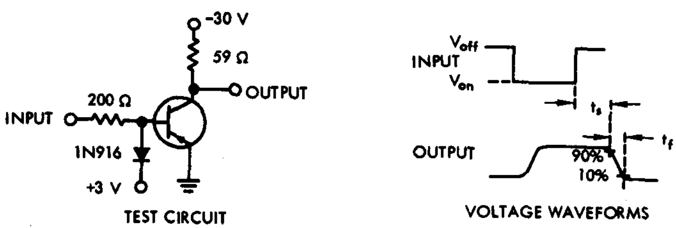
†Voltages and current values shown are nominal, exact values vary slightly with transistor parameters. Nominal base current for delay and rise times is calculated using the minimum values of V_{BE}. Nominal base currents for storage and fall times are calculated using the maximum value of V_{BE}.

*PARAMETER MEASUREMENT INFORMATION



$V_{on} = -10.75$ V for 2N3244, 2N3245
$V_{on} = -10.8$ V for 2N3467, 2N3468

FIGURE 1 — DELAY AND RISE TIMES



$V_{off} = 8.5$ V for 2N3244, 2N3245
$V_{off} = 8.8$ V for 2N3467, 2N3468
$V_{on} = -11.5$ V for 2N3244, 2N3245
$V_{on} = -11.[illegible] V for 2N3467, 2N3468

FIGURE 2 — STORAGE AND FALL TIMES

C = 1400 pF for 2N3244
C = 1200 pF for 2N3245
C = 600 pF for 2N3467, 2N3468

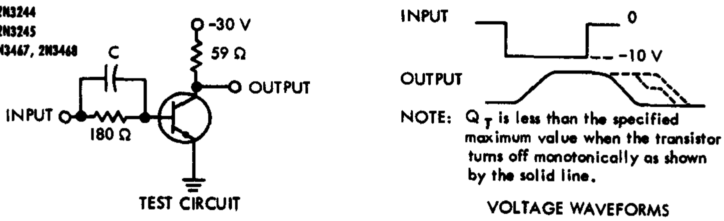


FIGURE 3 — TOTAL CONTROL CHARGE

NOTES: a. The input waveforms have the following characteristics:
For measuring delay and rise times: $t_r \leq 2$ ns, $t_p = 200$ ns, duty cycle $= 2\%$.
For measuring storage and fall times: $t_f \leq 5$ ns, $t_p = 2$ to 500 µs, duty cycle $= 2\%$.
For measuring Q_T: $t_f \leq 10$ ns, $t_p = 10$ µs, duty cycle $= 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

*Indicates JEDEC registered data

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PRINTED IN U.S.A.

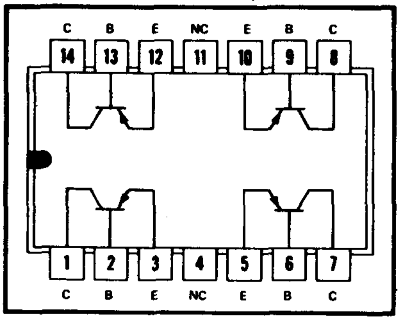
TYPE Q2T3244
QUAD P-N-P SILICON TRANSISTOR

BULLETIN NO. DL-S 7311704, APRIL 1972—REVISED MARCH 1973

FAST, HIGH-CURRENT CORE DRIVER

- h_{FE} . . . Guaranteed from 150 mA to 1 A
- $V_{(BR)CEO}$ . . . 40 V
- V_{BE} and $V_{CE(sat)}$ . . . Guaranteed from 150 mA to 1 A
- Guaranteed Switching Time at 500 mA

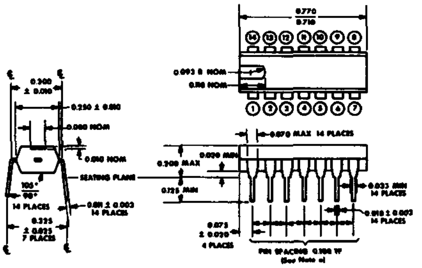
(TOP VIEW)



NC—No internal connection

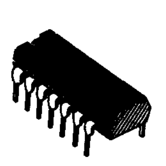
mechanical data

14-PIN PLASTIC DUAL-IN-LINE PACKAGE



NOTES:
a. The true-position pin spacing is 0.100 between centerlines. Each pin centerline is located within 0.010 of its true longitudinal position relative to pins 4 and 11.
b. All dimensions are in inches unless otherwise noted.

Falls Within JEDEC TO-116 and MO-001AA Dimensions



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	−40 V	
Collector-Emitter Voltage (See Note 1)	−40 V	
Emitter-Base Voltage	−5 V	
Continuous Collector Current	−1 A	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.5 W†	1.5 W†
Storage Temperature Range	−55°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←260°C→	

NOTES: 1. This value applies between 0 and 1 A collector current when the emitter-base diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rates of 4 mW/°C for each triode and 12 mW/°C for the total device.

†Previous editions of this data sheet showed higher power dissipation ratings which have been found to be in error. The new ratings correct these errors and do not represent product changes.

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TYPE Q2T3244
QUAD P-N-P EPITAXIAL PLANAR SILICON TRANSISTOR

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$		−40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA,	$I_B = 0$,	See Note 3	−40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V,	$I_E = 0$			−50	nA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30$ V,	$V_{BE} = 3$ V			−50	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30$ V,	$V_{BE} = 3$ V			80	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V,	$I_C = 0$			−30	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V,	$I_C = -150$ mA	See Note 3	60		
		$V_{CE} = -1$ V,	$I_C = -500$ mA		50	150	
		$V_{CE} = -5$ V,	$I_C = -750$ mA		25		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA,	$I_C = -150$ mA	See Note 3		−1.1	V
		$I_B = -50$ mA,	$I_C = -500$ mA		−0.75	−1.5	
		$I_B = -75$ mA,	$I_C = -750$ mA			−2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA,	$I_C = -150$ mA	See Note 3		−0.3	V
		$I_B = -50$ mA,	$I_C = -500$ mA			−0.5	
		$I_B = -100$ mA,	$I_C = -1$ A			−1	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -50$ mA,	f = 100 MHz	1.75		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V,	$I_E = 0$,	f = 1 MHz		25	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V,	$I_C = 0$,	f = 1 MHz		100	pF

NOTE 3: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$I_C = -500$ mA, $I_{B(1)} = -50$ mA, $V_{BE(off)} = 2$ V,	15	ns
t_r	Rise Time	$R_L = 59\ \Omega$, See Figure 1	35	ns
t_s	Storage Time	$I_C = -500$ mA, $I_{B(1)} = -50$ mA, $I_{B(2)} = 50$ mA,	140	ns
t_f	Fall Time	$R_L = 59\ \Omega$, See Figure 2	45	ns

†Voltages and current values shown are nominal; exact values vary slightly with transistor parameters. Nominal base current for delay and rise time is calculated using the minimum values of V_{BE}. Nominal base currents for storage and fall times are calculated using the maximum value of V_{BE}.

PARAMETER MEASUREMENT INFORMATION

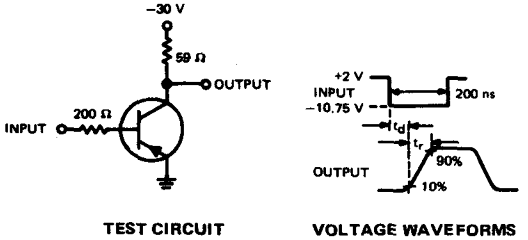


FIGURE 1—DELAY AND RISE TIMES

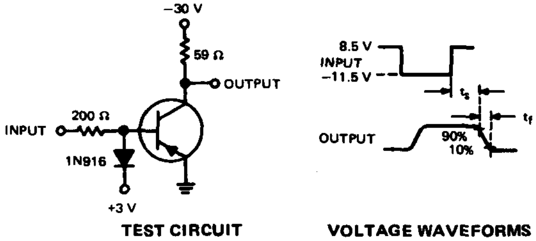


FIGURE 2—STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics:
For measuring delay and rise times: $t_r \leq 2$ ns, $t_w = 200$ ns, duty cycle = 2%.
For measuring storage and fall times: $t_f \leq 5$ ns, $t_w = 10$ to $500\ \mu s$, duty cycle = 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 7$ pF.

PRINTED IN U.S.A. 1078

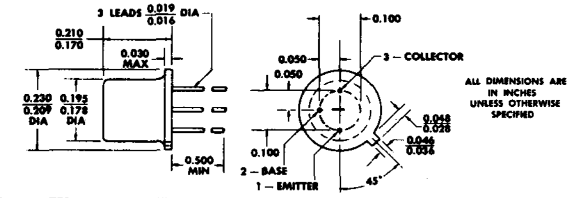
TYPES 2N3250, 2N3250A, 2N3251, 2N3251A
P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 679650, MARCH 1967

DESIGNED FOR LOW-POWER SATURATED-SWITCHING AND AMPLIFIER APPLICATIONS

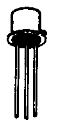
- Low-Level h_{FE}: 80 Min at 100 μA (2N3251 and 2N3251A)

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3250 2N3251	2N3250A 2N3251A
Collector-Base Voltage	−50 V	−60 V
Collector-Emitter Voltage (See Note 1)	−40 V	−60 V
Emitter-Base Voltage	−5 V	−5 V
Continuous Collector Current	←−200 mA→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 0.36 W →	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 1.2 W →	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 60 Seconds	← 300°C →	

*electrical characteristics at 25°C free-air temperature

	PARAMETER	TEST CONDITIONS		2N3250 MIN	2N3250 MAX	2N3250A MIN	2N3250A MAX	2N3251 MIN	2N3251 MAX	2N3251A MIN	2N3251A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−50		−60		−50		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 4	−40		−60		−40		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−5		−5		−5		−5		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 3$ V			−20		−20		−20		−20	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -40$ V, $V_{BE} = 3$ V			50		50		50		50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -0.1$ mA	See Note 4	40		40		80		80		
		$V_{CE} = -1$ V, $I_C = -1$ mA		45		45		90		90		
		$V_{CE} = -1$ V, $I_C = -10$ mA		50	150	50	150	100	300	100	300	
		$V_{CE} = -1$ V, $I_C = -50$ mA		15		15		30		30		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA, $I_C = -10$ mA	See Note 4	−0.6	−0.9	−0.6	−0.9	−0.6	−0.9	−0.6	−0.9	V
		$I_B = -5$ mA, $I_C = -50$ mA			−1.2		−1.2		−1.2		−1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA			−0.25		−0.25		−0.25		−0.25	V
		$I_B = -5$ mA, $I_C = -50$ mA			−0.5		−0.5		−0.5		−0.5	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -1$ mA, $f = 1$ kHz		1	6	1	6	2	12	2	12	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio			50	200	50	200	100	400	100	400	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio				10×10^{-4}		10×10^{-4}		20×10^{-4}		20×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance			4	40	4	40	10	60	10	60	μmho

NOTES: 1. These values apply between 0 and 200 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.06 mW/deg.
3. Derate linearly to 200°C case temperature at the rate of 6.9 mW/deg.
4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

*Indicates JEDEC registered data

USES CHIP P23

*electrical characteristics at 25°C free-air temperature (continued)

PARAMETER		TEST CONDITIONS	2N3250 2N3250A MIN	2N3250 2N3250A MAX	2N3251 2N3251A MIN	2N3251 2N3251A MAX	UNIT
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -20$ V, $I_C = -10$ mA, f = 100 MHz	2.5		3		
f_T	Transition Frequency	$V_{CE} = -20$ V, $I_C = -10$ mA, See Note 5	250		300		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 100 kHz		6		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -1$ V, $I_C = 0$, f = 100 kHz		8		8	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CE} = -20$ V, $I_C = -10$ mA, f = 31.8 MHz		250		250	ps

NOTE 5: To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

*operating characteristics at 25°C free-air temperature

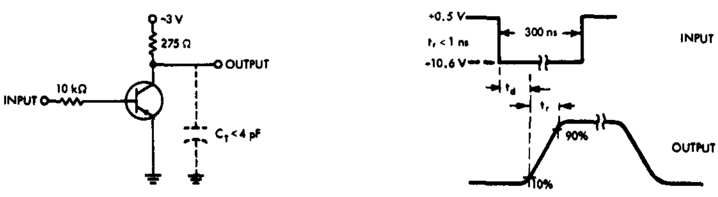
PARAMETER		TEST CONDITIONS	2N3250 2N3250A MAX	2N3251 2N3251A MAX	UNIT
NF	Spot Noise Figure	$V_{CE} = -5$ V, $I_C = -100\ \mu$A, $R_G = 1\ k\Omega$, f = 100 Hz	6	6	dB

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N3250 2N3250A MAX	2N3251 2N3251A MAX	UNIT
t_d	Delay Time	$I_C = -10$ mA, $I_{B(1)} = -1$ mA, $V_{BE(off)} = 0.5$ V,	35	35	ns
t_r	Rise Time	$R_L = 275\ \Omega$, See Figure 1	35	35	ns
t_s	Storage Time	$I_C = -10$ mA, $I_{B(1)} = -1$ mA, $I_{B(2)} = 1$ mA,	175	200	ns
t_f	Fall Time	$R_L = 275\ \Omega$, See Figure 2	50	50	ns

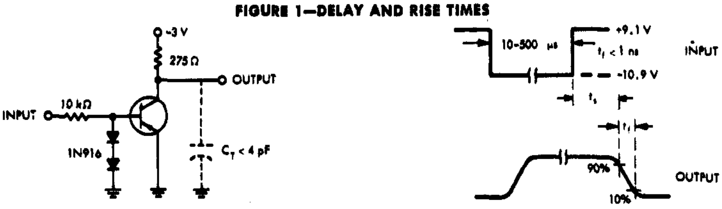
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters. Nominal base current for delay and rise times is calculated using the minimum value of V_{BE}. Nominal base currents for storage and fall times are calculated using the maximum value of V_{BE}.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 1—DELAY AND RISE TIMES



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 2 — STORAGE AND FALL TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, duty cycle = 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \le 1$ ns, $R_{in} \ge 100\ k\Omega$.

*Indicates JEDEC registered data

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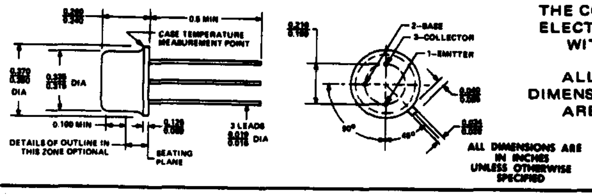
TYPES 2N3252, 2N3253
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 737436, MARCH 1965—REVISED MARCH 1973

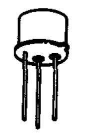
DESIGNED FOR HIGH-SPEED, HIGH-CURRENT SWITCHING APPLICATIONS

mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3252	2N3253
Collector-Base Voltage	60 v*	75 v*
Collector-Emitter Voltage (See Note 1)	30 v*	40 v*
Emitter-Base Voltage	5 v*	5 v*
Collector Current	←— 1 a* —→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←— 1 w* —→	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← {10 w†, 5 w*} →	
Storage Temperature Range	−65°C to +200°C*	
Lead Temperature 1/16 Inch from Case for 60 Seconds	←— 300°C* —→	

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N3252 MIN	2N3252 MAX	2N3253 MIN	2N3253 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu a$, $I_E = 0$		60		75		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$,	See Note 4	30		40		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$		5		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40$ v, $I_E = 0$			0.5			μa
		$V_{CB} = 60$ v, $I_E = 0$					0.5	μa
		$V_{CB} = 40$ v, $I_E = 0$,	$T_A = +100°C$		75			μa
		$V_{CB} = 60$ v, $I_E = 0$,	$T_A = +100°C$				75	μa
I_{CEV}	Collector Cutoff Current	$V_{CE} = 40$ v, $V_{BE} = -4$ v			0.5			μa
		$V_{CE} = 60$ v, $V_{BE} = -4$ v					0.5	μa
I_{BEV}	Base Cutoff Current	$V_{CE} = 40$ v, $V_{BE} = -4$ v			−0.5			μa
		$V_{CE} = 60$ v, $V_{BE} = -4$ v					−0.5	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ v, $I_C = 0$			50		50	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ v, $I_C = 150$ ma	See Note 4	30		25		
		$V_{CE} = 1$ v, $I_C = 500$ ma		30	90	25	75	
		$V_{CE} = 5$ v, $I_C = 1$ a		25		20		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma	See Note 4		1		1	v
		$I_B = 50$ ma, $I_C = 500$ ma		0.7	1.3	0.7	1.3	v
		$I_B = 100$ ma, $I_C = 1$ a			1.8		1.8	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma	See Note 4		0.3		0.35	v
		$I_B = 50$ ma, $I_C = 500$ ma			0.5		0.6	v
		$I_B = 100$ ma, $I_C = 1$ a			1		1.2	v
f_T	Transition Frequency	$V_{CE} = 10$ v, $I_C = 50$ ma,	See Note 5	200		175		Mc
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$,	f = 100 kc		12			pf
		$V_{CB} = 20$ v, $I_E = 0$,	f = 100 kc				12	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$,	f = 100 kc		80		80	pf

NOTES:
1. This value applies between 0 and 1 a collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 5.71 mw/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mw/°C. Derate the 5-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 28.6 mw/°C.
4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.
5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 db per octave from f = 100 Mc to the frequency at which $|h_{fe}| = 1$.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

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***switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS†	2N3252 MAX	2N3253 MAX	UNIT
t_d	Delay Time	$I_C = 500$ ma, $I_{B(1)} = 50$ ma, $V_{BE(off)} = -2$ v, $R_L = 59\ \Omega$, See Figure 1	15	15	nsec
t_r	Rise Time		30	35	nsec
t_s	Storage Time	$I_C = 500$ ma, $I_{B(1)} = -I_{B(2)} = 50$ ma, $R_L = 59\ \Omega$, See Figure 2	40	40	nsec
t_f	Fall Time		30	30	nsec
Q_T	Total Control Charge	$I_C = 500$ ma, $I_B = 50$ ma, See Figure 3	5	5	ncb

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION

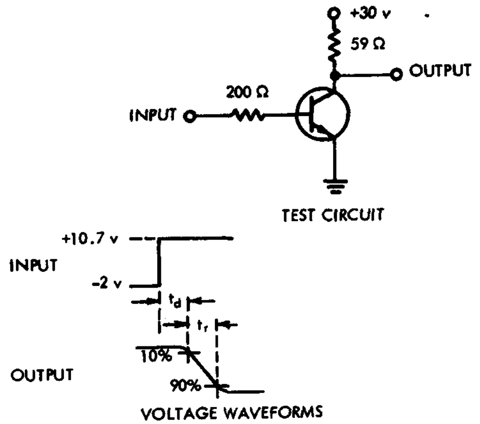


FIGURE 1 — DELAY AND RISE TIMES

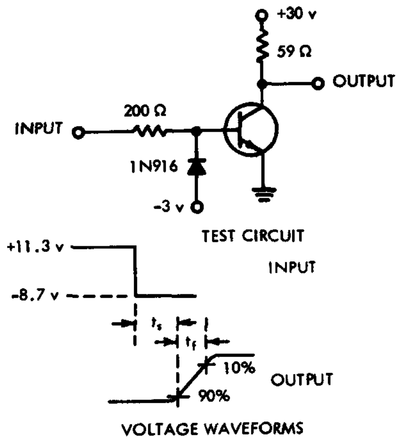
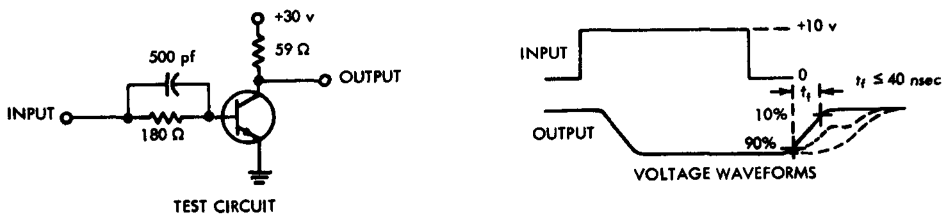


FIGURE 2 — STORAGE AND FALL TIMES



NOTE: $Q_T < 5$ ncb when the transistor turns off monotonically as shown by the solid line.

FIGURE 3 — TOTAL CONTROL CHARGE

NOTES: a. The input waveforms have the following characteristics:
For measuring delay and rise times: $t_r \leq 2$ nsec, PW ≥ 200 nsec, Duty Cycle $\leq 2\%$.
For measuring storage and fall times: $t_f \leq 5$ nsec, PW $= 10$ to 500 μsec, Duty Cycle $\leq 2\%$.
For measuring Q_T: $t_f \leq 10$ nsec, PW $= 10$ μsec, Duty Cycle $= 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec; $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pf.

*Indicates JEDEC registered data

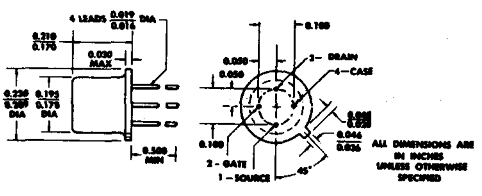
TYPES 2N3329 THRU 2N3332
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 644905, MARCH 1964

FOR SMALL-SIGNAL, LOW-NOISE APPLICATIONS

- **Active Elements Insulated from Case**
- **High Input Impedance (> 5 megohms at 1 kc)**

*mechanical data



THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Continuous Forward Gate Current . . . . −10 ma
Total Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1) . . . . 0.3 w
Storage Temperature Range . . . . −65°C to +200°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		2N3329		2N3330		2N3331		2N3332		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 10\ \mu a$,	$V_{DS} = 0$	20		20		20		20		v
I_{GSS}	Gate Cutoff Current	$V_{GS} = 10$ v,	$V_{DS} = 0$		0.01		0.01		0.01		0.01	µa
I_{GSS}	Gate Cutoff Current	$V_{GS} = 10$ v,	$V_{DS} = 0$, $T_A = 150°C$		10		10		10		10	µa
$I_{D(on)}$	Zero-Gate-Voltage Drain Current	$V_{DS} = -10$ v,	$V_{GS} = 0$	−1	−3	−2	−6	−5	−15	−1	−6	ma
V_{GS}	Gate-Source Cutoff Voltage	$V_{DS} = -15$ v,	$I_D = -10\ \mu a$		5		6		8		6	v
r_{DS}	Static Drain-Source Resistance	$I_D = -100\ \mu a$,	$V_{GS} = 0$		1000		800		600			ohm
$\lvert y_{is} \rvert$	Small-Signal Common-Source Input Admittance	$V_{DS} = -10$ v, $f = 1$ kc	I_D — See Note 2,		0.2		0.2		0.2		0.2	µmho
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ v, $f = 1$ kc	I_D — See Note 2,	1000	2000	1500	3000	2000	4000	1000	2200	µmho
$\lvert y_{rs} \rvert$	Small-Signal Common-Source Reverse Transfer Admittance	$V_{DS} = -10$ v, $f = 1$ kc	I_D — See Note 2,		0.1		0.1		0.1		0.1	µmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = -10$ v, $f = 1$ kc	I_D — See Note 2,		20		40		100		20	µmho
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ v, $f = 10$ Mc	I_D — See Note 2,	900		1350		1800		900		µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -10$ v, $f = 1$ Mc	$V_{GS} = 1$ v,		20		20		20		20	pf

*operating characteristics at 25°C free-air temperature

				2N3329	2N3330	2N3331	2N3332	
NF	Spot Noise Figure	$V_{DS} = -5$ v, $f = 1$ kc,	$I_D = -1$ ma, $R_G = 1\ M\Omega$	3	3	4	1	db
NF	Spot Noise Figure	$V_{DS} = -5$ v, $f = 10$ cps,	$I_D = -1$ ma, $R_G = 10\ M\Omega$				5	db

NOTE 1: Derate linearly to 175°C free-air temperature at the rate of 2 mw/C°.

	2N3329	2N3330	2N3331	2N3332
NOTE 2: I_D =	−1 ma	−2 ma	−5 ma	−1 ma

†The fourth lead (case) is connected to the source for all measurements.

*Indicates JEDEC registered data.

USES CHIP JP71

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TEXAS INSTRUMENTS INCORPORATED
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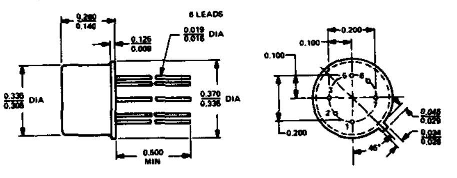
BULLETIN NO. DL-S 7211681, MARCH 1972

TWO P-N-P TRANSISTORS IN ONE PACKAGE

- Each Triode Electrically Similar to 2N2604 and 2N2605 Transistors
- Recommended for Low-Noise, High-Gain Differential Amplifiers
- Designed for Complementary Use with 2N2639 through 2N2644 Dual N-P-N Transistors

*mechanical data

ALL LEADS INSULATED FROM CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

*absolute maximum ratings at 25° C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	−60 V	
Collector-Emitter Voltage (See Note 1)	−45 V	
Emitter-Base Voltage	−6 V	
Continuous Collector Current	−30 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.3 W	0.6 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.6 W	1.2 W
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 230°C →	

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rates of 2 mW/°C for each triode and 4 mW/°C for total device.
3. Derate linearly to 175°C case temperature at the rates of 4 mW/°C for each triode and 8 mW/°C for total device.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	2N3347 2N3348 2N3349 MIN	2N3347 2N3348 2N3349 MAX	2N3350 2N3351 2N3352 MIN	2N3350 2N3351 2N3352 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−60		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 5	−45		−45		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−6		−6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -45$ V, $I_E = 0$		−10		−10	nA
		$V_{CB} = -45$ V, $I_E = 0$, $T_A = 150°C$		−10		−10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -6$ V, $I_C = 0$		−2		−2	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -10\ \mu A$	40	300	100	300	
		$V_{CE} = -5$ V, $I_C = -1$ mA	60		150		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -10$ mA		−0.9		−0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.5$ mA, $I_C = -10$ mA		−0.5		−0.5	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz	1.5	20	3.7	20	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		60	600	150	600	
h_{oe}	Small-Signal Common-Emitter Output Admittance			100		100	μmho
$\lvert h_{fe}\rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 30 MHz	2	8	2	8	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 1 MHz		6		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 1 MHz		8		8	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N3347 2N3350 MIN	2N3347 2N3350 MAX	2N3348 2N3351 MIN	2N3348 2N3351 MAX	2N3349 2N3352 MIN	2N3349 2N3352 MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current-Gain Balance Ratio	$V_{CE} = -5$ V, $I_C = -10\ \mu A$, See Note 6	0.9	1	0.8	1	0.6	1	
$\lvert V_{BE1} - V_{BE2}\rvert$	Base-Emitter-Voltage Differential	$V_{CE} = -5$ V, $I_C = -10\ \mu A$		5		10		20	mV
$\lvert \Delta(V_{BE1} - V_{BE2})/\Delta T_A\rvert$	Base-Emitter-Voltage-Differential Change with Temperature	$V_{CE} = -5$ V, $I_C = -10\ \mu A$, $T_{A(1)} = 25°C$, $T_{A(2)} = -55°C$		0.8		1.6		3.2	mV
		$V_{CE} = -5$ V, $I_C = -10\ \mu A$, $T_{A(1)} = 25°C$, $T_{A(2)} = 125°C$		1		2		4	mV

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	ALL TYPES MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -10\ \mu A$, $R_G = 10$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 7	4	dB

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
6. The lower of the two h_{FE} readings is taken as h_{FE1}.
7. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data

473 PRINTED IN U.S.A.

BULLETIN NO. DL-S 7311931, MARCH 1973

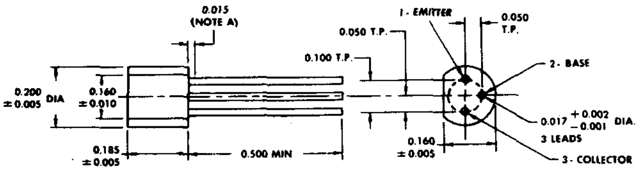
SILECT† TRANSISTORS‡

- For Small-Signal Amplifier Applications
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration
- A7T3391, A7T3391A, and A7T3392 are Plug-In Replacements for 2N3391, 2N3391A, 2N3392 (TO-98 Package)

mechanical data

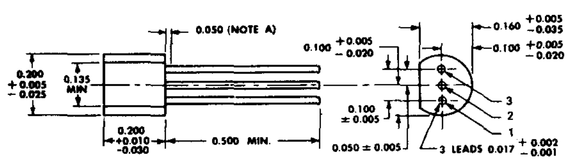
These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

A5T3391, A5T3391A, A5T3392



NOTES A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

A7T3391, A7T3391A, A7T3392, A8T3391, A8T3391A, A8T3392



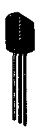
NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

DEVICE	LEADS 1	2	3
A7T3391, A7T3391A, A7T3392	Emitter	Collector	Base
A8T3391, A8T3391A, A8T3392	Emitter	Base	Collector

A7T3391
A7T3391A
A7T3392

A8T3391
A8T3391A
A8T3392



ECB

EBC

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	25 V
Collector-Emitter Voltage (See Note 1)	25 V
Emitter-Base Voltage	5 V
Continuous Collector Current	100 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C at the rate of 5 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		A5T3391 A7T3391 A8T3391 A5T3391A A7T3391A A8T3391A MIN	MAX	A5T3392 A7T3392 A8T3392 MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA, $I_B = 0$	See Note 3			25		V
		$I_C = 10$ mA, $I_B = 0$	See Note 3	25				V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 25$ V, $I_B = 0$			100		100	nA
		$V_{CB} = 25$ V, $I_B = 0$,	$T_A = 100°C$		10		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$			100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 4.5$ V, $I_C = 2$ mA		250	500	150	300	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 4.5$ V, $I_C = 2$ mA,	f = 1 kHz	250	800	150	500	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$,	f = 1 MHz	2	10	2	10	pF

NOTE 3: This parameter must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.

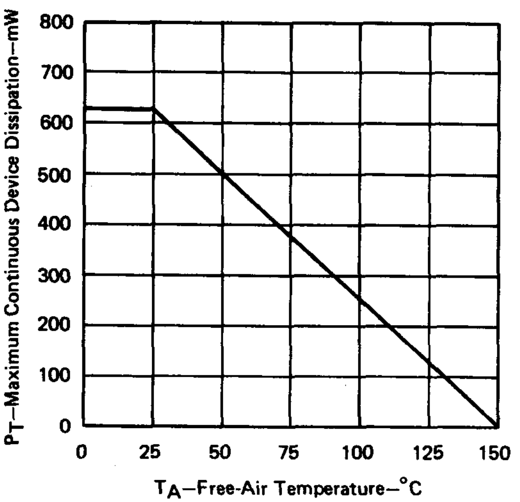
operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T3391A A7T3391A A8T3391A MIN	MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{CE} = 4.5$ V, $I_C = 100$ μA, $R_G = 500$ Ω, Noise Bandwidth = 15.7 kHz, See Note 4		5	dB

NOTE 4: Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

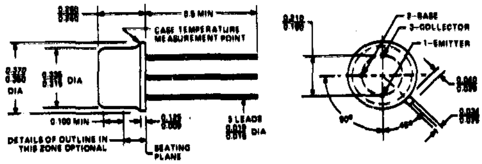


BULLETIN NO. DL-S 737437, MARCH 1965—REVISED MARCH 1973

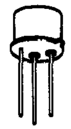
DESIGNED FOR HIGH-SPEED, HIGH-CURRENT SWITCHING APPLICATIONS

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	80 v*
Collector-Emitter Voltage (See Note 1)	50 v*
Emitter-Base Voltage	5 v*
Collector Current	1 a*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	1 w*
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	10 w† / 5 w*
Storage Temperature Range	−65°C to 200°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C† / 240°C*

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS		MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu a$, $I_E = 0$		80		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$,	See Note 4	50		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$		5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60$ v, $I_E = 0$			0.5	μa
		$V_{CB} = 60$ v, $I_E = 0$,	$T_A = 100°C$		75	μa
I_{CEV}	Collector Cutoff Current	$V_{CE} = 60$ v, $V_{BE} = -4$ v			0.5	μa
I_{BEV}	Base Cutoff Current	$V_{CE} = 60$ v, $V_{BE} = -4$ v			−0.5	μa
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ v, $I_C = 0$			50	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ v, $I_C = 150$ ma	See Note 4	20		
		$V_{CE} = 1$ v, $I_C = 500$ ma		20	60	
		$V_{CE} = 5$ v, $I_C = 1$ a		15		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma	See Note 4		1	v
		$I_B = 50$ ma, $I_C = 500$ ma		0.7	1.3	v
		$I_B = 100$ ma, $I_C = 1$ a			1.8	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma	See Note 4		0.35	v
		$I_B = 50$ ma, $I_C = 500$ ma			0.6	v
		$I_B = 100$ ma, $I_C = 1$ a			1.2	v
f_T	Transition Frequency	$V_{CE} = 10$ v, $I_C = 50$ ma,	See Note 5	150		Mc
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$,	f = 100 kc		12	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ v, $I_C = 0$,	f = 100 kc		80	pf

NOTES:
1. This value applies between 0 and 1 a collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 5.71 mw/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mw/°C. Derate the 5-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 28.6 mw/°C.
4. These parameters must be measured using pulse techniques. PW = 300 μs, Duty Cycle ≤ 2%.
5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 db per octave from f = 100 Mc to the frequency at which $|h_{fe}| = 1$.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of *lead length*.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†These values are guaranteed by Texas Instruments in addition to the JEDEC registered values which are also shown.

USES CHIP N13

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***switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$I_C = 500$ ma, $I_{B(1)} = 50$ ma, $V_{BE(off)} = -2$ v,	15	nsec
t_r	Rise Time	$R_L = 59\ \Omega$, See Figure 1	35	nsec
t_s	Storage Time	$I_C = 500$ ma, $I_{B(1)} = -I_{B(2)} = 50$ ma,	40	nsec
t_f	Fall Time	$R_L = 59\ \Omega$, See Figure 2	30	nsec
Q_T	Total Control Charge	$I_C = 500$ ma, $I_B = 50$ ma, See Figure 3	5	ncb

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION

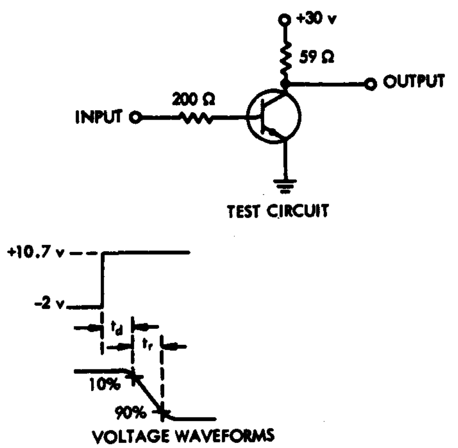


FIGURE 1 — DELAY AND RISE TIMES

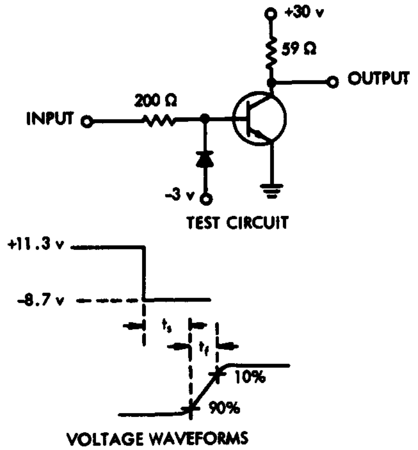
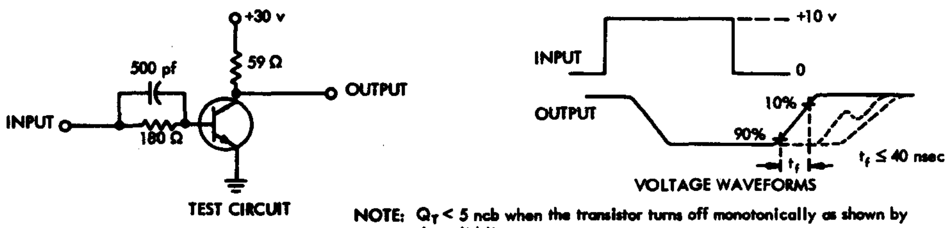


FIGURE 2 — STORAGE AND FALL TIMES



NOTE: $Q_T < 5$ ncb when the transistor turns off monotonically as shown by the solid line.

FIGURE 3 — TOTAL CONTROL CHARGE

NOTES: a. The input waveforms have the following characteristics:
For measuring delay and rise times; $t_r \leq 2$ nsec, PW ≥ 200 nsec, Duty Cycle $\leq 2\%$.
For measuring storage and fall times; $t_f \leq 5$ nsec, PW $= 10$ to $200\ \mu$sec, Duty Cycle $\leq 2\%$.
For measuring Q_T; $t_f \leq 10$ nsec, PW $= 10\ \mu$sec, Duty Cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pf.

*Indicates JEDEC registered data

TEXAS INSTRUMENTS
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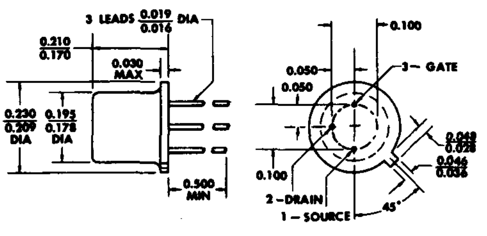
TYPES 2N3458, 2N3459, 2N3460
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7011297, APRIL 1970

FOR INDUSTRIAL AND CONSUMER SMALL-SIGNAL, LOW-NOISE APPLICATIONS

*mechanical data

THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	50 V
Reverse Gate-Source Voltage	–50 V
Continuous Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	–65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE 1: Derate linearly to 200°C free-air temperature at the rate of 1.71 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN51

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N3458 MIN	2N3458 MAX	2N3459 MIN	2N3459 MAX	2N3460 MIN	2N3460 MAX	UNIT
I_{GSS}	Gate Reverse Current	$V_{GS} = -30$ V,	$V_{DS} = 0$		−0.25		−0.25		−0.25	nA
		$V_{GS} = -30$ V, $T_A = 150°C$	$V_{DS} = 0$,		−0.5		−0.5		−0.5	μA
I_{DGO}	Drain Reverse Current	$V_{DG} = 50$ V,	$I_S = 0$		1		1		1	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 20$ V,	$I_D = 1$ nA		−8		−4		−2	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 20$ V,	$I_D = 1$ μA		−7.8		−3.4		−1.8	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 20$ V, See Note 2	$V_{GS} = 0$,	3	15	0.8	4	0.2	1	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 20$ V, f = 1 kHz,	$V_{GS} = 0$, See Note 3	2.5	10	1.5	6	0.8	4.5	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 10$ V, f = 1 MHz	$V_{GS} = 0$,		18					pF
		$V_{DS} = 6$ V, f = 1 MHz	$V_{GS} = 0$,				18			pF
		$V_{DS} = 4$ V, f = 1 MHz	$V_{GS} = 0$,						18	pF
C_{oss}	Common-Source Short-Circuit Output Capacitance	$V_{DS} = 30$ V, f = 1 MHz,	$V_{GS} = 0$, See Notes 3 and 4		5		5		5	pF
g_{os}	Small-Signal Common-Source Output Conductance	$V_{DS} = 30$ V, f = 1 MHz,	$V_{GS} = 0$, See Note 3		35		20		5	μmho

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3458 MIN	2N3458 MAX	2N3459 MIN	2N3459 MAX	2N3460 MIN	2N3460 MAX	UNIT
NF	Common-Source Spot Noise Figure	$V_{DS} = 10$ V, $V_{GS} = 0$, $R_G = 1$ MΩ, f = 20 Hz, Noise Bandwidth = 6 Hz		6		4		4	dB

NOTES: 2. This parameter must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
3. These parameters must be measured with bias conditions applied for less than 5 seconds to avoid overheating.
4. C_{oss} is defined as the imaginary part of small-signal common-source output susceptance divided by $2\pi f$.

*JEDEC registered data

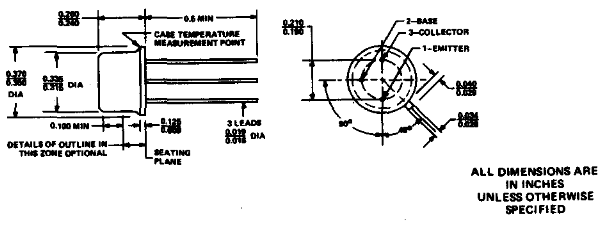
BULLETIN NO. DL-S 7310576, MAY 1968—REVISED MARCH 1973

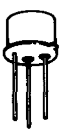
DESIGNED FOR HIGH-SPEED CORE-DRIVER APPLICATIONS

- **High Dissipation Capability . . . 10 Watts at 25°C Case Temperature**
- **High $V_{(BR)CEO}$ . . . 50 V Min (2N3245, 2N3468)**
- **High Speed . . . 60 ns Max t_s at 500 mA (2N3467, 2N3468)**
- **High Collector Current Rating . . . 1 A**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE◆

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3244	2N3245	2N3467	2N3468	UNIT
Collector-Base Voltage	−40*	−50*	−40*	−50*	V
Collector-Emitter Voltage (See Note 1)	−40*	−50*	−40*	−50*	V
Emitter-Base Voltage	−5*	−5*	−5*	−5*	V
Continuous Collector Current	−1*	−1*	−1*	−1*	A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	1*	1*	1*	1*	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	10† 5*	10† 5*	10	10	W
Storage Temperature Range	−65 to 200*				°C
Lead Temperature 1/16 Inch from Case for 10 Seconds			230*		°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300*		300†		°C

NOTES: 1. These values apply between 0 and 1 A collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 5.71 mW/°C.
3. *Derate the 10-watt TI value linearly to 200°C case temperature at the rate of 57.1 mW/°C.*
Derate the 5-watt JEDEC value linearly to 200°C case temperature at the rate of 28.6 mW/°C.

◆The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable data in effect at the time of publication.
†These values are guaranteed by Texas Instruments in addition to the JEDEC registered values which are also shown.

USES CHIP P12

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		2N3244 MIN	2N3244 MAX	2N3245 MIN	2N3245 MAX	2N3467 MIN	2N3467 MAX	2N3468 MIN	2N3468 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−40		−50		−40		−50		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 4	−40		−50		−40		−50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−5		−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V, $I_E = 0$			−50				−100		−100	nA
		$V_{CB} = -30$ V, $I_E = 0$,	$T_A = 100°C$						−15		−15	μA
		$V_{CB} = -50$ V, $I_E = 0$					−50					nA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 3$ V			−50		−50		−100		−100	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 3$ V			80		80		120		120	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$			−30		−30					nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -150$ mA	See Note 4	60		35		40		25		
		$V_{CE} = -1$ V, $I_C = -500$ mA		50	150	30	90	40	120	25	75	
		$V_{CE} = -5$ V, $I_C = -750$ mA		25								
		$V_{CE} = -5$ V, $I_C = -1$ A				20		40		20		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA, $I_C = -150$ mA	See Note 4		−1.1		−1.1		−1		−1	V
		$I_B = -50$ mA, $I_C = -500$ mA		−0.75	−1.5	−0.75	−1.5	−0.8	−1.2	−0.8	−1.2	V
		$I_B = -75$ mA, $I_C = -750$ mA			−2							V
		$I_B = -100$ mA, $I_C = -1$ A					−2		−1.6		−1.6	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA, $I_C = -150$ mA	See Note 4		−0.3		−0.35		−0.3		−0.35	V
		$I_B = -50$ mA, $I_C = -500$ mA			−0.5		−0.6		−0.5		−0.6	V
		$I_B = -100$ mA, $I_C = -1$ A			−1		−1.2		−1		−1.2	V
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -50$ mA,	See Note 5	175		150		175		150		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$,	f = 100 kHz		25		25		25		25	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$,	f = 100 kHz		100		100		100		100	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

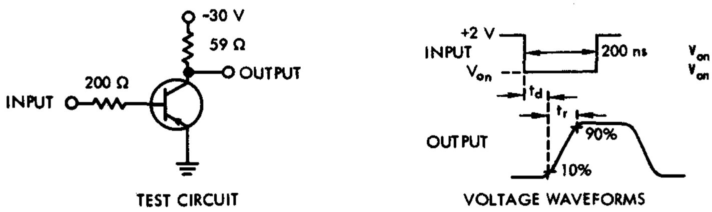
*Indicates JEDEC registered data

***switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS†	2N3244 MAX	2N3245 MAX	2N3467 MAX	2N3468 MAX	UNIT
t_d	Delay Time	$I_C = -500$ mA, $I_{B(1)} = -50$ mA, $V_{BE(off)} = 2$ V,	15	15	10	10	ns
t_r	Rise Time	$R_L = 59\ \Omega$, See Figure 1	35	40	30	30	ns
t_s	Storage Time	$I_C = -500$ mA, $I_{B(1)} = -50$ mA, $I_{B(2)} = 50$ mA,	140	120	60	60	ns
t_f	Fall Time	$R_L = 59\ \Omega$, See Figure 2	45	45	30	30	ns
Q_T	Total Control Charge	$I_C = -500$ mA, $I_B = -50$ mA, See Figure 3	14	12	6	6	nC

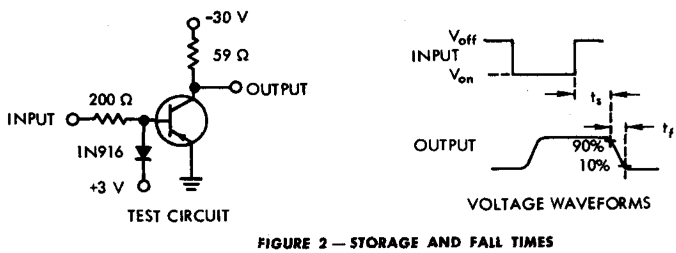
†Voltages and current values shown are nominal, exact values vary slightly with transistor parameters. Nominal base current for delay and rise times is calculated using the minimum values of V_{BE}. Nominal base currents for storage and fall times are calculated using the maximum value of V_{BE}.

*PARAMETER MEASUREMENT INFORMATION



$V_{on} = -10.75$ V for 2N3244, 2N3245
$V_{on} = -10.8$ V for 2N3467, 2N3468

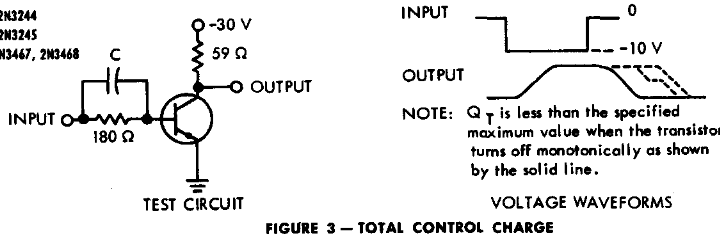
FIGURE 1 — DELAY AND RISE TIMES



$V_{off} = 8.5$ V for 2N3244, 2N3245
$V_{off} = 8.8$ V for 2N3467, 2N3468
$V_{on} = -11.5$ V for 2N3244, 2N3245
$V_{on} = -11.2$ V for 2N3467, 2N3468

FIGURE 2 — STORAGE AND FALL TIMES

C = 1400 pF for 2N3244
C = 1200 pF for 2N3245
C = 600 pF for 2N3467, 2N3468



NOTE: Q_T is less than the specified maximum value when the transistor turns off monotonically as shown by the solid line.

VOLTAGE WAVEFORMS

FIGURE 3 — TOTAL CONTROL CHARGE

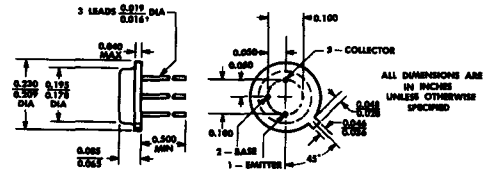
NOTES: a. The input waveforms have the following characteristics:
For measuring delay and rise times: $t_r \leq 2$ ns, $t_p = 200$ ns, duty cycle = 2%.
For measuring storage and fall times: $t_f \leq 5$ ns, $t_p = 2$ to 500 μs, duty cycle = 2%.
For measuring Q_T: $t_f \leq 10$ ns, $t_p = 10$ μs, duty cycle = 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

*Indicates JEDEC registered data

DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **Electrically Identical to 2N2906, 2N2906A, 2N2907, and 2N2907A in Space-Saving TO-46 Package**
- **High Breakdown Voltage Combined With Very Low Saturation Voltage**

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE.

ALL JEDEC TO-46 DIMENSIONS AND NOTES ARE APPLICABLE.

†TI guaranteed minimum. The JEDEC registered minimum lead diameter for the TO-46 is 0.012.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3485 2N3486	2N3485A 2N3486A
*Collector-Base Voltage	−60 v	−60 v
*Collector-Emitter Voltage (See Note 1)	−40 v	−60 v
*Emitter-Base Voltage	−5 v	−5 v
*Collector Current	←— −0.6 a —→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←— 0.4 w —→	
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	←— 2 w —→	
*Storage Temperature Range	−65°C to +200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←— 300°C —→	

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3485 MIN	2N3485 MAX	2N3486 MIN	2N3486 MAX	2N3485A MIN	2N3485A MAX	2N3486A MIN	2N3486A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu a$, $I_E = 0$	−60		−60		−60		−60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ ma, $I_B = 0$, See Note 4	−40		−40		−60		−60		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu a$, $I_C = 0$	−5		−5		−5		−5		v
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ v, $I_E = 0$		−20		−20		−10		−10	na
		$V_{CB} = -50$ v, $I_E = 0$, $T_A = 150°C$		−20		−20		−10		−10	μa
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30$ v, $V_{BE} = 0.5$ v		−50		−50		−50		−50	na
I_{BEV}	Base Cutoff Current	$V_{CE} = -30$ v, $V_{BE} = 0.5$ v		50		50		50		50	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -100\ \mu a$	20		35		40		75		
		$V_{CE} = -10$ v, $I_C = -1$ ma	25		50		40		100		
		$V_{CE} = -10$ v, $I_C = -10$ ma	35		75		40		100		
		$V_{CE} = -10$ v, $I_C = -150$ ma, See Note 4	40	120	100	300	40	120	100	300	
		$V_{CE} = -10$ v, $I_C = -500$ ma, See Note 4	20		30		40		50		
		$V_{CE} = -1$ v, $I_C = -150$ ma, See Note 4	20		50		20		50		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ ma, $I_C = -150$ ma, See Note 4		−1.3		−1.3		−1.3		−1.3	v
		$I_B = -50$ ma, $I_C = -500$ ma, See Note 4		−2.6		−2.6		−2.6		−2.6	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ ma, $I_C = -150$ ma, See Note 4		−0.4		−0.4		−0.4		−0.4	v
		$I_B = -50$ ma, $I_C = -500$ ma, See Note 4		−1.6		−1.6		−1.6		−1.6	v

NOTES: 1. This value applies between 0 and 100 ma collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.28 mw/°C.
3. Derate linearly to 200°C case temperature at the rate of 11.43 mw/°C.
4. These parameters must be measured using pulse techniques. PW ≤ 300 μsec, Duty Cycle ≤ 2%.

*JEDEC registered data

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TYPES 2N3485, 2N3485A, 2N3486, 2N3486A
P-N-P SILICON TRANSISTORS

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	ALL TYPES MIN	ALL TYPES MAX	UNIT
$\lvert h_{fe}\rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -20$ v, $I_C = -50$ ma, $f = 100$ Mc	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ v, $I_E = 0$, $f = 100$ kc		8	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -2$ v, $I_C = 0$, $f = 100$ kc		30	pf

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	ALL TYPES MAX	UNIT
t_d	Delay Time	$I_C = -150$ ma, $I_{B(1)} = -15$ ma, $V_{BE(off)} = 0$,	10	nsec
t_r	Rise Time	$R_L = 200\ \Omega$, See Figure 1	40	nsec
t_s	Storage Time	$I_C = -150$ ma, $I_{B(1)} = -13$ ma, $I_{B(2)} = 17$ ma,	80	nsec
t_f	Fall Time	$R_L = 37\ \Omega$, See Figure 2	30	nsec

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION

TEST CIRCUIT

(See Notes a and b)
VOLTAGE WAVEFORMS

FIGURE 1—DELAY AND RISE TIMES

TEST CIRCUIT

(See Notes a and b)
VOLTAGE WAVEFORMS

FIGURE 2—STORAGE AND FALL TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 2$ nsec, $t_f \leq 2$ nsec, PW = 200 nsec, PRR = 150 pps.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ nsec, $R_{in} = 10$ MΩ.

* JEDEC registered data.

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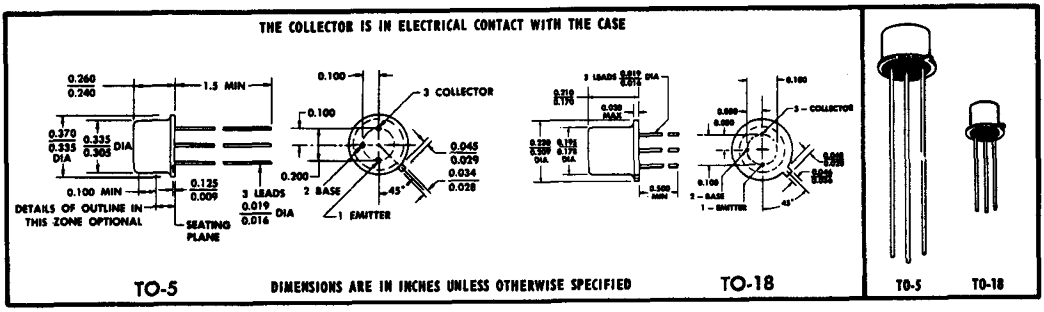
BULLETIN NO. DL-S 679868, MARCH 1967

HIGH-VOLTAGE TRANSISTORS
FULLY CHARACTERIZED FOR HIGH-SPEED, LOW-NOISE, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **h_{FE} Guaranteed from 100 μA to 100 mA**

*mechanical data

Device types 2N3494 and 2N3495 are in JEDEC TO-5 packages.
Device types 2N3496 and 2N3497 are in JEDEC TO-18 packages.



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3494	2N3495	2N3496	2N3497	UNIT
Collector-Base Voltage	−80	−120	−80	−120	V
Collector-Emitter Voltage (See Note 1)	−80	−120	−80	−120	V
Emitter-Base Voltage	−4.5	−4.5	−4.5	−4.5	V
Continuous Collector Current	−100	−100	−100	−100	mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 2 and 3)	0.6	0.6	0.4	0.4	W
Storage Temperature Range	−65 to 200				°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300				°C

NOTES: 1. These values apply between 0 and 100 mA collector current when the base-emitter diode is open-circuited.
2. Derate 2N3494 and 2N3495 linearly to 200°C free-air temperature at the rate of 3.43 mW/deg. See Figure 3.
3. Derate 2N3496 and 2N3497 linearly to 200°C free-air temperature at the rate of 2.28 mW/deg. See Figure 4.

*JEDEC registered data

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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		TO-5 → 2N3494 / TO-18 → 2N3496 MIN	MAX	2N3495 / 2N3497 MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−80		−120		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 4	−80		−120		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−4.5		−4.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V, $I_E = 0$			−0.1			μA
		$V_{CB} = -90$ V, $I_E = 0$					−0.1	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$			−25		−25	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -100\ \mu A$	See Note 4	35		35		
		$V_{CE} = -10$ V, $I_C = -1$ mA		40		40		
		$V_{CE} = -10$ V, $I_C = -10$ mA		40		40		
		$V_{CE} = -10$ V, $I_C = -50$ mA		40		40		
		$V_{CE} = -10$ V, $I_C = -100$ mA		35				
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA, $I_C = -10$ mA,	See Note 4	−0.6	−0.9	−0.6	−0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA,	See Note 4		−0.3		−0.35	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz		0.1	1.2	0.1	1.2	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio			40	300	40	300	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio				2×10^{-4}		2×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance				300		300	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -20$ mA, $f = 100$ MHz		2		1.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, $f = 100$ kHz			7		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -2$ V, $I_C = 0$, $f = 100$ kHz			30		30	pF
$Re(h_{ie})$	Small-Signal Common-Emitter Input Resistance	$V_{CE} = -10$ V, $I_C = -20$ mA, $f = 300$ MHz			30		30	Ω

NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle ≤ 2%.

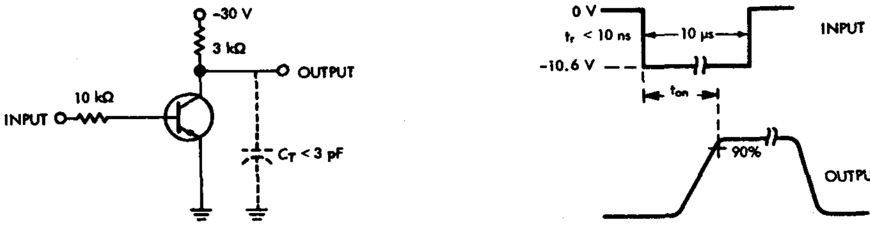
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_{on}	Turn-On Time	$I_C = -10$ mA, $I_{B(1)} = -1$ mA, $V_{BE(off)} = 0$, $R_L = 3$ kΩ, See Figure 1	300	ns
t_{off}	Turn-Off Time	$I_C = -10$ mA, $I_{B(1)} = -1$ mA, $I_{B(2)} = 1$ mA, $R_L = 3$ kΩ, See Figure 2	1	μs

*JEDEC registered data

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters. Nominal base current for turn-on time is calculated using a minimum value of V_{BE}. Nominal base currents for turn-off times are calculated using the maximum value of V_{BE}.

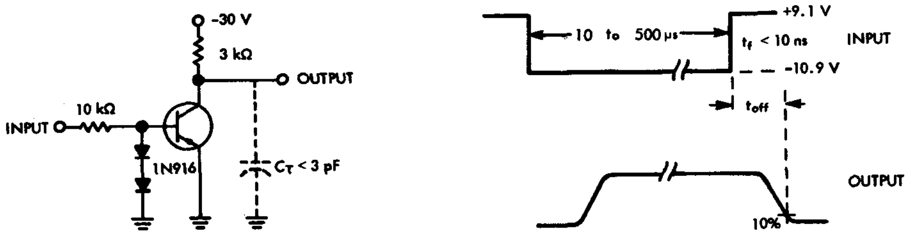
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 1 — TURN-ON TIME



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 2 — TURN-OFF TIME

NOTES: a. The input waveforms are supplied by a generator with $Z_{out} = 50\ \Omega$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 10$ ns, $R_{in} \geq 100$ kΩ.

* JEDEC registered data

THERMAL INFORMATION

2N3494, 2N3495
DISSIPATION DERATING CURVE

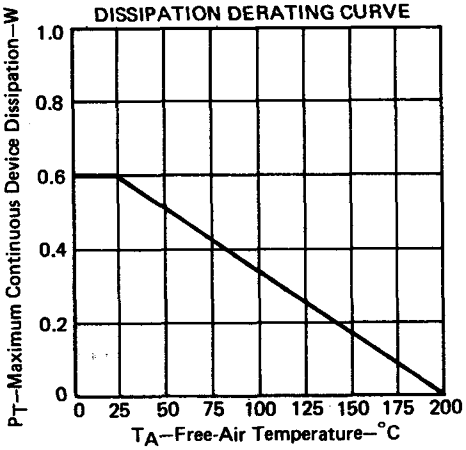


FIGURE 3

2N3496, 2N3497
DISSIPATION DERATING CURVE

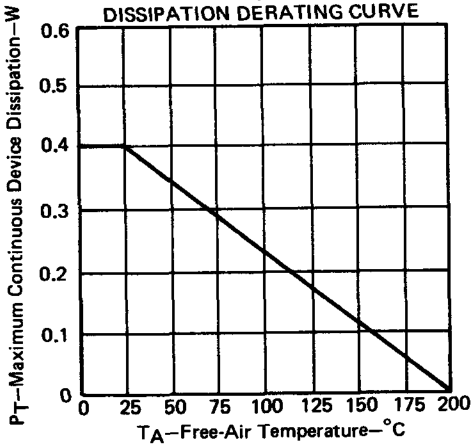


FIGURE 4

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TYPES A5T3496, A5T3497
P-N-P SILICON TRANSISTORS

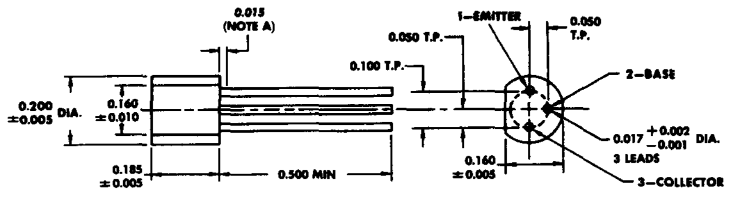
BULLETIN NO. DL-S 7311953, MARCH 1973

SILECT† TRANSISTORS‡
FOR HIGH-VOLTAGE, MEDIUM-SPEED, GENERAL PURPOSE APPLICATIONS

- **High $V_{(BR)CEO}$ . . . 80 V (A5T3496), 120 V (A5T3497)**
- **h_{FE} Guaranteed from 100 μA to 100 mA**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES. A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T3496	A5T3497
Collector-Base Voltage	−80 V	−120 V
Collector-Emitter Voltage (See Note 1)	−80 V	−120 V
Emitter-Base Voltage	−4.5 V	−4.5 V
Continuous Collector Current	−100 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	

NOTES: 1. These values apply between 0 and 100 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C. See Figure 3.

†Trademark of Texas Instruments
‡U.S. Patent Number 3,439,238

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T3496 MIN	A5T3496 MAX	A5T3497 MIN	A5T3497 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−80		−120		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 3	−80		−120		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−4.5		−4.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V, $I_E = 0$		−0.1			μA
		$V_{CB} = -90$ V, $I_E = 0$				−0.1	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$		−25		−25	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -100\ \mu A$	35		35		
		$V_{CE} = -10$ V, $I_C = -1$ mA	40		40		
		$V_{CE} = -10$ V, $I_C = -10$ mA, See Note 3	40		40		
		$V_{CE} = -10$ V, $I_C = -50$ mA, See Note 3	40		40		
		$V_{CE} = -10$ V, $I_C = -100$ mA, See Note 3	35				
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 3	−0.6	−0.9	−0.6	−0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 3		−0.3		−0.35	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz	0.1	1.2	0.1	1.2	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz	40	300	40	300	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz		2×10^{-4}		2×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz		300		300	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -20$ mA, $f = 100$ MHz	2		1.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, $f = 1$ MHz		7		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -2$ V, $I_C = 0$, $f = 1$ MHz		30		30	pF
$Re(h_{ie})$	Small-Signal Common-Emitter Input Resistance	$V_{CE} = -10$ V, $I_C = -20$ mA, $f = 300$ MHz		30		30	Ω

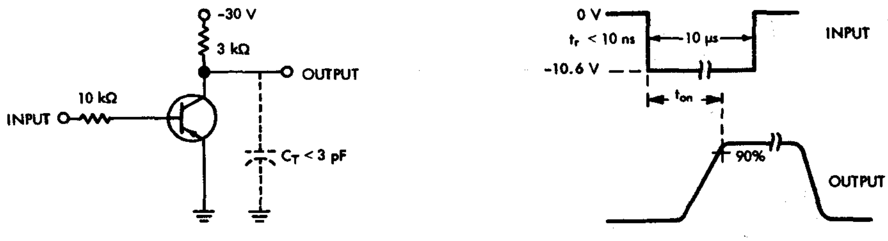
NOTE 3: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_{on}	Turn-On Time	$V_{CC} = -30$ V, $I_C = -10$ mA, $I_{B(1)} = -1$ mA, $V_{BE(off)} = 0$, See Figure 1	300	ns
t_{off}	Turn-Off Time	$V_{CC} = -30$ V, $I_C = -10$ mA, $I_{B(1)} = -1$ mA, $I_{B(2)} = 1$ mA, See Figure 2	1	μs

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters. Nominal base current for turn-on time is calculated using the minimum value of V_{BE}. Nominal base currents for turn-off times are calculated using the maximum value of V_{BE}.

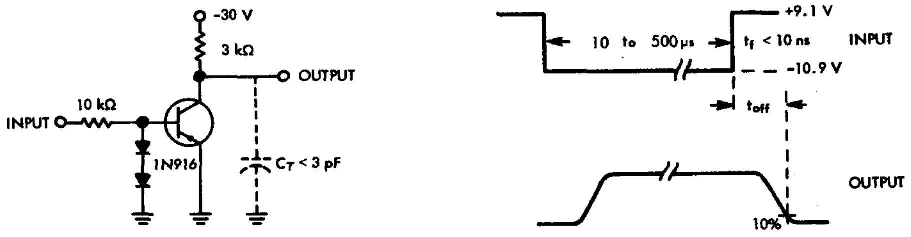
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 1—TURN-ON TIME



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 2—TURN-OFF TIME

NOTES: a. The input waveforms are supplied by a generator with Z_{out} = 50 Ω.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ≤ 10 ns, R_{in} ≥ 100 kΩ.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

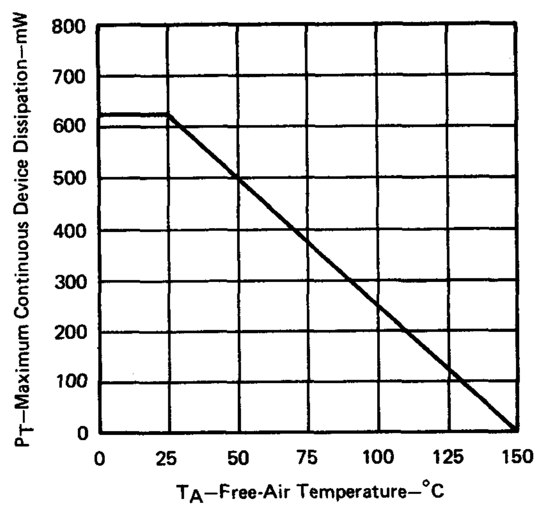


FIGURE 3

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PRINTED IN U.S.A.

BULLETIN NO. DL-S 668278, MARCH 1966

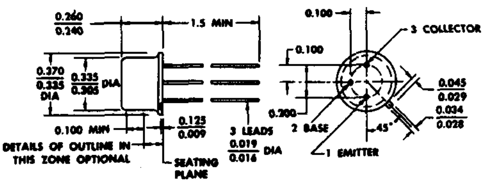
FULLY CHARACTERIZED FOR HIGH-SPEED, LOW-NOISE, MEDIUM-POWER SWITCHING AND GENERAL-PURPOSE AMPLIFIER APPLICATIONS

- h_{FE} Guaranteed from 10 μA to 500 mA

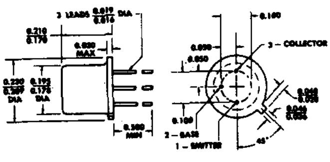
*mechanical data

Device types 2N3502 and 2N3503 are in JEDEC TO-5 packages.
Device types 2N3504 and 2N3505 are in JEDEC TO-18 packages.

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

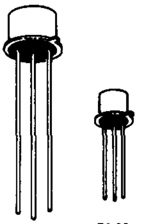


TO-5



TO-18

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3502	2N3503	2N3504	2N3505	UNIT
*Collector-Base Voltage	−45	−60	−45	−60	V
*Collector-Emitter Voltage (See Note 1)	−45	−60	−45	−60	V
*Emitter-Base Voltage	−5	−5	−5	−5	V
*Continuous Collector Current	−600	−600	−600	−600	mA
*Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Notes 2 and 3)	0.7	0.7	0.4	0.4	W
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Notes 4 and 5)	3	3	1.2	1.2	W
*Storage Temperature Range	−65 to 200				°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300	300	300	300	°C

NOTES: 1. This value applies between 0.01 and 600 mA collector current when the base-emitter diode is open-circuited.
2. Derate 2N3502 and 2N3503 linearly to 200°C free-air temperature at the rate of 4 mW/deg.
3. Derate 2N3504 and 2N3505 linearly to 200°C free-air temperature at the rate of 2.28 mW/deg.
4. Derate 2N3502 and 2N3503 linearly to 200°C case temperature at the rate of 17.2 mW/deg.
5. Derate 2N3504 and 2N3505 linearly to 200°C case temperature at the rate of 6.85 mW/deg.

* JEDEC registered data.

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

	PARAMETER	TEST CONDITIONS		2N3502 (TO-5) / 2N3504 (TO-18) MIN	2N3502 / 2N3504 MAX	2N3503 (TO-5) / 2N3505 (TO-18) MIN	2N3503 / 2N3505 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A, I_E = 0$		−45		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 6	−45		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A, I_C = 0$		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V, $I_E = 0$,	$T_A = 150°C$		−10			μA
		$V_{CB} = -50$ V, $I_E = 0$,	$T_A = 150°C$				−10	μA
I_{CES}	Collector Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 0$			−10			nA
		$V_{CE} = -50$ V, $V_{BE} = 0$					−10	nA
I_B	Base Current	$V_{CE} = -30$ V, $V_{BE} = 0$			10			nA
		$V_{CE} = -50$ V, $V_{BE} = 0$					10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10\ \mu A$		80		80		
		$V_{CE} = -10$ V, $I_C = -100\ \mu A$		120		120		
		$V_{CE} = -10$ V, $I_C = -1$ mA		135		135		
		$V_{CE} = -10$ V, $I_C = -10$ mA	See Note 6	140		140		
		$V_{CE} = -10$ V, $I_C = -150$ mA	See Note 6	100	300	100	300	
		$V_{CE} = -10$ V, $I_C = -500$ mA	See Note 6	50		50		
		$V_{CE} = -1$ V, $I_C = -50$ mA	See Note 6	115	300	115	300	
		$V_{CE} = -1$ V, $I_C = -50$ mA, $T_A = -55°C$	See Note 6	50		50		
V_{BE}	Base-Emitter Voltage	$I_B = -2.5$ mA, $I_C = -50$ mA	See Note 6		−1		−1	V
		$I_B = -15$ mA, $I_C = -150$ mA	See Note 6		−1.3		−1.3	V
		$I_B = -30$ mA, $I_C = -300$ mA	See Note 6		−2		−2	V
		$I_B = -50$ mA, $I_C = -500$ mA	See Note 6		−2		−2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -2.5$ mA, $I_C = -50$ mA	See Note 6		−0.25		−0.25	V
		$I_B = -15$ mA, $I_C = -150$ mA	See Note 6		−0.4		−0.4	V
		$I_B = -30$ mA, $I_C = -300$ mA	See Note 6		−1		−1	V
		$I_B = -50$ mA, $I_C = -500$ mA	See Note 6		−1.6		−1.6	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -10$ mA,	$f = 1$ kc/s		23		23	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA,	$f = 1$ kc/s	135	420	135	420	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA,	$f = 1$ kc/s		15×10^{-4}		15×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -10$ mA,	$f = 1$ kc/s		800		800	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -20$ V, $I_C = -50$ mA,	$f = 100$ Mc/s, See Note 7	2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$,	$f = 140$ kc/s		8		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$,	$f = 140$ kc/s		25		25	pF

NOTES: 6. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 1\%$.

7. Because of the high level of dissipation involved, the time of application of collector current must be limited so that the case temperature does not exceed 142°C for the 2N3502 and 2N3503, 54°C for the 2N3504 and 2N3505.

*JEDEC registered data.

4

TEXAS INSTRUMENTS
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*operating characteristics at 25°C free-air temperature

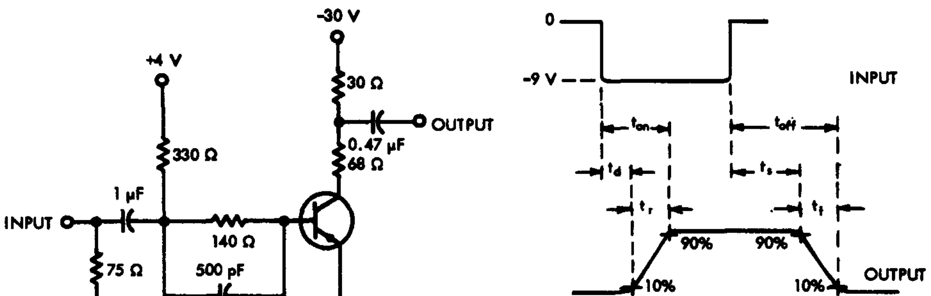
PARAMETER		TEST CONDITIONS	MAX	UNIT
NF	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -30$ μA, $R_g = 10$ kΩ, f = 1 kc/s, Noise bandwidth = 200 c/s	4	dB

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$I_C = -300$ mA, $I_{B(1)} = -30$ mA, $V_{BE(off)} = 4$ V, See Figure 1	25	ns
t_r	Rise Time		35	ns
t_{on}	Turn-On Time		40	ns
t_s	Storage Time	$I_C = -300$ mA, $I_{B(1)} = -30$ mA, See Figure 1	70	ns
t_f	Fall Time		50	ns
t_{off}	Turn-Off Time		100	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

(See Notes a and b)
VOLTAGE WAVEFORMS

FIGURE 1 — TURN-ON AND TURN-OFF TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{in} = 50$ Ω, $t_r \leq 6$ ns, $t_f \leq 6$ ns, $t_p = 500$ ns.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} = 10$ pF.

* JEDEC registered data.

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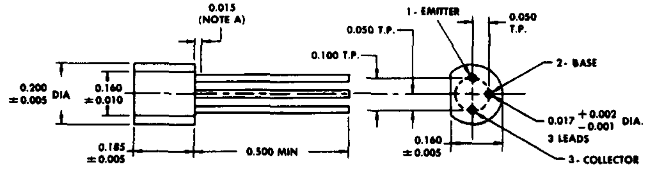
BULLETIN NO. DL-S 7311968, MARCH 1973

SILECT† TRANSISTORS‡ FOR HIGH-SPEED SWITCHING OR LOW-NOISE GENERAL PURPOSE AMPLIFIER APPLICATIONS

- h_{FE} Guaranteed from 10 μA to 500 mA
- *Noise Figure . . . 4 dB Max*
- Switching Characteristics Guaranteed at 300 mA

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T3504	A5T3505
Collector-Base Voltage	−45 V	−60 V
Collector-Emitter Voltage (See Note 1)	−45 V	−60 V
Emitter-Base Voltage	−5 V	−5 V
Continuous Collector Current	−600 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	1.25 W	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	

NOTES: 1. These values apply between 0 and 600 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP P20

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		A5T3504 MIN	A5T3504 MAX	A5T3505 MIN	A5T3505 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A, I_E = 0$		−45		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ mA, I_B = 0$,	See Note 4	−45		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A, I_C = 0$		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30\ V, I_E = 0$, $T_A = 100°C$			−1			μA
		$V_{CB} = -50\ V, I_E = 0$, $T_A = 100°C$					−1	
I_{CES}	Collector Cutoff Current	$V_{CE} = -30\ V, V_{BE} = 0$			−10			nA
		$V_{CE} = -50\ V, V_{BE} = 0$					−10	
I_B	Base Current	$V_{CE} = -30\ V, V_{BE} = 0$			10			nA
		$V_{CE} = -50\ V, V_{BE} = 0$					10	
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10\ V, I_C = -10\ \mu A$		80		80		
		$V_{CE} = -10\ V, I_C = -100\ \mu A$		120		120		
		$V_{CE} = -10\ V, I_C = -1\ mA$		135		135		
		$V_{CE} = -10\ V, I_C = -10\ mA$	See Note 4	140		140		
		$V_{CE} = -10\ V, I_C = -150\ mA$		100	300	100	300	
		$V_{CE} = -10\ V, I_C = -500\ mA$		50		50		
		$V_{CE} = -1\ V, I_C = -50\ mA$		115	300	115	300	
V_{BE}	Base-Emitter Voltage	$I_B = -2.5\ mA, I_C = -50\ mA$	See Note 4		−1		−1	V
		$I_B = -15\ mA, I_C = -150\ mA$			−1.3		−1.3	
		$I_B = -30\ mA, I_C = -300\ mA$			−2		−2	
		$I_B = -50\ mA, I_C = -500\ mA$			−2		−2	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -2.5\ mA, I_C = -50\ mA$	See Note 4		−0.25		−0.25	V
		$I_B = -15\ mA, I_C = -150\ mA$			−0.4		−0.4	
		$I_B = -30\ mA, I_C = -300\ mA$			−1		−1	
		$I_B = -50\ mA, I_C = -500\ mA$			−1.6		−1.6	
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10\ V, I_C = -10\ mA, f = 1\ kHz$			23		23	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio			135	420	135	420	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio				15×10^{-4}		15×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance				800		800	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -20\ V, I_C = -50\ mA, f = 100\ MHz$		2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10\ V, I_E = 0$, $f = 1\ MHz$			8		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5\ V, I_C = 0$, $f = 1\ MHz$			25		25	pF

NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MAX	UNIT
F	Spot Noise Figure	$V_{CE} = -5$ V, $I_C = -30\ \mu A$, $R_G = 10\ k\Omega$, $f = 1$ kHz, Noise bandwidth = 200 Hz	4	dB

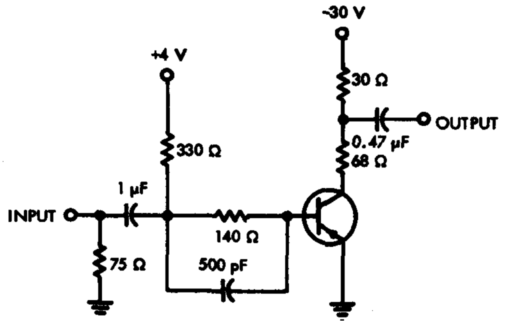
switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$I_C = -300$ mA, $I_{B(1)} = -30$ mA, $V_{BE(off)} = 4$ V, See Figure 1	25	ns
t_r	Rise Time		35	ns
t_{on}	Turn-On Time		40	ns
t_s	Storage Time	$I_C = -300$ mA, $I_{B(1)} = -30$ mA, See Figure 1	70	ns
t_f	Fall Time		50	ns
t_{off}	Turn-Off Time		100	ns

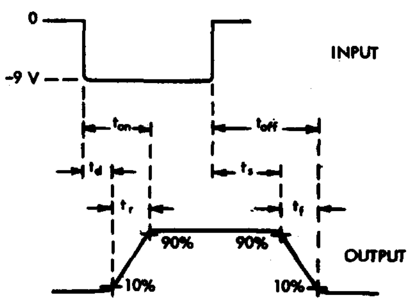
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

4



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

FIGURE 1 — TURN-ON AND TURN-OFF TIMES

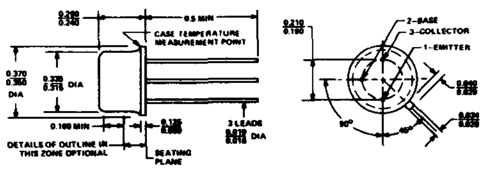
NOTES: a. The input waveform is supplied by a generator with the following characteristics: $Z_{in} = 50\ \Omega$, $t_r \leq 6$ ns, $t_f \leq 6$ ns, $t_w = 500$ ns.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} = 10$ pF.

BULLETIN NO. DL-S 736276, NOVEMBER 1964—REVISED MARCH 1973

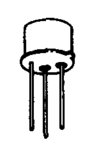
DESIGNED FOR HIGH-SPEED, HIGH-CURRENT SWITCHING APPLICATIONS

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE ◆

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage . . . . 60 v*
Collector-Emitter Voltage (See Note 1) . . . . 30 v*
Emitter-Base Voltage . . . . 5 v*
Collector Current . . . . 1.2 a*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2) . . . . 0.8 w*
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3) . . . . . {10 w† / 5 w*}
Storage Temperature Range . . . . −65°C to +200°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds . . . . 300°C*

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu a$, $I_E = 0$	60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ ma, $I_B = 0$, See Note 4	30		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$	5		v
I_{CES}	Collector Cutoff Current	$V_{CE} = 40$ v, $V_{BE} = 0$		0.5	μa
		$V_{CE} = 40$ v, $V_{BE} = 0$, $T_A = 100°C$		700	μa
I_B	Base Current	$V_{CE} = 40$ v, $V_{BE} = 0$		−0.5	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ v, $I_C = 10$ ma, See Note 4	20		
		$V_{CE} = 1$ v, $I_C = 100$ ma, See Note 4	25		
		$V_{CE} = 1$ v, $I_C = 750$ ma, See Note 4	25	100	
		$V_{CE} = 2$ v, $I_C = 1$ a, See Note 4	20		
V_{BE}	Base-Emitter Voltage	$I_B = 75$ ma, $I_C = 750$ ma, See Note 4	0.9	1.4	v
		$I_B = 100$ ma, $I_C = 1$ a, See Note 4	1.0	1.6	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 75$ ma, $I_C = 750$ ma, See Note 4		0.7	v
		$I_B = 100$ ma, $I_C = 1$ a, See Note 4		1.0	v
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 50$ ma, f = 100 Mc	1.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, f = 1 Mc		25	pf

NOTES: 1. This value applies between 1 ma and 300 ma collector current when the base-emitter diode is open-circuited. Above 300 ma derate linearly to 10 v at 1.2 a at the rate of 22.2 mv/ma. The instantaneous product of collector-emitter voltage and collector current must not exceed 5 w for longer than 300 μsec.
2. Derate linearly to 200°C free-air temperature at the rate of 4.57 mw/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mw/°C. Derate the 5-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 28.6 mw/°C.
4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

◆The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

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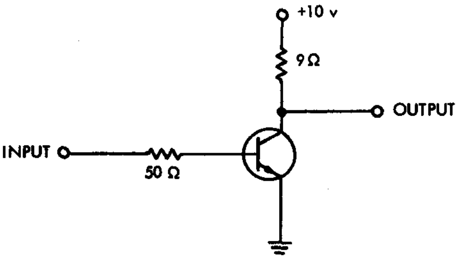
***switching characteristics at 25°C free-air temperature**

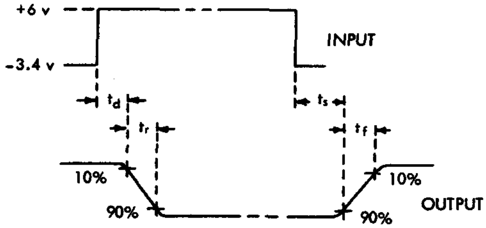
PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$I_C = 1$ a,	15	nsec
t_r	Rise Time	$I_{B(1)} = -I_{B(2)} = 100$ ma,	35	nsec
t_s	Storage Time	$V_{BE(off)} = -3.4$ v, $R_L = 9\ \Omega$,	65	nsec
t_f	Fall Time	See Figure 1	40	nsec

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveforms have the following characteristics:
For measuring delay and rise times $t_r \leq 2$ nsec, PW = 450 nsec, Duty Cycle $\leq$ 2%.
For measuring storage and fall times $t_f \leq 5$ nsec, PW = 1 μsec, Duty Cycle $\leq$ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ nsec, $R_{in} \geq 1$ MΩ, $C_{in} \leq 7$ pf.

* JEDEC registered data

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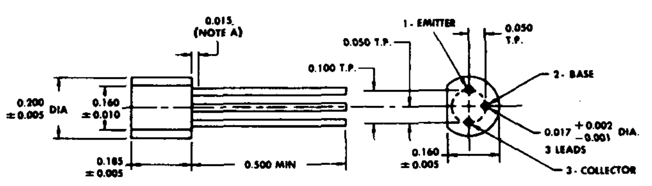
SILECT† TRANSISTOR‡
FOR HI-FI AUDIO AND GENERAL PURPOSE LOW-FREQUENCY AMPLIFIER APPLICATIONS

- **High h_{FE} . . . 150 to 600**
- **Plug-In Replacement for 2N3565 (TO-106)**
- **High Continuous Device Dissipation Rating . . . 625 mW**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	30 V
Collector-Emitter Voltage (See Note 1)	25 V
Emitter-Base Voltage	6 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N21

TYPE A5T3565
N-P-N SILICON TRANSISTOR

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	30		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 2\ mA$, $I_B = 0$, See Note 3	25		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 25\ V$, $I_E = 0$		50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 6\ V$, $I_C = 0$		10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 100\ \mu A$	70		
		$V_{CE} = 10\ V$, $I_C = 1\ mA$	150	600	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.1\ mA$, $I_C = 1\ mA$		0.35	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	2	20	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		120	750	
h_{oe}	Small-Signal Common-Emitter Output Admittance		0.5	100	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 20\ MHz$	2	12	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5\ V$, $I_E = 0$, $f = 1\ MHz$		4	pF

NOTE 3: This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

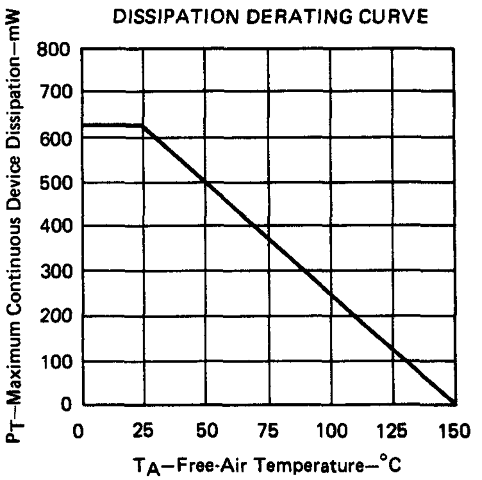


FIGURE 1

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TEXAS INSTRUMENTS RESERVES THE RIGHT TO MAKE CHANGES AT ANY TIME IN ORDER TO IMPROVE DESIGN AND TO SUPPLY THE BEST PRODUCT POSSIBLE.

BULLETIN NO. DL-S 7311956, MARCH 1973

FOR LOW-NOISE VHF/UHF AMPLIFIER, OSCILLATOR, AND MIXER APPLICATIONS

2N3570 Features:

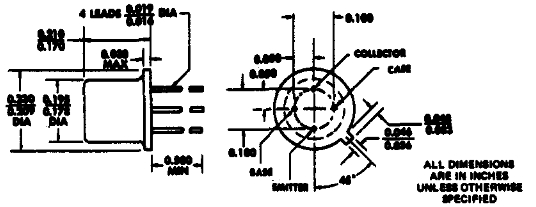
- Low Noise Figure . . . 7 dB Max at 1 GHz
- High f_T . . . 1.5 GHz Min
- Low $r_b'C_c$ . . . 8 ps Max

description

These transistors are ideally suited for such applications as amplifiers, oscillators, and mixers. The guaranteed minimum gain-bandwidth products range from 1 to 1.5 GHz. Guaranteed minimum calculated f_{max} ranges from 1.7 to 2.7 GHz†. These features coupled with low noise figure ensure VHF through L-band amplifier and oscillator capability.

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3570	2N3571	2N3572
Collector-Base Voltage	30 V	25 V	25 V
Collector-Emitter Voltage (See Note 1)	15 V	15 V	13 V
Emitter-Base Voltage	3 V	3 V	3 V
Continuous Collector Current		50 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)		200 mW	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)		350 mW	
Storage Temperature Range		−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds		300°C	

NOTES: 1. These values apply between 0 and 15 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 1.14 mW/°C.
3. Derate linearly to 200°C case temperature at the rate of 2 mW/°C.

†Maximum Frequency of Oscillation may be calculated from the equation: $f_{max}\ (\mathrm{MHz}) = 200\sqrt{\dfrac{|h_{fe}| \times f_{meas}\ (\mathrm{MHz})}{r_b'C_c\ (\mathrm{ps})}}$

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP N28

TYPES 2N3570, 2N3571, 2N3572
N-P-N SILICON TRANSISTORS

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	2N3570 MIN	2N3570 MAX	2N3571 MIN	2N3571 MAX	2N3572 MIN	2N3572 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 1\ \mu A$, $I_E = 0$	30		25		25		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 2$ mA, $I_B = 0$, See Note 4	15		15		13		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	3		3		3		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 6$ V, $I_E = 0$		10		10		10	nA
		$V_{CB} = 6$ V, $I_E = 0$, $T_A = 150°C$		1		1		1	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 6$ V, $I_C = 5$ mA	20	150	20	200	20	300	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 6$ V, $I_C = 5$ mA, f = 1 kHz	20	200	20	250	20	350	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 6$ V, $I_C = 5$ mA, f = 400 MHz	3.75	6	3	6	2.5	6	
C_{cb}	Collector-Base Capacitance	$V_{CB} = 6$ V, $I_E = 0$, f = 1 MHz, See Note 5		0.75		0.85		0.85	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 6$ V, $I_E = -5$ mA, f = 79.8 MHz	1	8	1	10	1	13	ps

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N3570 MIN	2N3570 MAX	2N3571 MIN	2N3571 MAX	2N3572 MIN	2N3572 MAX	UNIT
F	Spot Noise Figure	$V_{CB} = 6$ V, $I_E = -2$ mA, $R_G = 50\ \Omega$, f = 1 GHz		7					dB
		$V_{CB} = 6$ V, $I_E = -2$ mA, $R_G = 100\ \Omega$, f = 450 MHz				4		6	dB

operating characteristics at 25°C case temperature

PARAMETER		TEST CONDITIONS	2N3570 MIN	2N3570 TYP	2N3570 MAX	UNIT
P_O	Oscillator Power Output	$V_{CC} = 20$ V, $I_C = 15$ mA, f = 1 GHz, See Figure 1		60		mW

NOTES: 4. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter and case are connected to the guard terminal of the bridge.

†The fourth lead (case) is grounded for all measurements except C_{cb} and Oscillator Power Output.

PARAMETER MEASUREMENT INFORMATION

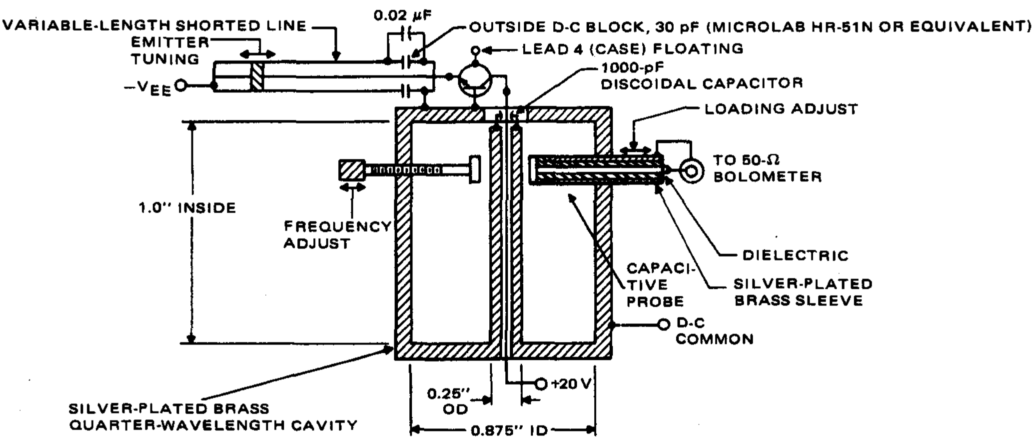


FIGURE 1—1-GHz OSCILLATOR POWER OUTPUT TEST CIRCUIT

*JEDEC registered data

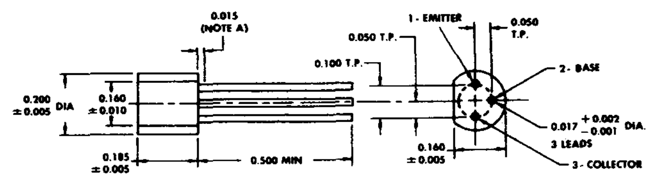
BULLETIN NO. DL-S 7311950, MARCH 1973

SILECT† TRANSISTORS‡
FOR LOW-NOISE VHF/UHF AMPLIFIER, OSCILLATOR, AND MIXER APPLICATIONS

- **Minimum Calculated f_{max}§ . . . 2.2 GHz (A5T3571)**
- **Low Noise Figure . . . 4 dB Maximum (A5T3571)**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T3571	A5T3572
Collector-Base Voltage	25 V	25 V
Collector-Emitter Voltage (See Note 1)	15 V	13 V
Emitter-Base Voltage	3 V	3 V
Continuous Collector Current	← 50 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 500 mW →	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 260°C →	

NOTES: 1. These values apply between 0 and 15 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 4 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Maximum Frequency of Oscillation may be calculated from the equation: $f_{max}\ (\text{MHz}) = 200\sqrt{\frac{|h_{fe}| \times f_{meas}\ (\text{MHz})}{r_b'C_c\ (\text{ps})}}$

USES CHIP N28

TEXAS INSTRUMENTS
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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			A5T3571 MIN	A5T3571 MAX	A5T3572 MIN	A5T3572 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 1\ \mu A$,	$I_E = 0$		25		25		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 2$ mA,	$I_B = 0$,	See Note 3	15		13		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$		3		3		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 6$ V,	$I_E = 0$			10		10	nA
		$V_{CB} = 6$ V,	$I_E = 0$,	$T_A = 100°C$		200		200	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 6$ V,	$I_C = 5$ mA		20	200	20	300	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 6$ V,	$I_C = 5$ mA,	f = 1 kHz	20	250	20	350	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 6$ V,	$I_C = 5$ mA,	f = 400 MHz	3	6	2.5	6	
C_{cb}	Collector-Base Capacitance	$V_{CB} = 6$ V, See Note 4	$I_E = 0$,	f = 1 MHz,		0.85		0.85	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 6$ V,	$I_E = -5$ mA,	f = 79.8 MHz	1	10	1	13	ps

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T3571 MIN	A5T3571 MAX	A5T3572 MIN	A5T3572 MAX	UNIT
F	Spot Noise Figure	$V_{CB} = 6$ V, $I_E = -2$ mA, $R_G = 100\ \Omega$, f = 450 MHz		4		6	dB

NOTES: 3. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

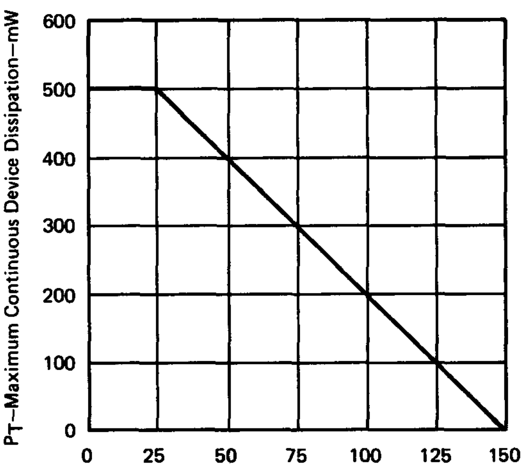

FIGURE 1

TEXAS INSTRUMENTS
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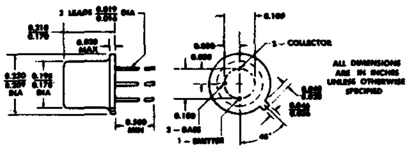
TYPE 2N3576
P-N-P SILICON TRANSISTOR

BULLETIN NO. DL-S 645916, AUGUST 1964

DESIGNED FOR HIGH-SPEED SWITCHING APPLICATIONS

- **Low Guaranteed $V_{CE(sat)}$ — 0.5 v max at 100 ma**
- **High f_T — 400 Mc min at 10 v, 10 ma**
- **Low Total Switching Time — 80 nsec max at 10 ma**

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise specified)

Collector-Base Voltage	−20 v
Collector-Emitter Voltage (See Note 1)	−15 v
Emitter-Base Voltage	−5 v
Collector Current	−200 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mw
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 w
Storage Temperature Range	−65°C to +200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise specified)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu a$, $I_E = 0$	−20		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ ma, $I_B = 0$, See Note 4	−15		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu a$, $I_C = 0$	−5		v
I_{CES}	Collector Cutoff Current	$V_{CE} = -15$ v, $V_{BE} = 0$		−10	na
		$V_{CE} = -15$ v, $V_{BE} = 0$, $T_A = 150°C$		−10	μa
I_B	Base Current	$V_{CE} = -15$ v, $V_{BE} = 0$		10	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.5$ v, $I_C = -10$ ma	40	120	
		$V_{CE} = -0.5$ v, $I_C = -10$ ma, $T_A = -55°C$	20		
		$V_{CE} = -1$ v, $I_C = -100$ ma, See Note 4	10		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ ma, $I_C = -10$ ma, See Note 4	−0.75	−0.95	v
		$I_B = -10$ ma, $I_C = -100$ ma, See Note 4		−1.1	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ ma, $I_C = -10$ ma, See Note 4		−0.15	v
		$I_B = -10$ ma, $I_C = -100$ ma, See Note 4		−0.5	v
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -10$ ma, f = 100 Mc	4		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ v, $I_E = 0$, f = 140 kc		4.5	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ v, $I_C = 0$, f = 140 kc		5	pf

NOTES:
1. This value applies between 0 and 80 ma collector current when the base-emitter diode is open-circuited. Above 80 ma derate linearly to 5 v at 200 ma at the rate of 83.3 mv/ma.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mw/C°.
3. Derate linearly to 175°C case temperature at the rate of 8.0 mw/C°.
4. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

*Indicates JEDEC registered data

USES CHIP P11

4

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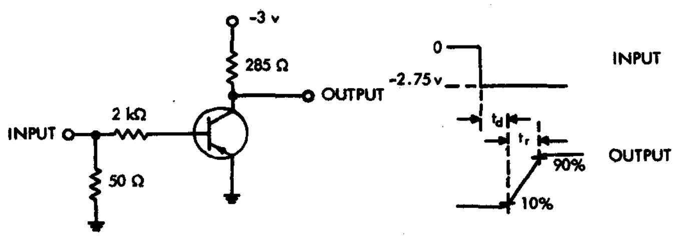
***switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$I_C = -10$ ma, $I_{B(1)} = -1$ ma, $V_{BE(off)} = 0$, $R_L = 285\ \Omega$, See Figure 1	12	nsec
t_r	Rise Time		18	nsec
t_s	Storage Time	$I_C = -10$ ma, $I_{B(1)} = -1$ ma, $I_{B(2)} = 1$ ma, $R_L = 285\ \Omega$, See Figure 2	30	nsec
t_f	Fall Time		20	nsec

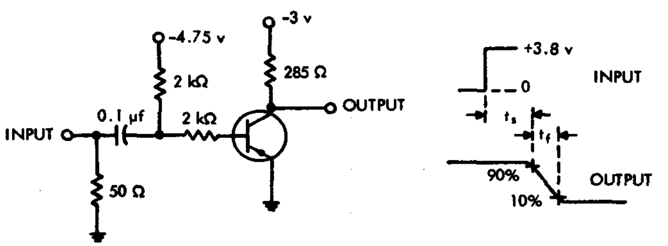
†Voltage and Current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 1



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 2

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 1$ nsec, PW ≥ 500 nsec, Duty Cycle $\leq 2\%$.
b. Output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 10$ pf.

*Indicates JEDEC registered data

TEXAS INSTRUMENTS
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PRINTED IN U.S.A.

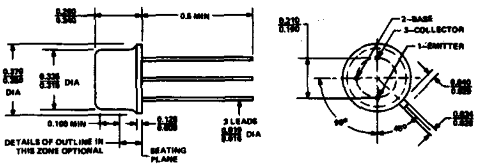
BULLETIN NO. DL-S 7311934, JUNE 1973

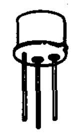
HIGH-VOLTAGE TRANSISTORS
FOR GENERAL PURPOSE AMPLIFIER AND SWITCHING APPLICATIONS

- **High $V_{(BR)CEO}$ . . . 140 V (2N3634, 2N3635) or 175 V (2N3636, 2N3637)**
- **High Dissipation Capability . . . 10 W at 25°C Case Temperature**

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

4

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3634 2N3635	2N3636 2N3637
Collector-Base Voltage	−140 V*	−175 V*
Collector-Emitter Voltage (See Note 1)	−140 V*	−175 V*
Emitter-Base Voltage	−5 V*	−5 V*
Continuous Collector Current	←−1 A*→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 1 W* →	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 10 W† / 5 W* →	
Storage Temperature Range	−65°C to 200°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C† / 240°C* →	

NOTES: 1. These values apply between 0 and 10 mA collector current when the emitter-base diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 5.71 mW/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mW/°C. Derate the 5-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 28.6 mW/°C.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†These values are guaranteed by Texas Instruments in addition to the JEDEC registered values which are also shown.

USES CHIP **P22**

***electrical characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS		2N3634		2N3635		2N3636		2N3637		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$		−140		−140		−175		−175		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 4		−140		−140		−175		−175		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−5		−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -100$ V, $I_E = 0$			−100		−100		−100		−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$			−50		−50		−50		−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -0.1$ mA		40		80		40		80		
		$V_{CE} = -10$ V, $I_C = -1$ mA		45		90		45		90		
		$V_{CE} = -10$ V, $I_C = -10$ mA	See Note 4	50		100		50		100		
		$V_{CE} = -10$ V, $I_C = -50$ mA		50	150	100	300	50	150	100	300	
		$V_{CE} = -10$ V, $I_C = -150$ mA		25		50		25		50		
V_{BE}	Base-Emitter Voltage	$I_C = -10$ mA, $I_B = -1$ mA	See Note 4		−0.8		−0.8		−0.8		−0.8	V
		$I_C = -50$ mA, $I_B = -5$ mA		−0.65	−0.9	−0.65	−0.9	−0.65	−0.9	−0.65	−0.9	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = -10$ mA, $I_B = -1$ mA	See Note 4		−0.3		−0.3		−0.3		−0.3	V
		$I_C = -50$ mA, $I_B = -5$ mA			−0.5		−0.5		−0.5		−0.5	
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -10$ mA, f = 1 kHz		0.1	0.6	0.2	1.2	0.1	0.6	0.2	1.2	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio			40	160	80	320	40	160	80	320	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio				3×10^{-4}		3×10^{-4}		3×10^{-4}		3×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance				200		200		200		200	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -30$ V, $I_C = -30$ mA, f = 100 MHz		1.5		2		1.5		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -20$ V, $I_E = 0$, f = 100 kHz			10		10		10		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -1$ V, $I_C = 0$, f = 100 kHz			75		75		75		75	pF

NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

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***operating characteristics at 25°C free-air temperature**

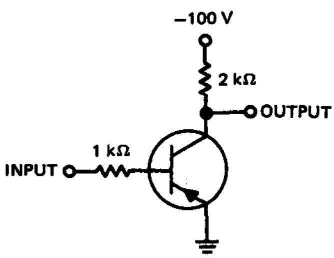
PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
F Spot Noise Figure	$V_{CE} = -10$ V, $I_C = -0.5$ mA, $R_G = 1$ kΩ, f = 1 kHz		3	dB

***switching characteristics at 25°C free-air temperature**

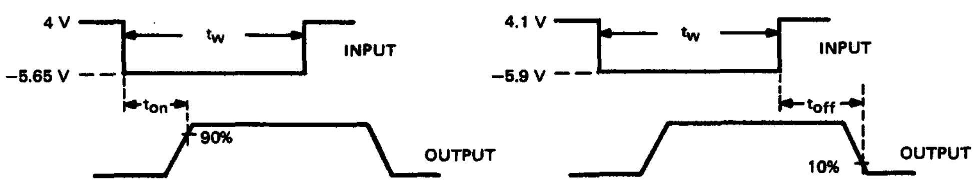
PARAMETER	TEST CONDITIONS†	MIN	MAX	UNIT
t_{on} Turn-On Time	$V_{CC} = -100$ V, $I_C = -50$ mA, $I_{B(1)} = -5$ mA, $V_{BE(off)} = 4$ V, See Figure 1		400	ns
t_{off} Turn-Off Time	$V_{CC} = -100$ V, $I_C = -50$ mA, $I_{B(1)} = -5$ mA, $I_{B(2)} = 5$ mA, See Figure 1		600	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: A. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 20$ ns, $t_f \leq 20$ ns, $t_w \approx 20\ \mu s$, duty cycle $\leq 2\%$.
B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 10$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 5$ pF.

*JEDEC registered data

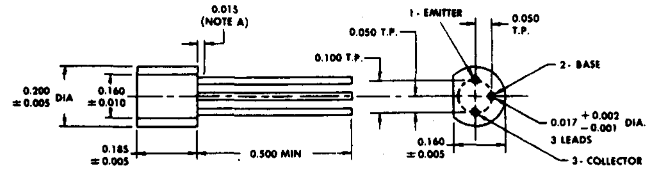
TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

SILECT† TRANSISTORS‡
FOR HIGH-CURRENT, MEDIUM-SPEED SWITCHING APPLICATIONS

- **High Collector Current . . . 500 mA**
- **Electrically Identical to 2N3638, 2N3638A (TO-105)**
- **High Dissipation Capability**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−25 V
Collector-Emitter Voltage (See Note 1)	−25 V
Emitter-Base Voltage	−4 V
Continuous Collector Current	−500 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	1.25 W
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies between 0.01 mA and 500 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP P20

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	A5T3638 MIN	A5T3638 MAX	A5T3638A MIN	A5T3638A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−25		−25		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 4	−25		−25		V
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = -100\ \mu A$, $V_{BE} = 0$	−25		−25		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−4		−4		V
I_{CES}	Collector Cutoff Current	$V_{CE} = -15$ V, $V_{BE} = 0$		−35		−35	nA
		$V_{CE} = -15$ V, $V_{BE} = 0$, $T_A = 65°C$		−2		−2	µA
I_B	Base Current	$V_{CE} = -15$ V, $V_{BE} = 0$		35		35	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, See Note 4			80		
		$V_{CE} = -10$ V, $I_C = -10$ mA, See Note 4	20		100		
		$V_{CE} = -1$ V, $I_C = -50$ mA, See Note 4	30		100		
		$V_{CE} = -2$ V, $I_C = -300$ mA, See Note 4	20		20		
V_{BE}	Base-Emitter Voltage	$I_B = -2.5$ mA, $I_C = -50$ mA, See Note 4		−1.1		−1.1	V
		$I_B = -30$ mA, $I_C = -300$ mA, See Note 4	−0.8	−2	−0.8	−2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -2.5$ mA, $I_C = -50$ mA, See Note 4		−0.25		−0.25	V
		$I_B = -30$ mA, $I_C = -300$ mA, See Note 4		−1		−1	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz		2		2	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz	25		100		
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz		26×10^{-4}		15×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -10$ mA, $f = 1$ kHz		1.2		1.2	mmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -3$ V, $I_C = -50$ mA, $f = 100$ MHz	1		1.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, $f = 1$ MHz		20		10	pF
C_{ibo}	Common-Base Open Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, $f = 1$ MHz		65		35	pF

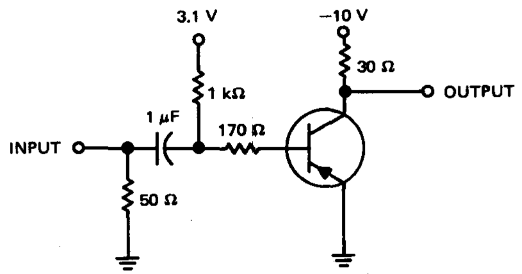
NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

switching characteristics at 25°C free-air temperature

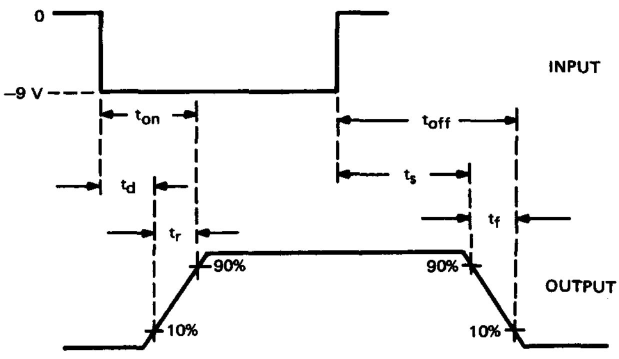
PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_d	Delay Time	$V_{CC} = -10$ V, $I_C = -300$ mA,		20	ns
t_r	Rise Time	$I_{B(1)} = -30$ mA, $V_{BE(off)} = 3.1$ V,		70	ns
t_{on}	Turn-On Time	See Figure 1		75	ns
t_s	Storage Time	$V_{CC} = -10$ V, $I_C = -300$ mA,		140	ns
t_f	Fall Time	$I_{B(1)} = -30$ mA, $I_{B(2)} = 30$ mA,		70	ns
t_{off}	Turn-Off Time	See Figure 1		170	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \le 6$ ns, $t_f \le 6$ ns, $t_w = 500$ ns, duty cycle $\le 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \le 1$ ns, $R_{in} \ge 100$ kΩ, $C_{in} \le 10$ pF.

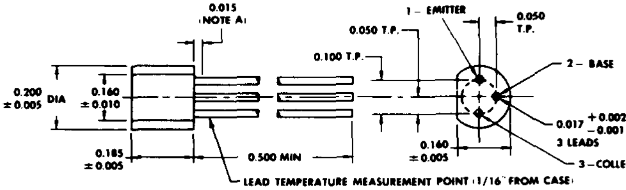
BULLETIN NO. DL-S 7311318, MARCH 1970—REVISED MARCH 1973

SILECT† TRANSISTORS‡
DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- A5T2907, A5T3644, and A5T3645 Electrically Similar to 2N2907, 2N3644, and 2N3645
- TIS112 Processing Includes Operational Aging at 300 mW for 24 Hours

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T2907 TIS112	A5T3644	A5T3645
Collector-Base Voltage	−60 V	−45 V	−60 V
Collector-Emitter Voltage (See Note 1)	−40 V	−45 V	−60 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	←	−600 mA	→
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←	625 mW	→
Continuous Device Dissipation at (or below) 25°C Case and Lead Temperature (See Note 3)	←	1.6 W	→
Storage Temperature Range	←	−65°C to 150°C	→
Lead Temperature 1/16 Inch from Case for 10 Seconds	←	260°C	→

NOTES: 1. This value applies between 0 and 600 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

USES CHIP P20

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		A5T3644 MIN	A5T3644 MAX	A5T3645 MIN	A5T3645 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$		−45		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 4	−45		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−5		−5		V
I_{CES}	Collector Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 0$			−35			nA
		$V_{CE} = -50$ V, $V_{BE} = 0$					−35	nA
		$V_{CE} = -30$ V, $V_{BE} = 0$,	$T_A = 65°C$		−2			μA
		$V_{CE} = -50$ V, $V_{BE} = 0$,	$T_A = 65°C$				−2	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -100\ \mu A$	See Note 4	40		40		
		$V_{CE} = -10$ V, $I_C = -1$ mA		80		80		
		$V_{CE} = -10$ V, $I_C = -10$ mA		100		100		
		$V_{CE} = -10$ V, $I_C = -150$ mA		100	300	100	300	
		$V_{CE} = -1$ V, $I_C = -50$ mA		80	240	80	240	
		$V_{CE} = -2$ V, $I_C = -300$ mA		20		20		
V_{BE}	Base-Emitter Voltage	$I_B = -2.5$ mA, $I_C = -50$ mA	See Note 4		−1		−1	V
		$I_B = -15$ mA, $I_C = -150$ mA			−1.3		−1.3	V
		$I_B = -30$ mA, $I_C = -300$ mA		−0.8	−2	−0.8	−2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -2.5$ mA, $I_C = -50$ mA	See Note 4		−0.25		−0.25	V
		$I_B = -15$ mA, $I_C = -150$ mA			−0.4		−0.4	V
		$I_B = -30$ mA, $I_C = -300$ mA			−1		−1	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -10$ mA,	f = 1 kHz		1.8		1.8	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA,	f = 1 kHz	100		100		
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA,	f = 1 kHz		3×10^{-4}		3×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -10$ mA,	f = 1 kHz		300		300	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -15$ V, $I_C = -20$ mA,	f = 100 MHz	2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$,	f = 1 MHz		8		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$,	f = 1 MHz		35		35	pF

NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T3644 MAX	A5T3645 MAX	UNIT
t_d	Delay Time	$I_C \approx -300$ mA, $R_L = 98\ \Omega$, See Figure 1	25	25	ns
t_r	Rise Time		35	35	ns
t_{on}	Turn-On Time		40	40	ns
t_s	Storage Time		70	70	ns
t_f	Fall Time		50	50	ns
t_{off}	Turn-Off Time		100	100	ns

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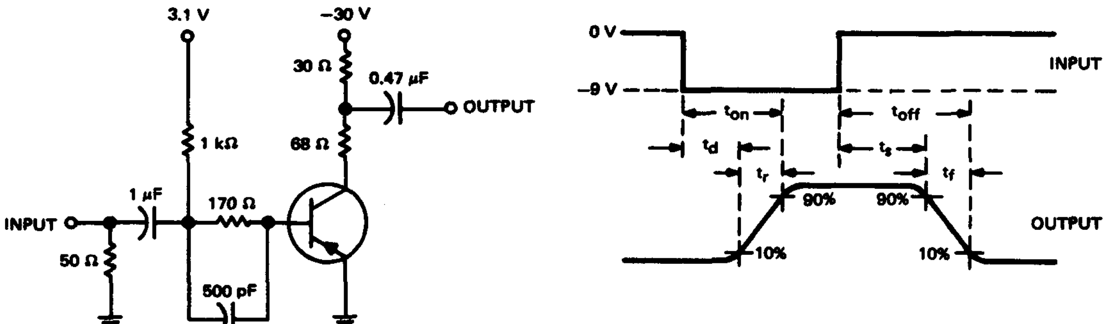
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

(See Notes A and B)
VOLTAGE WAVEFORMS

FIGURE 1—A5T3644 and A5T3645

NOTES: A. The input waveform is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, t_r ≤ 6 ns, t_f ≤ 6 ns, t_w = 500 ns, duty cycle ≤ 2%.

B. The output waveform is monitored on an oscilloscope with the following characteristics: t_r ≤ 1 ns, R_{in} ≤ 0.1 MΩ, C_{in} ≤ 4 pF.

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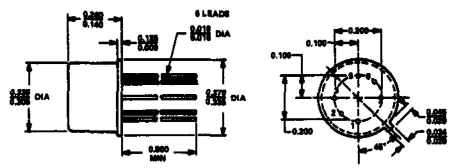
TYPE 2N3680 DUAL N-P-N SILICON TRANSISTOR

RECOMMENDED FOR DIFFERENTIAL AMPLIFIERS

- **Featuring Matching and Tracking Improvements over 2N2453, 2N2642, and 2N2920**
- **Each Triode Electrically Similar to 2N2484 and 2N930**
- **h_{FE} at 1 μA: 80 Min**
- **Matched from −55°C to 125°C**
- **$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$: 5 μV/°C Max, Averaged over Temperature Range**
- **Also Recommended for Low-Level Flip-Flops, High-Gain Low-Noise Audio Amplifiers, and Transducer Signal-Conditioner Amplifiers**

***mechanical data**

ALL LEADS INSULATED FROM CASE



ALL DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED

Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" -0.000" below the seating plane of the device shall be within 0.007" of their true position relative to a maximum width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

***absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)**

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	60 V	
Collector-Emitter Voltage (See Note 1)	50 V	
Emitter-Base Voltage	6 V	
Collector-1—Collector-2 Voltage		±120 V
Lead-to-Case Voltage		±120 V
Continuous Collector Current	30 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.3 W	0.6 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	0.6 W	1.2 W
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←— 300°C —→	

NOTES:
1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rates of 2 mW/°C for each triode and 4 mW/°C for total device.
3. Derate linearly to 175°C case temperature at the rates of 4 mW/°C for each triode and 8 mW/°C for total device.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 10 μA, I_E = 0	60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, I_B = 0, See Note 5	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 μA, I_C = 0	6		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 45 V, I_E = 0		10	nA
		V_{CB} = 45 V, I_E = 0, T_A = 150°C		10	μA
I_{CEO}	Collector Cutoff Current	V_{CE} = 5 V, I_B = 0		10	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		10	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 1 μA	80		
		V_{CE} = 5 V, I_C = 10 μA	150	600	
		V_{CE} = 5 V, I_C = 10 μA, T_A = −55°C	45		
		V_{CE} = 5 V, I_C = 100 μA	225		
		V_{CE} = 5 V, I_C = 1 mA	300		
V_{BE}	Base-Emitter Voltage	V_{CE} = 5 V, I_C = 10 mA	0.6	0.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 0.5 mA, I_C = 10 mA		0.7	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	V_{CE} = 5 V, I_C = 1 mA, f = 1 kHz	7.5	24	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		300	900	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			10 x 10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance			45	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 5 V, I_C = 500 μA, f = 30 MHz	2	6	
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 5 V, I_E = 0, f = 1 MHz		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	V_{EB} = 0.5 V, I_C = 0, f = 1 MHz		6	pF

triode matching characteristics

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current Gain Balance Ratio	V_{CE} = 5 V, I_C = 10 μA, See Note 6	0.9	1	
		V_{CE} = 5 V, I_C = 100 μA, See Note 6, T_A = −55°C to 125°C	0.85	1	
$\|V_{BE1}-V_{BE2}\|$	Base-Emitter-Voltage Differential	V_{CE} = 5 V, I_C = 10 μA		3	mV
$\|\Delta(V_{BE1}-V_{BE2})\Delta T_A\|$	Base-Emitter-Voltage-Differential Change with Temperature	V_{CE} = 5 V, I_C = 10 μA, $T_{A(1)}$ = 25°C, $T_{A(2)}$ = −55°C		400	μV
		V_{CE} = 5 V, I_C = 10 μA, $T_{A(1)}$ = 25°C, $T_{A(2)}$ = 125°C		500	μV

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$\overline{F}$	Average Noise Figure	V_{CB} = 5 V, I_E = −10 μA, R_G = 10 kΩ, Noise Bandwidth = 15.7 kHz, See Note 7		3	dB

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
6. The lower of the two h_{FE} readings is taken as h_{FE1}.
7. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data

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TYPES 2N3702, 2N3703, A8T3702, A8T3703
P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 7311772, JANUARY 1973

SILECT† TRANSISTORS‡

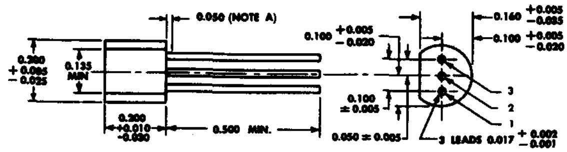
- For Medium-Power Amplifiers, Class B Audio Outputs, Hi-Fi Drivers
- Also Available in Pin-Circle Versions . . . 2N5447, 2N5448
- For Complementary Use with 2N3704 thru 2N3706 or A8T3704 thru A8T3706

4

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

DEVICE	LEADS 1	LEADS 2	LEADS 3
2N3702, 2N3703	Emitter	Collector	Base
A8T3702, A8T3703	Emitter	Base	Collector

2N3702
2N3703

ECB

A8T3702
A8T3703

EBC

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3702 A8T3702	2N3703 A8T3703
Collector-Base Voltage	−40 V*	−50 V*
Collector-Emitter Voltage (See Note 1)	−25 V*	−30 V*
Emitter-Base Voltage	−5 V*	−5 V*
Continuous Collector Current	←−200 mA*→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←625 mW§ / 360 mW*→	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	←1.25 W§ / 500 mW*→	
Storage Temperature Range	−65°C to 150°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←260°C*→	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 360-mW (JEDEC registered) rating linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.
3. Derate the 1.25-W rating linearly to 150°C lead temperature at the rate of 10 mW/°C. Derate the 500-mW (JEDEC registered) rating linearly to 150°C lead temperature at the rate of 4 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

*The asterisk identifies JEDEC registered data for the 2N3702 and 2N3703 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3702 A8T3702 MIN	2N3702 A8T3702 MAX	2N3703 A8T3703 MIN	2N3703 A8T3703 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−40		−50		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 4	−25		−30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -20$ V, $I_E = 0$		−100		−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$		−100		−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -50$ mA, See Note 4	60	300	30	150	
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -50$ mA, See Note 4	−0.6	−1	−0.6	−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -5$ mA, $I_C = -50$ mA, See Note 4		−0.25		−0.25	V
f_T	Transition Frequency	$V_{CE} = -5$ V, $I_C = -50$ mA, See Note 5	100		100		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 1 MHz		12		12	pF

NOTES: 4. These parameters must be measured using pulse techniques, $t_w = 300\ \mu s$, duty cycle ≤ 2%.
5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.

*The asterisk identifies JEDEC registered data for the 2N3702 and 2N3703 only.

THERMAL INFORMATION

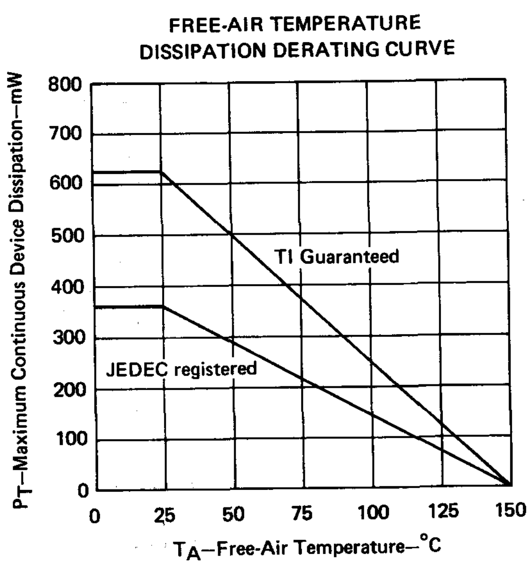


FIGURE 1

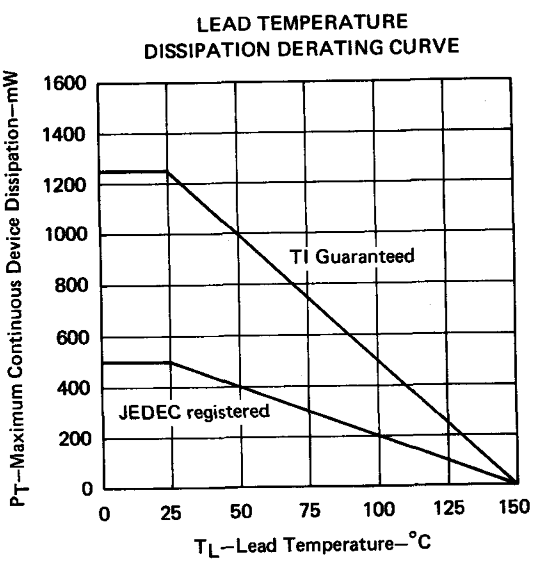


FIGURE 2

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N3704 THRU 2N3706, A8T3704 THRU A8T3706
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 7311771, JANUARY 1973

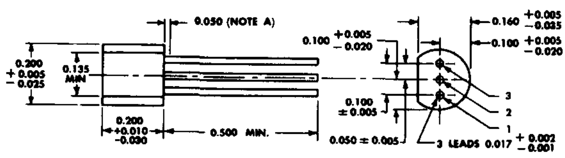
SILECT† TRANSISTORS‡

- For Medium-Power Amplifiers, Class B Audio Outputs, Hi-Fi Drivers
- Also Available in Pin-Circle Versions . . . 2N5449, 2N5451
- For Complementary Use with 2N3702, 2N3703 or A8T3702, A8T3703

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

DEVICE	LEAD 1	LEAD 2	LEAD 3
2N3704, 2N3705, 2N3706	Emitter	Collector	Base
A8T3704, A8T3705, A8T3706	Emitter	Base	Collector

2N3704
2N3705
2N3706

A8T3704
A8T3705
A8T3706

ECB   EBC

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3704, 2N3705, A8T3704, A8T3705	2N3706, A8T3706
Collector-Base Voltage	50 V*	40 V*
Collector-Emitter Voltage (See Note 1)	30 V*	20 V*
Emitter-Base Voltage	5 V*	5 V*
Continuous Collector Current	800 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ / 360 mW*	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	1.25 W§ / 500 mW*	
Storage Temperature Range	−65°C to 150°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C*	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 360-mW (JEDEC registered) rating linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.
3. Derate the 1.25-W rating linearly to 150°C lead temperature at the rate of 10 mW/°C. Derate the 500-mW (JEDEC registered) rating linearly to 150°C lead temperature at the rate of 4 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

*The asterisk identifies JEDEC registered data for the 2N3704, 2N3705, and 2N3706 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP N24

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		2N3704 A8T3704 MIN	2N3704 A8T3704 MAX	2N3705 A8T3705 MIN	2N3705 A8T3705 MAX	2N3706 A8T3706 MIN	2N3706 A8T3706 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$	50		50		40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, See Note 4	$I_B = 0$,	30		30		20		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$	5		5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20$ V,	$I_E = 0$		100		100		100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V,	$I_C = 0$		100		100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V, See Note 4	$I_C = 50$ mA,	100	300	50	150	30	600	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 2$ V, See Note 4	$I_C = 100$ mA,	0.5	1	0.5	1	0.5	1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ mA, See Note 4	$I_C = 100$ mA,		0.6		0.8		1	V
f_T	Transition Frequency	$V_{CE} = 2$ V, See Note 5	$I_C = 50$ mA,	100		100		100		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, f = 1 MHz	$I_E = 0$,		12		12		12	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.

*The asterisk identifies JEDEC registered data for the 2N3704, 2N3705, and 2N3706 only.

4

TYPICAL CHARACTERISTICS

2N3705, A8T3705

STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

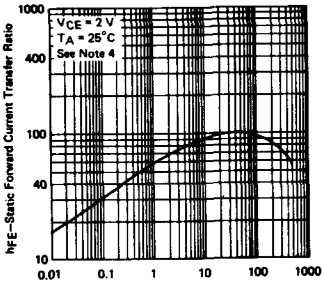


FIGURE 1

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

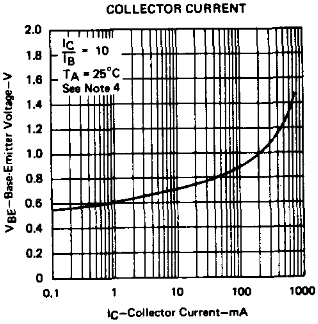


FIGURE 2

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

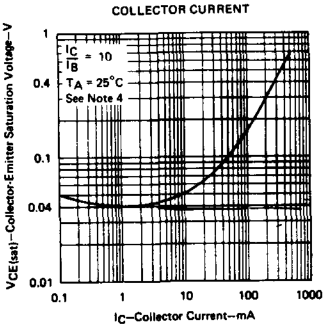


FIGURE 3

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311965, MARCH 1973

SILECT† TRANSISTORS‡

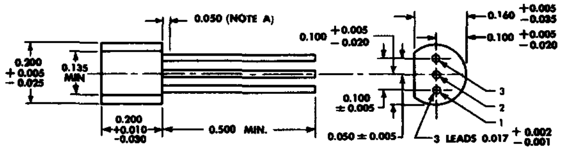
- Ideal for Low-Level Amplifier Applications
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration
- Recommended for Complementary Use with 2N4058 thru 2N4062, A5T4058 thru A5T4062, or A8T4058 thru A8T4062

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N3707 THRU 2N3711, A8T3707 THRU A8T3711

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

DEVICE	LEAD 1	LEAD 2	LEAD 3
2N3707 thru 2N3711	Emitter	Collector	Base
A8T3707 thru A8T3711	Emitter	Base	Collector

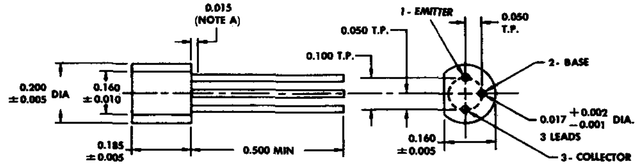
2N3707 thru 2N3711

ECB

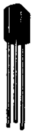
A8T3707 thru A8T3711

EBC

A5T3707 THRU A5T3711



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum diameter package.
C. All dimensions are in inches.



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	30 V*
Collector-Emitter Voltage (See Note 1)	30 V*
Emitter-Base Voltage	6 V*
Continuous Collector Current	30 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ / 360 mW*
Storage Temperature Range	−65°C to 150°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 360-mW (JEDEC registered) rating linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N3707 through 2N3711 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.

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TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		2N3707 A5T3707 A8T3707		2N3708 A5T3708 A8T3708		2N3709 A5T3709 A8T3709		2N3710 A5T3710 A8T3710		2N3711 A5T3711 A8T3711		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA,	$I_B = 0$	30		30		30		30		30		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20$ V,	$I_E = 0$		100		100		100		100		100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 6$ V,	$I_C = 0$		100		100		100		100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V,	$I_C = 100\ \mu A$	100	400									
		$V_{CE} = 5$ V,	$I_C = 1$ mA			45	660	45	165	90	330	180	660	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V,	$I_C = 1$ mA	0.5	1	0.5	1	0.5	1	0.5	1	0.5	1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ mA,	$I_C = 10$ mA		1		1		1		1		1	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, f = 1 kHz	$I_C = 100\ \mu A$,	100	550									
		$V_{CE} = 5$ V, f = 1 kHz	$I_C = 1$ mA,			45	800	45	250	90	450	180	800	

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3707, A5T3707, A8T3707 MIN	TYP	MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, $R_G = 5$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 3		1.9	5	dB

NOTE 3: Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*The asterisk identifies JEDEC registered data for 2N3707 through 2N3711 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

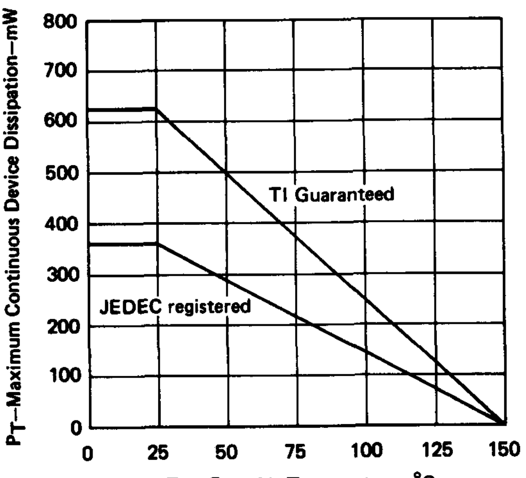


FIGURE 1

TYPES 2N3724, 2N3724A, 2N3725, 2N3725A
N-P-N SILICON TRANSISTORS

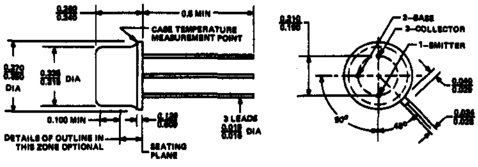
BULLETIN NO. DL-S 7310081, JUNE 1967–REVISED MARCH 1973

FAST, HIGH-VOLTAGE, HIGH-CURRENT CORE DRIVERS

- h_{FE} Guaranteed from 10 mA to 1.5 A
- Guaranteed Switching Times at One Ampere (2N3724A, 2N3725A)

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3724	2N3724A	2N3725	2N3725A	UNIT
Collector-Base Voltage	50*		80*		V
Collector-Emitter Voltage (See Note 1)	30*		50*		V
Emitter-Base Voltage	6*		6*		V
Continuous Collector Current	0.5*	1.2*	0.5*	1.2*	A
Peak Collector Current (See Note 2)		1.75*		1.75*	A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	0.8*	1*	0.8*	1*	W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	10† 3.5*	10† 5*	10† 3.5*	10† 5*	W
Storage Temperature Range	−65 to 200*		−65 to 200*		°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300*		300*		°C

NOTES:
1. These values apply between 0.01 mA and 500 mA collector current when the base-emitter diode is open-circuited.
2. This value applies for square-wave pulses. t_p = 300 μs, duty cycle ≤ 2%.
3. For the 2N3724 and 2N3725, derate linearly to 200°C free-air temperature at the rate of 4.57 mW/°C. For the 2N3724A and 2N3725A, derate linearly to 200°C free-air temperature at the rate of 5.71 mW/°C.
4. *Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mW/°C.* Derate the JEDEC registered ratings linearly to 200°C case temperature at the rates of 20 mW/°C for the 2N3724 and 2N3725 and 28.6 mW/°C for the 2N3724A and 2N3725A.

**JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.*

USES CHIP N13

TEXAS INSTRUMENTS
INCORPORATED
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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		2N3724 MIN	2N3724 MAX	2N3724A MIN	2N3724A MAX	2N3725 MIN	2N3725 MAX	2N3725A MIN	2N3725A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		50		50		80		80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$,	See Note 5	30		30		50		50		V
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ \mu A$, $V_{BE} = 0$		50		50		80		80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		6		6		6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40$ V, $I_E = 0$			1.7		0.5					μA
		$V_{CB} = 40$ V, $I_E = 0$, $T_A = 100°C$			120		50					μA
		$V_{CB} = 60$ V, $I_E = 0$							1.7		0.5	μA
		$V_{CB} = 60$ V, $I_E = 0$, $T_A = 100°C$							120		50	μA
I_{CES}	Collector Cutoff Current	$V_{CE} = 50$ V, $V_{BE} = 0$			10		10					μA
		$V_{CE} = 80$ V, $V_{BE} = 0$							10		10	μA
I_B	Base Current	$V_{CE} = 50$ V, $V_{BE} = 0$			−10		−10					μA
		$V_{CE} = 80$ V, $V_{BE} = 0$							−10		−10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V, $I_C = 10$ mA	See Note 5	30		30		30		30		
		$V_{CE} = 1$ V, $I_C = 100$ mA		60	150	60	150	60	150	60	150	
		$V_{CE} = 1$ V, $I_C = 100$ mA, $T_A = -55°C$		30		30		30		30		
		$V_{CE} = 1$ V, $I_C = 300$ mA		40		40		40		40		
		$V_{CE} = 1$ V, $I_C = 500$ mA		35		35		35		35		
		$V_{CE} = 1$ V, $I_C = 500$ mA, $T_A = -55°C$		20		20		20		20		
		$V_{CE} = 2$ V, $I_C = 800$ mA		25		30		20		25		
		$V_{CE} = 5$ V, $I_C = 1$ A		30		30		25		25		
		$V_{CE} = 5$ V, $I_C = 1.5$ A				25				20		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA, $I_C = 10$ mA	See Note 5		0.76		0.76		0.76		0.76	V
		$I_B = 10$ mA, $I_C = 100$ mA			0.86		0.86		0.86		0.86	V
		$I_B = 30$ mA, $I_C = 300$ mA			1.1		1		1.1		1	V
		$I_B = 50$ mA, $I_C = 500$ mA		0.8	1.1	0.8	1.1	0.8	1.1	0.8	1.1	V
		$I_B = 80$ mA, $I_C = 800$ mA			1.5		1.3		1.5		1.3	V
		$I_B = 100$ mA, $I_C = 1$ A			1.7	0.9	1.4		1.7	0.9	1.4	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA	See Note 5		0.25		0.25		0.25		0.25	V
		$I_B = 10$ mA, $I_C = 100$ mA			0.2		0.2		0.26		0.26	V
		$I_B = 30$ mA, $I_C = 300$ mA			0.32		0.32		0.4		0.4	V
		$I_B = 50$ mA, $I_C = 500$ mA			0.42		0.42		0.52		0.52	V
		$I_B = 80$ mA, $I_C = 800$ mA			0.65		0.65		0.8		0.8	V
		$I_B = 100$ mA, $I_C = 1$ A			0.75		0.75		0.95		0.9	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 50$ mA, $f = 100$ MHz		3		3		3		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz			12		12		10		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 1$ MHz			55		55		55		55	pF

NOTE 5: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 1\%$.

* JEDEC registered data

4

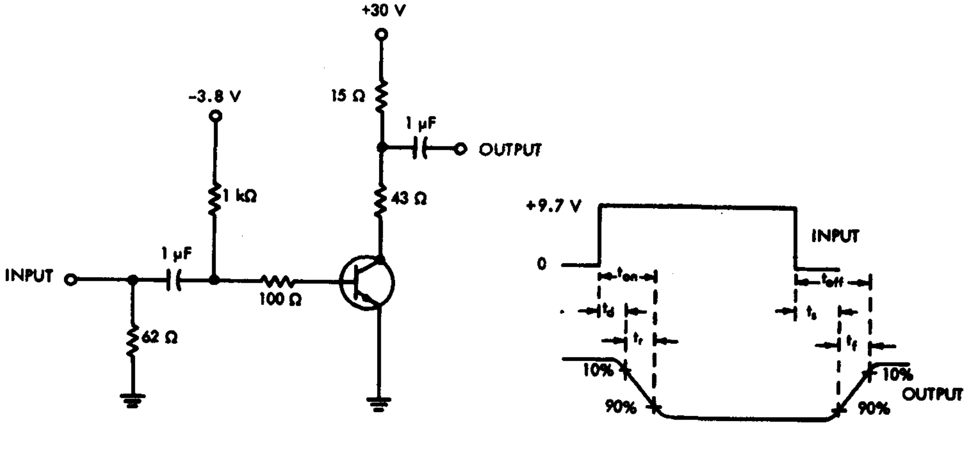
***switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS†		2N3724 MAX	2N3724A MAX	2N3725 MAX	2N3725A MAX	UNIT
t_d	Delay Time	I_C = 500 mA,		10	10	10	10	ns
t_r	Rise Time	$I_{B(1)}$ = 50 mA,	$V_{BE(off)}$ = −3.8 V,	30	30	30	30	ns
t_{on}	Turn-On Time	R_L = 58 Ω,	See Figure 1	35	35	35	35	ns
t_s	Storage Time	I_C = 500 mA,		50	50	50	50	ns
t_f	Fall Time	$I_{B(1)}$ = 50 mA,	$I_{B(2)}$ = −50 mA,	25	25	30	30	ns
t_{off}	Turn-Off Time	R_L = 58 Ω,	See Figure 1	60	60	60	60	ns
t_{on}	Turn-On Time	I_C = 1 A, $I_{B(1)}$ = 100 mA, R_L = 30 Ω,	$V_{BE(off)}$ = −2 V, See Figure 2		30		30	ns
t_{off}	Turn-Off Time	I_C = 1 A, $I_{B(1)}$ = 100 mA, R_L = 30 Ω,	$I_{B(2)}$ = −100 mA, See Figure 3		50		50	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

4

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

FIGURE 1 — 500-mA SWITCHING TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq 1$ ns, $t_f \leq 1$ ns, $t_p \approx 1$ μs, duty cycle ≤ 2%.
b. The waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

*JEDEC registered data

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*PARAMETER MEASUREMENT INFORMATION

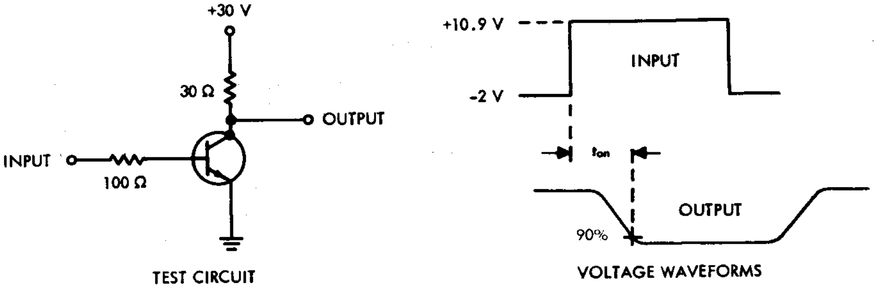

FIGURE 2 — 1-AMPERE TURN-ON TIME (2N3724A AND 2N3725A)

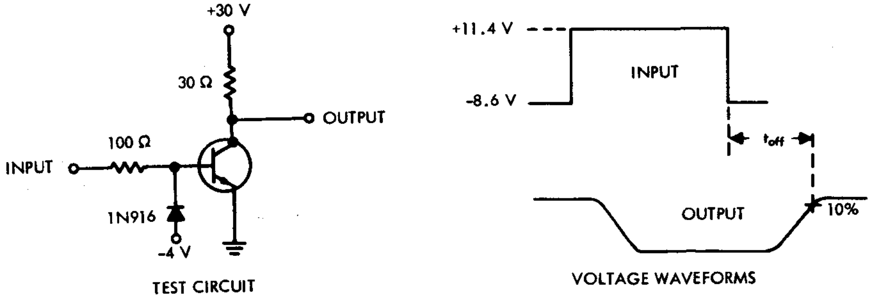

FIGURE 3 — 1-AMPERE TURN-OFF TIME (2N3724A AND 2N3725A)

NOTES: a. The input waveforms have the following characteristics:
For measuring turn-on time: $t_r \leq 2$ ns, $t_p = 200$ ns, duty cycle $\leq 2\%$.
For measuring turn-off time: $t_f \leq 3$ ns, $t_p = 200$ ns to 10 μs, duty cycle $= 2\%$.

b. The output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

*Indicates JEDEC registered data

THERMAL INFORMATION

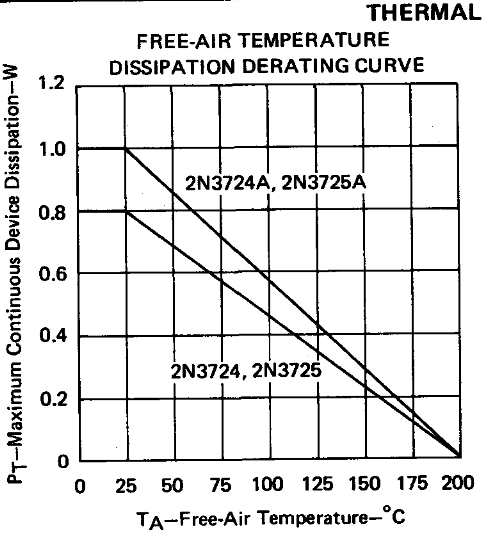

FIGURE 4

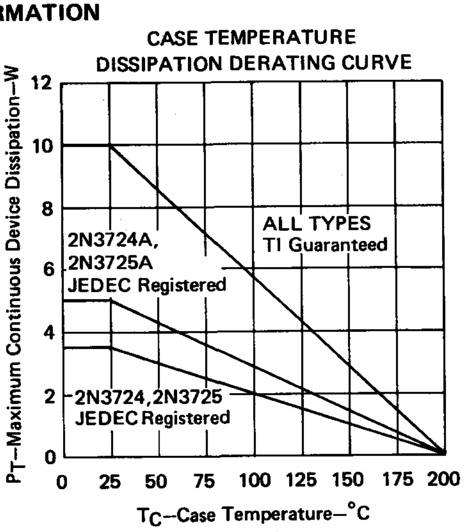

FIGURE 5

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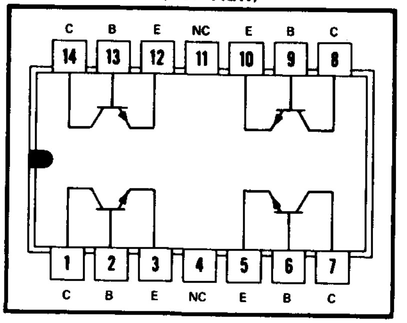
TYPE Q2T3725
QUAD N-P-N SILICON TRANSISTOR

BULLETIN NO. DL-S 7311518, AUGUST 1971—REVISED MARCH 1973

FAST, HIGH-VOLTAGE, HIGH-CURRENT CORE DRIVERS

- h_{FE} Guaranteed at 100 mA and 500 mA
- $V_{(BR)CEO}$ . . . 40 V Min
- $V_{(BR)CBO}$ . . . 60 V Min
- V_{BE} and $V_{CE(sat)}$ Guaranteed at 100 mA and 500 mA
- t_{on} . . . 35 ns Max at 500 mA
- t_{off} . . . 65 ns Max at 500 mA
- Monolithic Version Available . . . TIS127

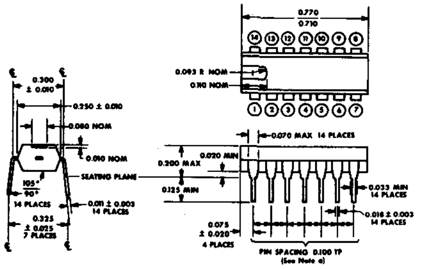
(TOP VIEW)



NC—No internal connection

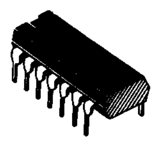
mechanical data

14-PIN PLASTIC DUAL-IN-LINE PACKAGE



NOTES:
a. The true-position pin spacing is 0.100 between centerlines. Each pin centerline is located within 0.010 of its true longitudinal position relative to pins 4 and 11.
b. All dimensions are in inches unless otherwise noted.

Falls Within JEDEC TO-116 and MO-001AA Dimensions



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	60 V	
Collector-Emitter Voltage (See Note 1)	40 V	
Emitter-Base Voltage	6 V	
Continuous Collector Current	500 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.5 W†	1.5 W†
Storage Temperature Range	−55°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds		260°C

NOTES: 1. This value applies between 0.01 mA and 500 mA collector current when the emitter-base diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rates of 4 mW/°C for each triode and 12 mW/°C for the total device.

†Previous editions of this data sheet showed higher power dissipation ratings which have been found to be in error. The new ratings correct these errors and do not represent product changes.

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$,	See Note 3	40		V
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ \mu A$, $V_{BE} = 0$		60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40\ V$, $I_E = 0$			1	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1\ V$, $I_C = 100\ mA$	See Note 3	60	200	
		$V_{CE} = 1\ V$, $I_C = 500\ mA$		30		
V_{BE}	Base-Emitter Voltage	$I_B = 10\ mA$, $I_C = 100\ mA$	See Note 3		0.86	V
		$I_B = 50\ mA$, $I_C = 500\ mA$		0.8	1	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 10\ mA$, $I_C = 100\ mA$	See Note 3		0.26	V
		$I_B = 50\ mA$, $I_C = 500\ mA$			0.52	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 50\ mA$,	f = 100 MHz	2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$,	f = 1 MHz		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$,	f = 1 MHz		70	pF

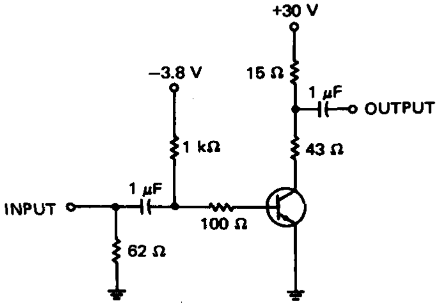
NOTE 3: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

switching characteristics at 25°C free-air temperature

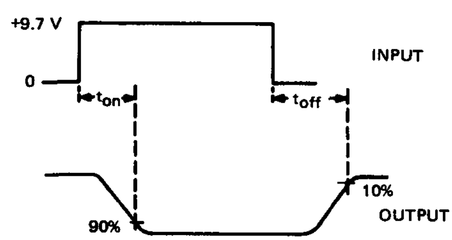
PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_{on}	Turn-On Time	$I_C = 500\ mA$, $I_{B(1)} = 50\ mA$, $V_{BE(off)} = -3.8\ V$, $R_L = 58\ \Omega$, See Figure 1	35	ns
t_{off}	Turn-Off Time	$I_C = 500\ mA$, $I_{B(1)} = 50\ mA$, $I_{B(2)} = -50\ mA$, $R_L = 58\ \Omega$, See Figure 1	65	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORM

FIGURE 1—500-mA SWITCHING TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 1$ ns, $t_f \leq 1$ ns, $t_w \approx 1\ \mu s$, duty cycle $\leq 2\%$.
b. The waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 7$ pF.

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BULLETIN NO. DL-S 11980, MARCH 1973 – REVISED OCTOBER 1978

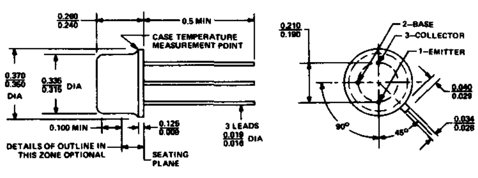
FOR HIGH-CURRENT, HIGH-SPEED SWITCHING AND DRIVER APPLICATIONS

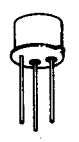
- h_{FE} Guaranteed from 10 mA to 1.5 A
- Guaranteed Switching Times at One Amp

4

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3734	2N3735
Collector-Base Voltage	50 V*	75 V*
Collector-Emitter Voltage (See Note 1)	30 V*	50 V*
Emitter-Base Voltage	5 V*	5 V*
Continuous Collector Current	1.5 A*	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	1 W*	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	10 W† / 4 W*	
Storage Temperature Range	−65°C to 200°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C† / 230°C*	

NOTES: 1. These values apply between 0 and 100 mA collector current for 2N3734 or 0 and 40 mA for 2N3735 when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 5.71 mW/°C.
3. Derate the 10-watt rating linearly to 200°C case temperature at the rate of 57.1 mW/°C. Derate the 4-watt (JEDEC registered) rating linearly to 200°C case temperature at the rate of 22.8 mW/°C.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†These values are guaranteed by Texas Instruments in addition to the JEDEC registered values which are also shown.

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1078

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3734 MIN	2N3734 MAX	2N3735 MIN	2N3735 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	50		75		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 4	30		50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	5		5		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = 25$ V, $V_{BE} = -2$ V		0.2			μA
		$V_{CE} = 25$ V, $V_{BE} = -2$ V, $T_A = 100°C$		20			
		$V_{CE} = 40$ V, $V_{BE} = -2$ V				0.2	
		$V_{CE} = 40$ V, $V_{BE} = -2$ V, $T_A = 100°C$				20	
I_{BEV}	Base Cutoff Current	$V_{CE} = 25$ V, $V_{BE} = -2$ V		0.3			μA
		$V_{CE} = 40$ V, $V_{BE} = -2$ V				0.3	
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V, $I_C = 10$ mA, See Note 4	35		35		
		$V_{CE} = 1$ V, $I_C = 150$ mA	40		40		
		$V_{CE} = 1$ V, $I_C = 500$ mA	35		35		
		$V_{CE} = 1.5$ V, $I_C = 1$ A	30	120	20	80	
		$V_{CE} = 5$ V, $I_C = 1.5$ A	30		20		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA, $I_C = 10$ mA, See Note 4		0.8		0.8	V
		$I_B = 15$ mA, $I_C = 150$ mA		1		1	
		$I_B = 50$ mA, $I_C = 500$ mA		1.2		1.2	
		$I_B = 100$ mA, $I_C = 1$ A	0.9	1.4	0.9	1.4	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA, See Note 4		0.2		0.2	V
		$I_B = 15$ mA, $I_C = 150$ mA		0.3		0.3	
		$I_B = 50$ mA, $I_C = 500$ mA		0.5		0.5	
		$I_B = 100$ mA, $I_C = 1$ A		0.9		0.9	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 50$ mA, f = 100 MHz	3		2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 100 kHz		9		9	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, f = 100 kHz		80		80	pF

NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$V_{CC} = 30$ V, $I_C = 1$ A, $I_{B(1)} = 100$ mA,	8	ns
t_r	Rise Time	$V_{BE(off)} = -2$ V, See Figure 1	40	ns
t_{off}	Turn-Off Time	$V_{CC} = 30$ V, $I_C = 1$ A, $I_{B(1)} = 100$ mA, $I_{B(2)} = -100$ mA, See Figure 2	60	ns
Q_T	Total Control Charge	$I_C = 1$ A, $I_B = 100$ mA, See Figure 3	10	nC

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*JEDEC registered data

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PARAMETER MEASUREMENT INFORMATION

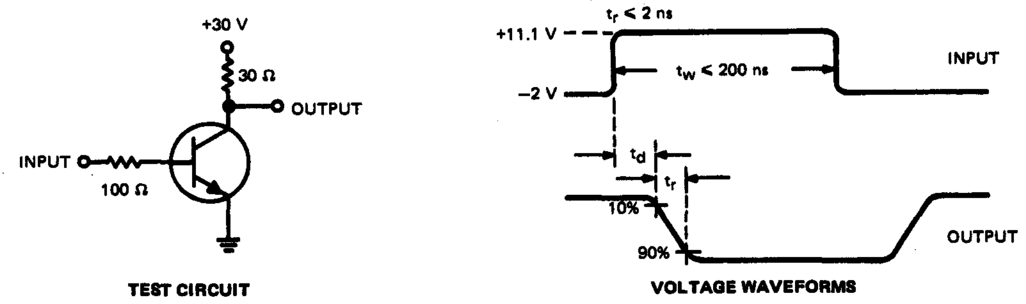


FIGURE 1—DELAY AND RISE TIMES

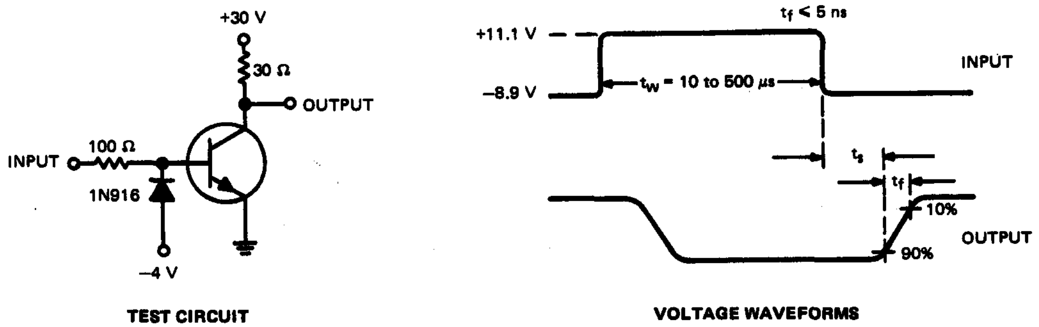
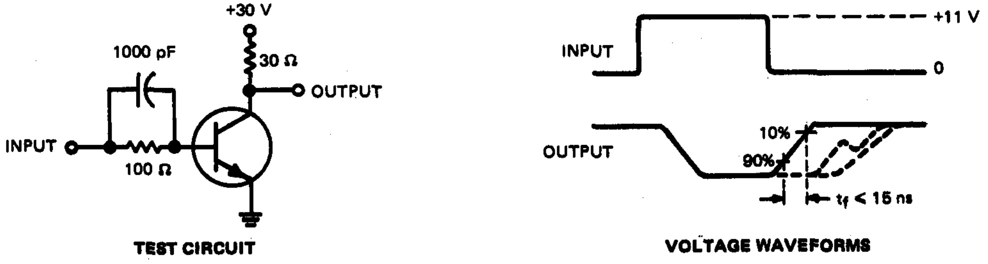


FIGURE 2—STORAGE AND FALL TIMES



NOTE: Q_T < 10 nC when the transistor turns off monotonically as shown by the solid line.

FIGURE 3—TOTAL CONTROL CHARGE

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, duty cycle ≤2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ≤ 5 ns, R_{in} ≥ 100 kΩ, C_{in} ≤ 12 pF.

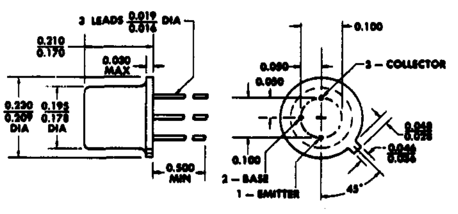
TYPES 2N3798, 2N3799
P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 739898, MARCH 1967—REVISED MARCH 1973

FOR LOW-LEVEL, LOW-NOISE, HIGH-GAIN AMPLIFIER APPLICATIONS

- **Recommended for Complementary Use with 2N2484 and 2N3117**
- **Guaranteed Low-Noise Characteristics**
- **Excellent h_{FE} Linearity from 10 μA to 10 mA Collector Current**

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−60 V
Collector-Emitter Voltage (See Note 1)	−60 V
Emitter-Base Voltage	−5 V
Continuous Collector Current	−50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

NOTES: 1. This value applies between 0 and 50 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.06 mW/deg.
3. Derate linearly to 200°C case temperature at the rate of 6.86 mW/deg.

*Indicates JEDEC registered data

USES CHIP P19

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	2N3798 MIN	2N3798 MAX	2N3799 MIN	2N3799 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−60		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 4	−60		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V, $I_E = 0$		−10		−10	nA
		$V_{CB} = -50$ V, $I_E = 0$, $T_A = 150°C$		−10		−10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$		−20		−20	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1\ \mu A$			75		
		$V_{CE} = -5$ V, $I_C = -10\ \mu A$	100		225		
		$V_{CE} = -5$ V, $I_C = -100\ \mu A$	150		300		
		$V_{CE} = -5$ V, $I_C = -500\ \mu A$	150	450	300	900	
		$V_{CE} = -5$ V, $I_C = -1$ mA	150		300		
		$V_{CE} = -5$ V, $I_C = -10$ mA	125		250		
		$V_{CE} = -5$ V, $I_C = -100\ \mu A$, $T_A = -55°C$	75		150		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -100\ \mu A$		−0.7		−0.7	V
		$I_B = -10\ \mu A$, $I_C = -100\ \mu A$		−0.7		−0.7	V
		$I_B = -100\ \mu A$, $I_C = -1$ mA		−0.8		−0.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -10\ \mu A$, $I_C = -100\ \mu A$		−0.2		−0.2	V
		$I_B = -100\ \mu A$, $I_C = -1$ mA		−0.25		−0.25	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -1$ mA, $f = 1$ kHz	3	30	10	40	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		150	600	300	900	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			25×10^{-4}		25×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance		5	60	5	60	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -500\ \mu A$, $f = 30$ MHz	1		1		
		$V_{CE} = -5$ V, $I_C = -1$ mA, $f = 100$ MHz	1	5	1	5	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, $f = 100$ kHz		4		4	pF

*operating characteristics at 25°C free-air temperature

	PARAMETER	TEST CONDITIONS	2N3798 MAX	2N3799 MAX	UNIT
NF	Spot Noise Figure	$V_{CE} = -10$ V, $I_C = -100\ \mu A$, $R_G = 3\ k\Omega$, $f = 100$ Hz, Noise Bandwidth = 20 Hz	7	4	dB
		$V_{CE} = -10$ V, $I_C = -100\ \mu A$, $R_G = 3\ k\Omega$, $f = 1$ kHz, Noise Bandwidth = 200 Hz	3	1.5	dB
		$V_{CE} = -10$ V, $I_C = -100\ \mu A$, $R_G = 3\ k\Omega$, $f = 10$ kHz, Noise Bandwidth = 2 kHz	2.5	1.5	dB
$\overline{NF}$	Average Noise Figure	$V_{CE} = -10$ V, $I_C = -100\ \mu A$, $R_G = 3\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 5	3.5	2.5	dB

NOTES: 4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.
5. Average Noise Figure is measured in an amplifier with low-frequency response down 3 dB at 10 Hz.

*Indicates JEDEC registered data

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

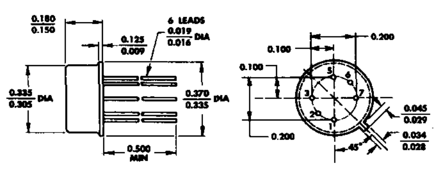
BULLETIN NO. DL-S 7211686, MARCH 1972

TWO TRANSISTORS IN ONE PACKAGE RECOMMENDED FOR

- **Differential Amplifiers**
- **High-Gain, Low-Noise Amplifiers**
- **Low-Level Flip-Flops**
- **Complementary Use With 2N2913 Thru 2N2920 And 2N2639 Thru 2N2644 Dual N-P-N Transistors**

*mechanical data

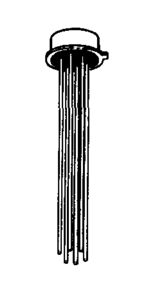
ALL LEADS INSULATED FROM CASE



Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" −0.000" below the seating plane of the device shall be within 0.007" of their true positions relative to a maximum-width tab.

1. COLLECTOR 1
2. BASE 1
3. EMITTER 1
5. EMITTER 2
6. BASE 2
7. COLLECTOR 2

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



4

quick-selection guide (for details see characteristics on pages 2 and 3)

TYPE	MIN–MAX h_{FE} (I_C = −0.1 to −1 mA)		MAX $\lvert V_{BE1} - V_{BE2} \rvert$ (I_C = −100 μA)		h_{FE} MATCHING (I_C = −100 μA)	
	150–450	300–900	3 mV	5 mV	10%	20%
2N3806	•					
2N3807		•				
2N3808	•			•		•
2N3809		•		•		•
2N3810	•		•		•	
2N3811		•	•		•	

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	−60 V	
Collector-Emitter Voltage (See Note 1)	−60 V	
Emitter-Base Voltage	−5 V	
Continuous Collector Current	−50 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	500 mW	600 mW
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 230°C →	

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rates of 2.9 mW/°C for each triode and 3.4 mW/°C for total device. See Dissipation Derating Curve, Figure 1.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 3)

PARAMETER		TEST CONDITIONS	2N3806 2N3808 2N3810 MIN	2N3806 2N3808 2N3810 MAX	2N3807 2N3809 2N3811 MIN	2N3807 2N3809 2N3811 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−60		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 4	−60		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V, $I_E = 0$		−10		−10	nA
		$V_{CB} = -50$ V, $I_E = 0$, $T_A = 150°C$		−10		−10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$		−20		−20	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -10\ \mu A$	100		225		
		$V_{CE} = -5$ V, $I_C = -100\ \mu A$	150	450	300	900	
		$V_{CE} = -5$ V, $I_C = -500\ \mu A$	150	450	300	900	
		$V_{CE} = -5$ V, $I_C = -1$ mA	150	450	300	900	
		$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 4	125		250		
		$V_{CE} = -5$ V, $I_C = -100\ \mu A$, $T_A = -55°C$	75		150		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -100\ \mu A$		−0.7		−0.7	V
		$I_B = -10\ \mu A$, $I_C = -100\ \mu A$		−0.7		−0.7	
		$I_B = -100\ \mu A$, $I_C = -1$ mA		−0.8		−0.8	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -10\ \mu A$, $I_C = -100\ \mu A$		−0.2		−0.2	V
		$I_B = -100\ \mu A$, $I_C = -1$ mA		−0.25		−0.25	
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	3	30	10	40	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		150	600	300	900	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			25×10^{-4}		25×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance		5	60	5	60	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -500\ \mu A$, f = 30 MHz	1		1		
		$V_{CE} = -5$ V, $I_C = -1$ mA, f = 100 MHz	1	5	1	5	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 100 kHz		4		4	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 100 kHz		8		8	pF

NOTES: 3. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
4. These parameters are measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 1\%$.

*JEDEC registered data

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N3808 2N3809 MIN	2N3808 2N3809 MAX	2N3810 2N3811 MIN	2N3810 2N3811 MAX	UNIT
$\frac{h_{FE1}}{h_{FE2}}$	Static Forward-Current-Gain Balance Ratio	$V_{CE} = -5$ V, $I_C = -100$ µA, See Note 5	0.8	1	0.9	1	
$\|V_{BE1}-V_{BE2}\|$	Base-Emitter-Voltage Differential	$V_{CE} = -5$ V, $I_C = -10$ µA to -10 mA		8		5	mV
		$V_{CE} = -5$ V, $I_C = -100$ µA		5		3	mV
$\|\Delta(V_{BE1}-V_{BE2})_{\Delta T_A}\|$	Base-Emitter-Voltage-Differential Change With Temperature	$V_{CE} = -5$ V, $I_C = -100$ µA, $T_{A(1)} = 25°C$, $T_{A(2)} = -55°C$		1.6		0.8	mV
		$V_{CE} = -5$ V, $I_C = -100$ µA, $T_{A(1)} = 25°C$, $T_{A(2)} = 125°C$		2		1	mV

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 3)

PARAMETER		TEST CONDITIONS	2N3806 2N3808 2N3810 MAX	2N3807 2N3809 2N3811 MAX	UNIT
F	Spot Noise Figure	$V_{CE} = -10$ V, $I_C = -100$ µA, $R_G = 3$ kΩ, f = 100 Hz, Noise Bandwidth = 20 Hz	7	4	dB
		$V_{CE} = -10$ V, $I_C = -100$ µA, $R_G = 3$ kΩ, f = 1 kHz, Noise Bandwidth = 200 Hz	3	1.5	dB
		$V_{CE} = -10$ V, $I_C = -100$ µA, $R_G = 3$ kΩ, f = 10 kHz, Noise Bandwidth = 2 kHz	2.5	1.5	dB
$\overline{F}$	Average Noise Figure	$V_{CE} = -10$ V, $I_C = -100$ µA, $R_G = 3$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 6	3.5	2.5	dB

NOTES 3. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. The lower of the two h_{FE} reading is taken as h_{FE1}.
6. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data

THERMAL INFORMATION

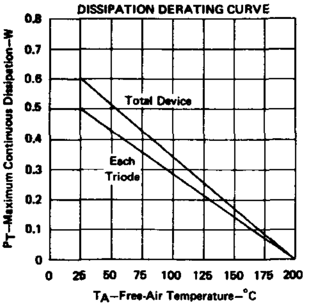

FIGURE 1

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TEXAS INSTRUMENTS INCORPORATED
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N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

BULLETIN NO. DL-S 688047, AUGUST 1965—REVISED MAY 1968

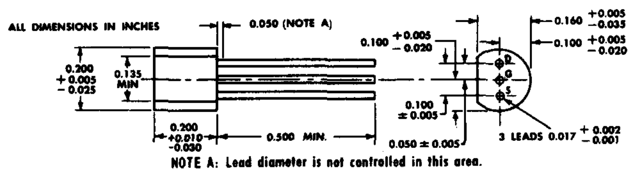
SILECT† FIELD-EFFECT TRANSISTOR‡

- For Industrial and Consumer Small-Signal Applications
- Low C_{rss}: ≤4 pf • High y_{fs}/C_{iss} Ratio (High-Frequency Figure of Merit)
- Cross Modulation Minimized by Square-Law Transfer Characteristics
- For New Designs, 2N5949 thru 2N5953 and A5T3821 thru A5T3824 Are Recommended

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. The device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



NOTE A: Lead diameter is not controlled in this area.

SGD

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	25 v
Drain-Source Voltage	25 v
Reverse Gate-Source Voltage	−25 v
Gate Current	10 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mw
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu a$, $V_{DS} = 0$	−25		v
I_{GSS}	Gate Cutoff Current	$V_{GS} = -15$ v, $V_{DS} = 0$		−2	na
		$V_{GS} = -15$ v, $V_{DS} = 0$, $T_A = 100°C$		−2	μa
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ v, $V_{GS} = 0$, See Note 2	2	20	ma
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ v, $I_D = 200\ \mu a$	−0.5	−7.5	v
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ v, $I_D = 2$ na		−8	v
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ v, $V_{GS} = 0$, f = 1 kc, See Note 2	2000	6500	μmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ v, $V_{GS} = 0$, f = 1 kc, See Note 2		50	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ v, $V_{GS} = 0$, f = 1 Mc		8	pf
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			4	pf
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ v, $V_{GS} = 0$, f = 100 Mc	1600		μmho

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2.88 mw/°C.
2. These parameters must be measured pulse techniques. $t_w \approx 100$ ms, duty cycle ≤ 10%.

*JEDEC registered data
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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TYPE 2N3820
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

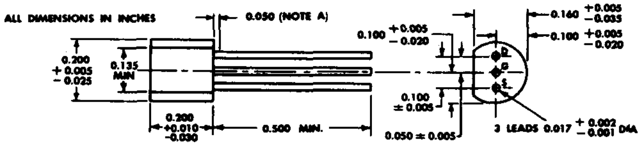
BULLETIN NO. DL-S 687947, AUGUST 1965—REVISED JULY 1968

SILECT† FIELD-EFFECT TRANSISTOR‡
For Industrial and Consumer Small-Signal Applications

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. The device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



NOTE A: Lead diameter is not controlled in this area.

SGD

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	−20 v
Drain-Source Voltage	−20 v
Reverse Gate-Source Voltage	20 v
Gate Current	−10 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mw
Storage Temperature Range	−65°C to +150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 10\ \mu a$, $V_{DS} = 0$	20		v
I_{GSS}	Gate Cutoff Current	$V_{GS} = 10$ v, $V_{DS} = 0$		20	na
		$V_{GS} = 10$ v, $V_{DS} = 0$, $T_A = 100°C$		2	μa
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -10$ v, $V_{GS} = 0$, See Note 2	−0.3	−15	ma
V_{GS}	Gate-Source Voltage	$V_{DS} = -10$ v, $I_D = -30\ \mu a$	0.3	7.9	v
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = -10$ v, $I_D = -10\ \mu a$		8	v
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ v, $V_{GS} = 0$, f = 1 kc, See Note 2	800	5000	μmho
$\lvert y_{os}\rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = -10$ v, $V_{GS} = 0$, f = 1 kc, See Note 2		200	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -10$ v, $V_{GS} = 0$, f = 1 Mc		32	pf
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			16	pf
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ v, $V_{GS} = 0$, f = 10 Mc	700		μmho

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2.88 mw/°C.
2. These parameters must be measured using pulse techniques. $t_w \approx 100$ ms, duty cycle ≤ 10%.

*JEDEC registered data
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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TEXAS INSTRUMENTS
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TYPES 2N3821 THRU 2N3824
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7311919, MARCH 1973

2N3821, 2N3822
FOR SMALL-SIGNAL APPLICATIONS

- Low I_{GSS}: <100 pA
- Low C_{iss}: <6 pF
- High y_{fs}/C_{iss} Ratio (High-Frequency Figure-of-Merit)

2N3823
FOR VHF AMPLIFIER AND MIXER APPLICATIONS

- Low Noise Figure: <2.5 dB at 100 MHz
- Low C_{rss}: <2 pF
- High y_{fs}/C_{iss} Ratio (High-Frequency Figure-of-Merit)

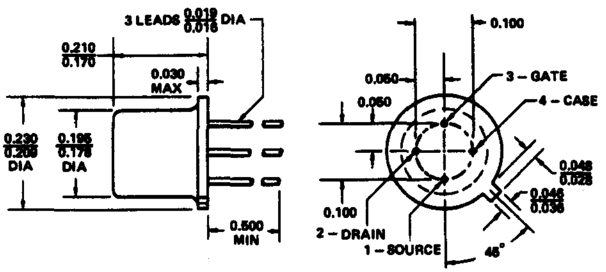
2N3824
FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

- Low $r_{ds(on)}$: <250 Ω
- Low $I_{D(off)}$: <100 pA
- Low C_{rss}: <3 pF

4

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3821 2N3822 2N3824	2N3823
Drain-Gate Voltage	50 V	30 V
Drain-Source Voltage	50 V	30 V
Reverse Gate-Source Voltage	−50 V	−30 V
Continuous Forward Gate Current	← 10 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	← 300 mW →	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 inch from Case for 10 Seconds	← 300°C →	

2N3821, 2N3822

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	2N3821 MIN	2N3821 MAX	2N3822 MIN	2N3822 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−50		−50		V
I_{GSS}	Gate Cutoff Current	$V_{GS} = -30$ V, $V_{DS} = 0$		−0.1		−0.1	nA
		$V_{GS} = -30$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.1		−0.1	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 0.5$ nA		−4		−6	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 50\ \mu A$	−0.5	−2			V
		$V_{DS} = 15$ V, $I_D = 200\ \mu A$			−1	−4	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2	0.5	2.5	2	10	mA
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 2	1500	4500	3000	6500	μmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 2		10		20	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		6		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		3		3	pF
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz	1500		3000		μmho

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N3821 2N3822 MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, $R_G = 1\ M\Omega$, f = 10 Hz, Noise Bandwidth = 5 Hz	5	dB
V_n	Equivalent Input Noise Voltage	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 10 Hz, Noise Bandwidth = 5 Hz	200	$nV/\sqrt{Hz}$

NOTES: 1. Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.
2. These parameters must be measured using pulse techniques. t_w = 100 ms, duty cycle < 10%.

*JEDEC registered data

†The fourth lead (case) is connected to the source for all measurements.

2N3823

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†			2N3823 MIN	2N3823 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$,	$V_{DS} = 0$		−30		V
I_{GSS}	Gate Cutoff Current	$V_{GS} = -20$ V,	$V_{DS} = 0$			−0.5	nA
		$V_{GS} = -20$ V,	$V_{DS} = 0$,	$T_A = 150°C$		−0.5	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V,	$I_D = 0.5$ nA			−8	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V,	$I_D = 400\ \mu A$		−1	−7.5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 2	4	20	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, See Note 2	$V_{GS} = 0$,	f = 1 kHz,	3500	6500	μmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, See Note 2	$V_{GS} = 0$,	f = 1 kHz,		35	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 MHz		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance					2	pF
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 200 MHz	3200		μmho
g_{is}	Small-Signal Common-Source Input Conductance					800	μmho
g_{os}	Small-Signal Common-Source Output Conductance					200	μmho

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N3823 MAX	UNIT
F	Common-Source Spot Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, $R_G = 1\ k\Omega$, f = 100 MHz	2.5	dB

2N3824

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†			2N3824 MIN	2N3824 MAX	UNIT
*$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$,	$V_{DS} = 0$		−50		V
*I_{GSS}	Gate Cutoff Current	$V_{GS} = -30$ V,	$V_{DS} = 0$			−0.1	nA
		$V_{GS} = -30$ V,	$V_{DS} = 0$,	$T_A = 150°C$		−0.1	μA
*$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 15$ V,	$V_{GS} = -8$ V			0.1	nA
		$V_{DS} = 15$ V,	$V_{GS} = -8$ V,	$T_A = 150°C$		0.1	μA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 2	12	24	mA
*$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$,	$I_D = 0$,	f = 1 MHz		250	Ω
*C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 MHz		6	pF
*C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$,	$V_{GS} = -8$ V,	f = 1 MHz		3	pF

NOTE 2: These parameters must be measured using pulse techniques. $t_w = 100$ ms, duty cycle ≤ 10%.
*JEDEC registered data
†The fourth lead (case) is connected to the source for all measurements.

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TEXAS INSTRUMENTS
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BULLETIN NO. DL-S 7111507, JULY 1971

SILECT† FIELD-EFFECT TRANSISTORS‡

- Rugged, One-Piece Construction with Standard TO-18 100-mil Pin-Circle

A5T3821, A5T3822
FOR SMALL-SIGNAL APPLICATIONS

- Low I_{GSS}: $\leq$100 pA
- Low C_{iss}: $\leq$6 pF
- High y_{fs}/C_{iss} Ratio (High-Frequency Figure-of-Merit)

A5T3823
FOR VHF AMPLIFIER AND MIXER APPLICATIONS

- Low Noise Figure: $\leq$2.5 dB at 100 MHz
- Low C_{rss}: $\leq$2 pF
- High y_{fs}/C_{iss} Ratio (High-Frequency Figure-of-Merit)

A5T3824
FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

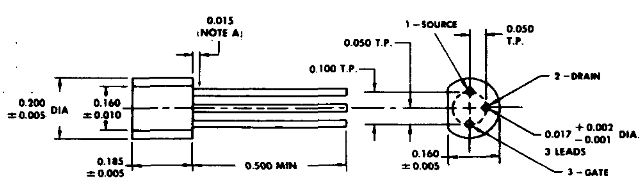
- Low $r_{ds(on)}$: $\leq$250 Ω
- Low $I_{D(off)}$: $\leq$100 pA
- Low C_{rss}: $\leq$3 pF

4

mechanical data

These transistors are built using the same chip type as for the metal-case types 2N3821 through 2N3824 and 2N5358 through 2N5364 and the Silect types 2N5949 through 2N5953.

Silect transistors are encapsulated in a plastic compound specifically designed for this purpose using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. Silect transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP JN51

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T3821 A5T3822 A5T3824	A5T3823
Drain-Gate Voltage	50 V	30 V
Drain-Source Voltage	50 V	30 V
Reverse Gate-Source Voltage	−50 V	−30 V
Continuous Forward Gate Current	← 10 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	← 300 mW →	
Storage Temperature Range	−55°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 260°C →	

A5T3821, A5T3822

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	A5T3821 MIN	A5T3821 MAX	A5T3822 MIN	A5T3822 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−50		−50		V
I_{GSS}	Gate Cutoff Current	$V_{GS} = -30$ V, $V_{DS} = 0$		−0.1		−0.1	nA
		$V_{GS} = -30$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.1		−0.1	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 0.5$ nA		−4		−6	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 50\ \mu A$	−0.5	−2			V
		$V_{DS} = 15$ V, $I_D = 200\ \mu A$			−1	−4	
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2	0.5	2.5	2	10	mA
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 2	1500	4500	3000	6500	μmho
$\lvert y_{os}\rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 2		10		20	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		6		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			3		3	pF
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz	1500		3000		μmho

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T3821 A5T3822 MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, $R_G = 1\ M\Omega$, f = 10 Hz, Noise Bandwidth = 5 Hz	5	dB
V_n	Equivalent Input Noise Voltage	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 10 Hz, Noise Bandwidth = 5 Hz	200	nV/$\sqrt{Hz}$

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2.4 mW/°C.
2. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

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A5T3823

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			A5T3823 MIN	A5T3823 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$,	$V_{DS} = 0$		−30		V
I_{GSS}	Gate Cutoff Current	$V_{GS} = -20$ V,	$V_{DS} = 0$			−0.5	nA
		$V_{GS} = -20$ V,	$V_{DS} = 0$,	$T_A = 150°C$		−0.5	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V,	$I_D = 0.5$ nA			−8	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V,	$I_D = 400\ \mu A$		−1	−7.5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 2	4	20	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, See Note 2	$V_{GS} = 0$,	f = 1 kHz,	3500	6500	µmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, See Note 2	$V_{GS} = 0$,	f = 1 kHz,		35	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 MHz		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance					2	pF
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 200 MHz	3200		µmho
g_{is}	Small-Signal Common-Source Input Conductance					800	µmho
g_{os}	Small-Signal Common-Source Output Conductance					200	µmho

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T3823 MAX	UNIT
F	Common-Source Spot Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, $R_G = 1\ k\Omega$, f = 100 MHz	2.5	dB

A5T3824

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			A5T3824 MIN	A5T3824 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$,	$V_{DS} = 0$		−50		V
I_{GSS}	Gate Cutoff Current	$V_{GS} = -30$ V,	$V_{DS} = 0$			−0.1	nA
		$V_{GS} = -30$ V,	$V_{DS} = 0$,	$T_A = 150°C$		−0.1	µA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 15$ V,	$V_{GS} = -8$ V			0.1	nA
		$V_{DS} = 15$ V,	$V_{GS} = -8$ V,	$T_A = 150°C$		0.1	µA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 2	12	24	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$,	$I_D = 0$,	f = 1 MHz		250	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 MHz		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$,	$V_{GS} = -8$ V,	f = 1 MHz		3	pF

NOTE 2: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

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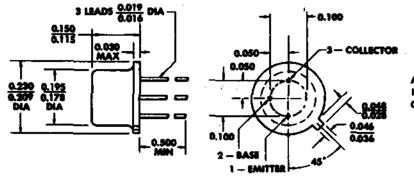
TYPE 2N3829
P-N-P SILICON TRANSISTOR

BULLETIN NO. DL-S 657455, MARCH 1965

DESIGNED FOR HIGH-SPEED SWITCHING APPLICATIONS

- **High f_T: 350 Mc min at 10 v, 30 ma**
- **Low Guaranteed $V_{CE(sat)}$: 0.18 v at 30 ma**

*mechanical data



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-52 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	–35 v
Collector-Emitter Voltage (See Note 1)	–35 v
Collector-Emitter Voltage (See Note 2)	–20 v
Emitter-Base Voltage	–5 v
Continuous Collector Current	–200 ma
Peak Collector Current (See Note 3)	–500 ma
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	360 mw
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 5)	1.2 w
Storage Temperature Range	–65°C to +200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu a$, $I_E = 0$		–35		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ ma, $I_B = 0$,	See Note 6	–20		v
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = -100\ \mu a$, $V_{BE} = 0$		–35		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu a$, $I_C = 0$		–5		v
I_{CES}	Collector Cutoff Current	$V_{CE} = -20$ v, $V_{BE} = 0$			–0.3	μa
		$V_{CE} = -20$ v, $V_{BE} = 0$,	$T_A = 125°C$		–40	μa
I_B	Base Current	$V_{CE} = -20$ v, $V_{BE} = 0$			0.3	μa
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.4$ v, $I_C = -10$ ma	See Note 6	25		
		$V_{CE} = -0.4$ v, $I_C = -30$ ma		30	120	
		$V_{CE} = -1$ v, $I_C = -100$ ma		25		
		$V_{CE} = -0.4$ v, $I_C = -30$ ma, $T_A = -55°C$		12		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ ma, $I_C = -10$ ma	See Note 6	–0.75	–0.85	v
		$I_B = -3$ ma, $I_C = -30$ ma		–0.75	–0.95	v
		$I_B = -10$ ma, $I_C = -100$ ma			–1.20	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ ma, $I_C = -10$ ma	See Note 6		–0.18	v
		$I_B = -3$ ma, $I_C = -30$ ma			–0.18	v
		$I_B = -10$ ma, $I_C = -100$ ma			–0.35	v
		$I_B = -3$ ma, $I_C = -30$ ma, $T_A = 125°C$			–0.25	v

NOTES: 1. This value applies when the base-emitter diode is short-circuited.
2. This value applies between 0 and 10 ma collector current when the base-emitter diode is open-circuited.
3. This value applies for PW ≤ 10 μsec, Duty Cycle ≤ 40%.
4. Derate linearly to 175°C free-air temperature at the rate of 2.4 mw/C°.
5. Derate linearly to 175°C case temperature at the rate of 8 mw/C°.
6. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

*Indicates JEDEC registered data

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ v, $I_C = -30$ ma, f = 100 Mc	3.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ v, $I_E = 0$, f = 140 kc		6	pf
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ v, $I_C = 0$, f = 140 kc		10	pf

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
t_d	Delay Time	$I_C = -30$ ma, $I_{B(1)} = -3$ ma, $V_{BE(off)} = 0$,		10	nsec
t_r	Rise Time	$R_L = 94\ \Omega$, See Figure 1		15	nsec
t_s	Storage Time	$I_C = -30$ ma, $I_{B(1)} = -I_{B(2)} = -3$ ma,		50	nsec
t_f	Fall Time	$R_L = 94\ \Omega$, See Figure 1		15	nsec
$V_{CEO(NL)}$‡	Collector-Emitter Nonlatching Voltage	$I_{C(on)} = -200$ ma, $I_{B(on)} = -20$ ma, $I_{B(off)} = 0$, See Figure 2	−20		v

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

‡This characteristic is the highest value of collector supply voltage which may be safely used with a resistive-load switching circuit in which the collector current approaches −200 ma.

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*PARAMETER MEASUREMENT INFORMATION

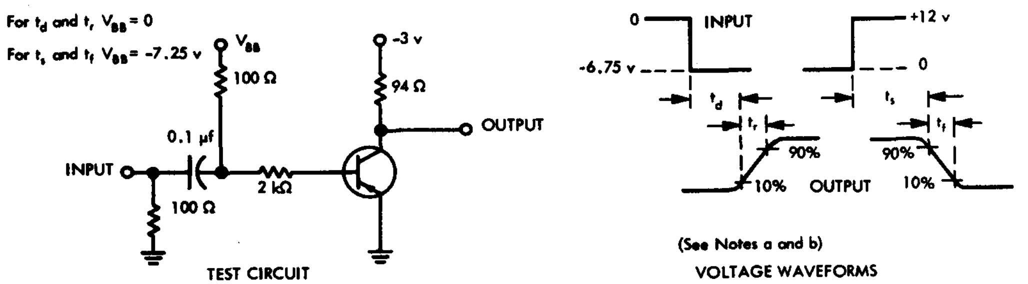

FIGURE 1

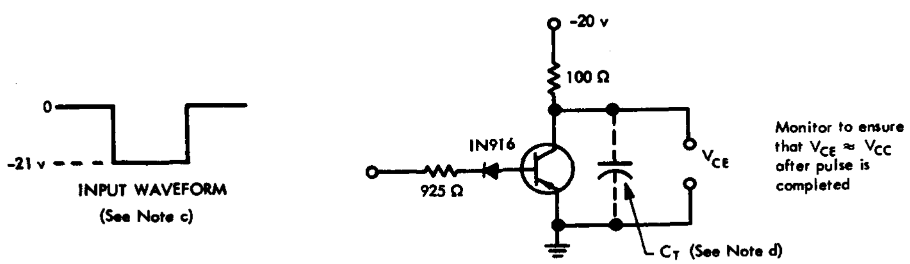

FIGURE 2 — COLLECTOR-EMITTER NONLATCHING VOLTAGE TEST CIRCUIT

NOTES: a. The input waveforms in Figure 1 are supplied by a pulse generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 1$ nsec, PW $\geq$ 300 nsec, Duty Cycle $\leq 2\%$.
b. Waveforms of Figure 1 are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 5$ pf.
c. The input waveform in Figure 2 has the following characteristics: PW ≤ 10 µsec, Duty Cycle $\leq 2\%$.
d. Total collector shunt capacitance $C_T \leq 15$ pf.

*Indicates JEDEC registered data

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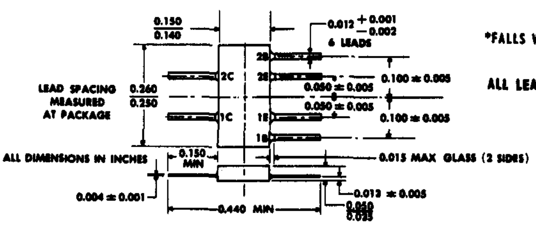
TYPE 2N3838
N-P-N, P-N-P DUAL SILICON TRANSISTOR

BULLETIN NO. DL-S 677501, MARCH 1965—REVISED APRIL 1967

DESIGNED FOR COMPLEMENTARY MEDIUM-POWER, HIGH-SPEED SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **Electrically Similar to 2N2222/2N2907**
- **D-C Beta — Guaranteed from 100 μa to 150 ma**
- **Miniature Flatpack Facilitates High-Density Packaging**

mechanical data



*FALLS WITHIN TO-89 DIMENSIONS

ALL LEADS ARE INSULATED FROM CASE

TERMINAL DESIGNATIONS
1B N-P-N BASE
1E N-P-N EMITTER
2E P-N-P EMITTER
2B P-N-P BASE
2C P-N-P COLLECTOR
1C N-P-N COLLECTOR

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)†

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	60 v	
Collector-Emitter Voltage (See Note 1)	40 v	
Emitter-Base Voltage	5 v	
Collector-1 — Collector-2 Voltage		±120 v
Lead-to-Case Voltage		±120 v
Continuous Collector Current	600 ma	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mw	350 mw
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	700 mw	1400 mw
Storage Temperature Range	−65°C to +200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds		300°C

NOTES: 1. This value applies between 0 and 10 ma when the base-emitter diode is open-circuited.

2. Derate linearly to 175°C free-air temperature at the rate of 1.67 mw/C° for each triode and 2.34 mw/C° for total device.

3. Derate linearly to 175°C case temperature at the rate of 4.67 mw/C° for each triode and 9.34 mw/C° for total device.

*Indicates JEDEC registered data

†Voltages and currents apply to the N-P-N triode. For the P-N-P triode, the values are the same, but the signs are reversed.

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)†

*individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu a$, $I_E = 0$	60		v
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ ma, $I_B = 0$, See Note 5	40		v
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu a$, $I_C = 0$	5		v
I_{CEV}	Collector Cutoff Current	$V_{CE} = 50$ v, $V_{BE} = -0.5$ v		10	na
		$V_{CE} = 50$ v, $V_{BE} = -0.5$ v, $T_A = 150°C$		10	μa
I_{BEV}	Base Cutoff Current	$V_{CE} = 50$ v, $V_{BE} = -0.5$ v		−10	na
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ v, $I_C = 0$		10	na
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ v, $I_C = 150$ ma, See Note 5	50		
		$V_{CE} = 10$ v, $I_C = 100\ \mu a$	35		
		$V_{CE} = 10$ v, $I_C = 1$ ma	50		
		$V_{CE} = 10$ v, $I_C = 10$ ma, See Note 5	75		
		$V_{CE} = 10$ v, $I_C = 150$ ma, See Note 5	100	300	
V_{BE}	Base-Emitter Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 5	0.85	1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ ma, $I_C = 150$ ma, See Note 5		0.4	v
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ v, $I_C = 1$ ma, $f = 1$ kc	1.5	9	kΩ
h_{fe}	Small-Signal Forward Current Transfer Ratio		60	300	
h_{oe}	Small-Signal Common-Emitter Output Admittance			50	μmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ v, $I_C = 20$ ma, $f = 100$ Mc	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ v, $I_E = 0$, $f = 140$ kc		8	pf

operating characteristics at 25°C free-air temperature†

*individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS‡	MIN	MAX	UNIT
t_d	Delay Time	$I_C = 150$ ma, $I_{B(1)} = 15$ ma, $V_{BE(off)} = 0$,		10	nsec
t_r	Rise Time	$R_L = 64\ \Omega$, See Figure 1		40	nsec
t_s	Storage Time	$I_C = 150$ ma, $I_{B(1)} = -I_{B(2)} = 15$ ma,		250	nsec
t_f	Fall Time	$R_L = 64\ \Omega$, See Figure 2		90	nsec
$V_{CEO(NL)}$	Collector-Emitter Nonlatching Voltage§	$I_{C(on)} = 600$ ma, $I_{B(on)} = 120$ ma, $I_{B(off)} = 0$, See Figure 3	40		v
NF	Spot Noise Figure	$V_{CE} = 10$ v, $I_C = 100\ \mu a$, $R_G = 1\ k\Omega$, $f = 1$ kc		8	db

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.

5. These parameters must be measured using pulse techniques. PW = 300 μsec, Duty Cycle ≤ 2%.

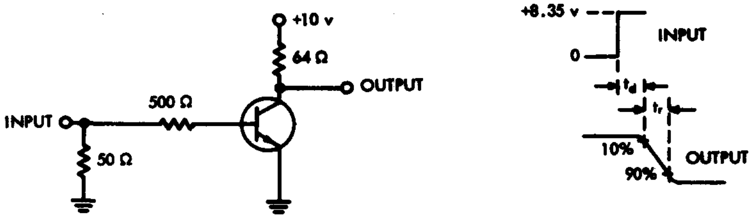
*Indicates JEDEC registered data

†Voltages and currents apply to the N-P-N triode. For the P-N-P triode, the values are the same, but the signs are reversed.

‡Voltages and current values shown are nominal; exact values vary with device parameters.

§This characteristic is the highest value of collector supply voltage which may be safely used with a resistive-load switching circuit in which the collector current approaches 600 ma.

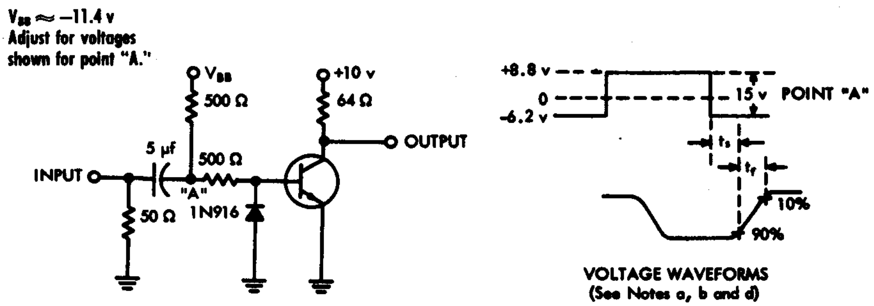
*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS (See Notes a, b and d)

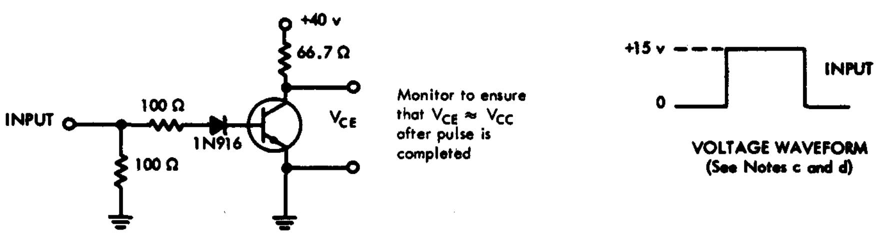
FIGURE 1



TEST CIRCUIT

VOLTAGE WAVEFORMS (See Notes a, b and d)

FIGURE 2



TEST CIRCUIT

VOLTAGE WAVEFORM (See Notes c and d)

FIGURE 3 — COLLECTOR-EMITTER NONLATCHING VOLTAGE TEST CIRCUIT

NOTES:
- a. The input waveforms are supplied by a generator with the following characteristics: for Figure 1, $Z_{out} = 50\ \Omega$, $t_r \leq 1$ nsec, PW $\geq$ 400 nsec, Duty Cycle $\leq$ 2%; for Figure 2, $Z_{out} = 50\ \Omega$, $t_r \leq 10$ nsec, PW = 10 µsec, Duty Cycle $\leq$ 2%.
- b. The waveforms are monitored on an oscilloscope with the following characteristics: for Figure 1, $t_r \leq 1$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 5$ pf; for Figure 2, $t_r \leq 5$ nsec, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pf.
- c. The input waveform in Figure 3 has the following characteristics: PW $\leq$ 10 µsec, Duty Cycle $\leq$ 2%.
- d. The signs and polarity symbols shown are for the N-P-N triode; the signs and polarity symbols are reversed for the P-N-P triode.

*Indicates JEDEC registered data

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PRINTED IN U.S.A.

BULLETIN NO. DL-S 7311576, NOVEMBER 1971—REVISED MARCH 1973

SILECT† TRANSISTORS‡

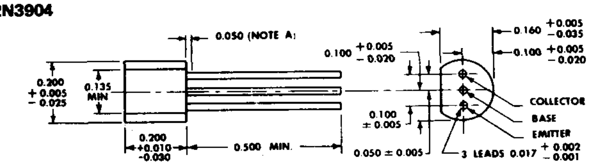
FOR GENERAL PURPOSE SATURATED-SWITCHING AND AMPLIFIER APPLICATIONS

- **For Complementary Use with P-N-P Types 2N3905, 2N3906, A5T3905, and A5T3906**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N3903, 2N3904

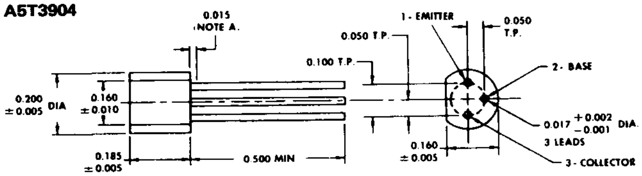


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T3903, A5T3904



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	60 V*
Collector-Emitter Voltage (See Note 1)	40 V*
Emitter-Base Voltage	6 V*
Continuous Collector Current	200 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES 1. This value applies between 10 μA and 200 mA collector current when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.81 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N3903 and 2N3904 only. This data sheet contains all applicable registered data in effect at the time of publication.

†Trademark of Texas Instruments

‡U.S. Patent No. 3,439,238

§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3903, A5T3903 MIN	2N3903, A5T3903 MAX	2N3904, A5T3904 MIN	2N3904, A5T3904 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\,\mu A$, $I_E = 0$	60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA, $I_B = 0$, See Note 3	40		40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\,\mu A$, $I_C = 0$	6		6		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = 30$ V, $V_{BE} = -3$ V		50		50	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = 30$ V, $V_{BE} = -3$ V		−50		−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V, $I_C = 100\,\mu A$	20		40		
		$V_{CE} = 1$ V, $I_C = 1$ mA	35		70		
		$V_{CE} = 1$ V, $I_C = 10$ mA, See Note 3	50	150	100	300	
		$V_{CE} = 1$ V, $I_C = 50$ mA, See Note 3	30		60		
		$V_{CE} = 1$ V, $I_C = 100$ mA, See Note 3	15		30		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA, $I_C = 10$ mA, See Note 3	0.65	0.85	0.65	0.85	V
		$I_B = 5$ mA, $I_C = 50$ mA, See Note 3		0.95		0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA, See Note 3		0.2		0.2	V
		$I_B = 5$ mA, $I_C = 50$ mA, See Note 3		0.3		0.3	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 kHz	1	8	1	10	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 kHz	50	200	100	400	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 kHz	0.1×10^{-4}	5×10^{-4}	0.5×10^{-4}	8×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 kHz	1	40	1	40	μmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 20$ V, $I_C = 10$ mA, f = 100 MHz	2.5		3		
f_T	Transition Frequency	$V_{CE} = 20$ V, $I_C = 10$ mA, See Note 4	250		300		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_E = 0$, f = 100 kHz to 1 MHz		4		4	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, f = 100 kHz to 1 MHz		8		8	pF

NOTES: 3. *These parameters must be measured using pulse techniques.* $t_w = 300\,\mu s$, duty cycle ≤ 2%.
4. To obtain f_T, the $\lvert h_{fe} \rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3903 A5T3903 MIN	2N3903 A5T3903 MAX	2N3904 A5T3904 MIN	2N3904 A5T3904 MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 100\,\mu A$, $R_G = 1$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 5		6		5	dB

NOTE 5: Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*The asterisk identifies JEDEC registered data for the 2N3903 and 2N3904 only.

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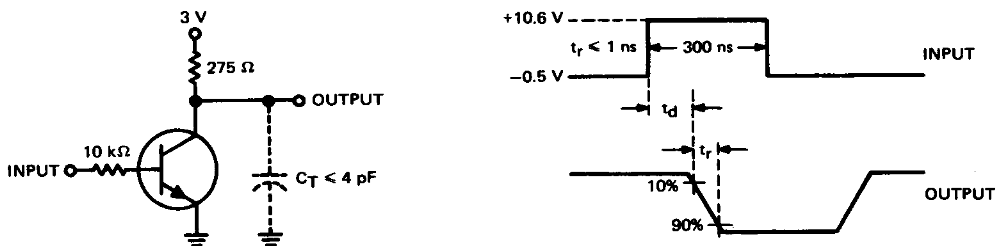
***switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS†			2N3903 A5T3903 MAX	2N3904 A5T3904 MAX	UNIT
t_d	Delay Time	I_C = 10 mA,	$I_{B(1)}$ = 1 mA,	$V_{BE(off)}$ = −0.5 V,	35	35	ns
t_r	Rise Time	R_L = 275 Ω,		See Figure 1	35	35	ns
t_s	Storage Time	I_C = 10 mA,	$I_{B(1)}$ = 1 mA,	$I_{B(2)}$ = −1 mA,	175	200	ns
t_f	Fall Time	R_L = 275 Ω,		See Figure 2	50	50	ns

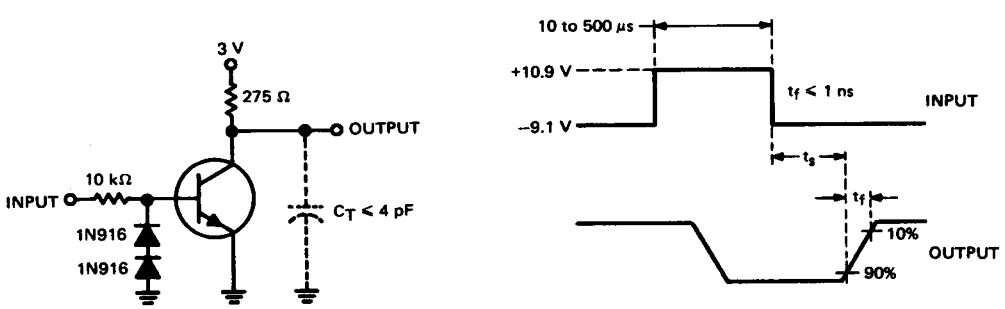
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters. Nominal base current for delay and rise times is calculated using the minimum value of V_{BE}. Nominal base currents for storage and fall times are calculated using the maximum value of V_{BE}.
*The asterisk identifies JEDEC registered data for the 2N3903 and 2N3904 only.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT | VOLTAGE WAVEFORMS

FIGURE 1–DELAY AND RISE TIMES



TEST CIRCUIT | VOLTAGE WAVEFORMS

FIGURE 2–STORAGE AND FALL TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, duty cycle = 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r < 1 ns, R_{in} = 10 MΩ, C_{in} < 4 pF.

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TYPES 2N3905, 2N3906, A5T3905, A5T3906
P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 7311577, NOVEMBER 1971—REVISED MARCH 1973

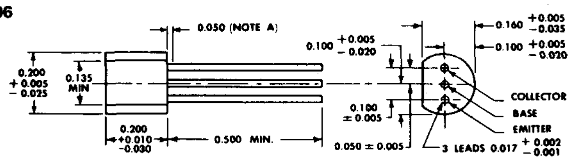
SILECT† TRANSISTORS‡
FOR GENERAL PURPOSE SATURATED-SWITCHING AND AMPLIFIER APPLICATIONS

- **For Complementary Use with N-P-N Types 2N3903, 2N3904, A5T3903, and A5T3904**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N3905, 2N3906

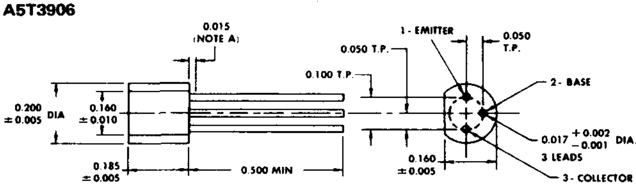


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T3905, A5T3906



NOTES:
A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−40 V*
Collector-Emitter Voltage (See Note 1)	−40 V*
Emitter-Base Voltage	−5 V*
Continuous Collector Current	−200 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies between 10 μA and 200 mA collector current when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.81 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N3905 and 2N3906 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3905 A5T3905 MIN	2N3905 A5T3905 MAX	2N3906 A5T3906 MIN	2N3906 A5T3906 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−40		−40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 3	−40		−40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−5		−5		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 3$ V		−50		−50	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30$ V, $V_{BE} = 3$ V		50		50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -100\ \mu A$	30		60		
		$V_{CE} = -1$ V, $I_C = -1$ mA	40		80		
		$V_{CE} = -1$ V, $I_C = -10$ mA, See Note 3	50	150	100	300	
		$V_{CE} = -1$ V, $I_C = -50$ mA, See Note 3	30		60		
		$V_{CE} = -1$ V, $I_C = -100$ mA, See Note 3	15		30		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 3	−0.65	−0.85	−0.65	−0.85	V
		$I_B = -5$ mA, $I_C = -50$ mA, See Note 3		−0.95		−0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 3		−0.25		−0.25	V
		$I_B = -5$ mA, $I_C = -50$ mA, See Note 3		−0.4		−0.4	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	0.5	8	2	12	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	50	200	100	400	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	0.1×10^{-4}	5×10^{-4}	0.1×10^{-4}	10×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	1	40	3	60	µmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -20$ V, $I_C = -10$ mA, f = 100 MHz	2		2.5		
f_T	Transition Frequency	$V_{CE} = -20$ V, $I_C = -10$ mA, See Note 4	200		250		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 100 kHz to 1 MHz		4.5		4.5	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 100 kHz to 1 MHz		10		10	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. To obtain f_T, the $|h_{fe}|$ response is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3905 A5T3905 MIN	2N3905 A5T3905 MAX	2N3906 A5T3906 MIN	2N3906 A5T3906 MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -100\ \mu A$, $R_G = 1$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 5		5		4	dB

NOTE 5: Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*The asterisk identifies JEDEC registered data for the 2N3905 and 2N3906 only.

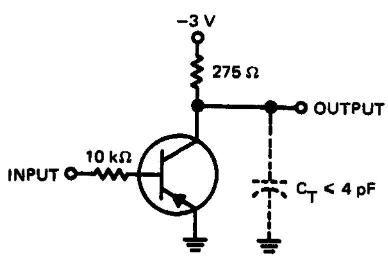
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N3905 A5T3905 MAX	2N3906 A5T3906 MAX	UNIT
t_d	Delay Time	$I_C = -10$ mA, $I_{B(1)} = -1$ mA, $V_{BE(off)} = 0.5$ V, $R_L = 275\ \Omega$, See Figure 1	35	35	ns
t_r	Rise Time		35	35	ns
t_s	Storage Time	$I_C = -10$ mA, $I_{B(1)} = -1$ mA, $I_{B(2)} = 1$ mA, $R_L = 275\ \Omega$, See Figure 2	200	225	ns
t_f	Fall Time		60	75	ns

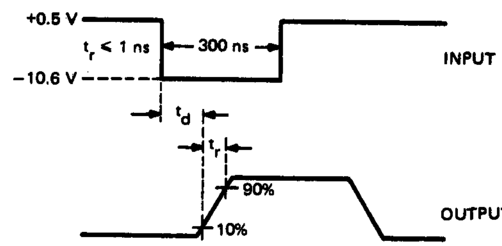
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters. Nominal base current for delay and rise times is calculated using the minimum value of V_{BE}. Nominal base currents for storage and fall times are calculated using the maximum value of V_{BE}.

*The asterisk identifies JEDEC registered data for the 2N3905 and 2N3906 only.

PARAMETER MEASUREMENT INFORMATION

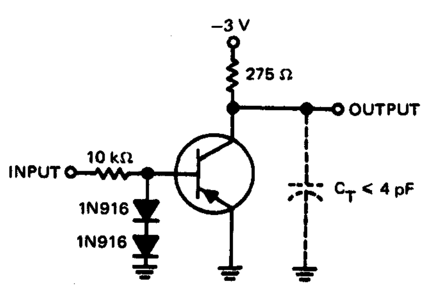


TEST CIRCUIT

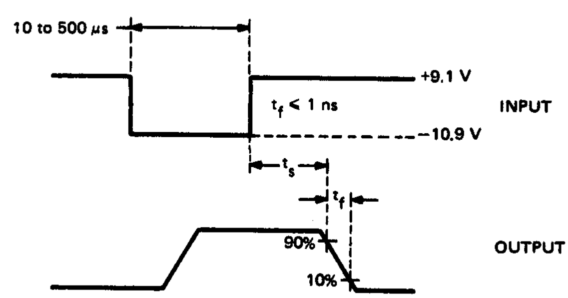


VOLTAGE WAVEFORMS

FIGURE 1—DELAY AND RISE TIMES



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 2—STORAGE AND FALL TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, duty cycle = 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} = 10\ M\Omega$, $C_{in} \leq 4$ pF.

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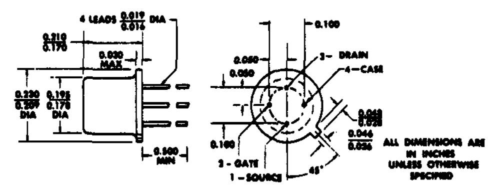
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 6810915, SEPTEMBER 1968

ELECTRICALLY SIMILAR TO 2N2386 AND 2N2386A
FOR AUDIO- TO HIGH-FREQUENCY SMALL-SIGNAL AMPLIFIERS
2N3909A offers greatly improved $|y_{fs}|/C_{rss}$ ratio resulting from process innovation:

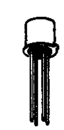
- **$|y_{fs}|$ Min Raised from 1 mmho to 2.2 mmho**
- **C_{rss} Max Lowered from 16 pF to 3 pF**

*mechanical data



THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	−20 V
Drain-Source Voltage	−20 V
Reverse Gate-Source Voltage	20 V
Continuous Forward Gate Current	−10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	2N3909 MIN	2N3909 MAX	2N3909A MIN	2N3909A MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 10\ \mu A$, $V_{DS} = 0$	20		20		V
I_{GSS}	Gate Reverse Current	$V_{GS} = 10$ V, $V_{DS} = 0$		10		10	nA
		$V_{GS} = 10$ V, $V_{DS} = 0$, $T_A = 100°C$		1		1	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = -10$ V, $I_D = -10\ \mu A$		8		8	V
V_{GS}	Gate-Source Voltage	$V_{DS} = -10$ V, $I_D = -30\ \mu A$	0.3	7.9	0.3	7.9	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -10$ V, $V_{GS} = 0$	−0.3	−15	−1	−15	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ V, $V_{GS} = 0$, $f = 1$ kHz	1	5	2.2	5	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			0.1		0.1	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -10$ V, $V_{GS} = 0$, $f = 1$ MHz		32		9	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			16		3	pF
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ V, $V_{GS} = 0$, $f = 10$ MHz	0.9		2		mmho

NOTE 1: Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.
‡The fourth lead (case) is connected to the source for all measurements.
*Indicates JEDEC registered data

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TYPES 2N3962 THRU 2N3965
P-N-P SILICON TRANSISTORS

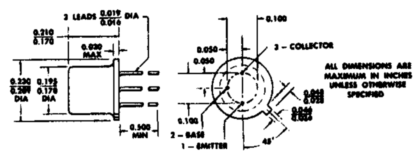
BULLETIN NO. DL-S 679563, FEBRUARY 1967

FOR LOW-LEVEL, LOW-NOISE, HIGH-GAIN, SMALL-SIGNAL AMPLIFIER APPLICATIONS

- **Guaranteed h_{FE} at 10 μA, T_A = −55°C and 25°C**
- **Guaranteed Low-Noise Characteristics at 20 μA**

4

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N3962 2N3965	2N3963	2N3964
Collector-Base Voltage	−60 V	−80 V	−45 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V	−45 V
Emitter-Base Voltage	−6 V	−6 V	−6 V
Continuous Collector Current	←	−200 mA	→
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←	360 mW	→
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	←	1.2 W	→
Storage Temperature Range	←	−65°C to 200°C	→
Lead Temperature 1/16 Inch from Case for 60 Seconds	←	300°C	→

NOTES: 1. These values apply between 10 μA and 5 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.06 mW/deg. See Figure 1.
3. Derate linearly to 200°C case temperature at the rate of 6.85 mW/deg. See Figure 2.

*Indicates JEDEC registered data

USES CHIP P18

TEXAS INSTRUMENTS
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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N3962		2N3963		2N3964		2N3965		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−60		−80		−45		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -5$ mA, $I_B = 0$,	See Note 4	−60		−80		−45		−60		V
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ \mu A$, $V_{BE} = 0$		−60		−80		−45		−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−6		−6		−6		−6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -40$ V, $I_E = 0$							−10			nA
		$V_{CB} = -50$ V, $I_E = 0$			−10						−10	nA
		$V_{CB} = -70$ V, $I_E = 0$					−10					nA
I_{CES}	Collector Cutoff Current	$V_{CE} = -40$ V, $V_{EB} = 0$							−10			nA
		$V_{CE} = -50$ V, $V_{EB} = 0$			−10						−10	nA
		$V_{CE} = -70$ V, $V_{EB} = 0$					−10					nA
		$V_{CE} = -40$ V, $V_{EB} = 0$	$T_A = 150°C$						−10			µA
		$V_{CE} = -50$ V, $V_{EB} = 0$	$T_A = 150°C$		−10						−10	µA
		$V_{CE} = -70$ V, $V_{EB} = 0$	$T_A = 150°C$				−10					µA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$			−10		−10		−10		−10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1\ \mu A$		60		60		180		180		
		$V_{CE} = -5$ V, $I_C = -10\ \mu A$		100	300	100	300	250	500	250	500	
		$V_{CE} = -5$ V, $I_C = -10\ \mu A$,	$T_A = -55°C$	40		40		100		100		
		$V_{CE} = -5$ V, $I_C = -100\ \mu A$		100		100		250		250		
		$V_{CE} = -5$ V, $I_C = -1$ mA		100	450	100	450	250	600	250	600	
		$V_{CE} = -5$ V, $I_C = -1$ mA,	$T_A = 100°C$		600		600		800		800	
		$V_{CE} = -5$ V, $I_C = -10$ mA,	See Note 4	100		100		200		200		
		$V_{CE} = -5$ V, $I_C = -50$ mA,	See Note 4	90		90		180		180		
		$V_{CE} = -5$ V, $I_C = -50$ mA,	$T_A = -55°C$, See Note 4	45		45		90		90		
V_{BE}	Base-Emitter Voltage	$I_C = -10$ mA, $I_B = -0.5$ mA	See Note 4		−0.9		−0.9		−0.9		−0.9	V
		$I_C = -50$ mA, $I_B = -5$ mA	See Note 4		−0.95		−0.95		−0.95		−0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = -10$ mA, $I_B = -0.5$ mA	See Note 4		−0.25		−0.25		−0.25		−0.25	V
		$I_C = -50$ mA, $I_B = -5$ mA	See Note 4		−0.4		−0.4		−0.4		−0.4	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5$ V, $I_C = -1$ mA,	f = 1 kHz	2.5	17	2.5	17	6	20	6	20	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA,	f = 1 kHz	100	550	100	550	250	700	250	700	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA,	f = 1 kHz		10×10^{-4}		10×10^{-4}		10×10^{-4}		10×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -5$ V, $I_C = -1$ mA,	f = 1 kHz	5	40	5	40	5	50	5	50	µmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -0.5$ mA,	f = 20 MHz	2	8	2	8	2.5	8	2.5	8	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$,	f = 1 MHz		6		6		6		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$,	f = 1 MHz		15		15		15		15	pF

NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 1\%$.

*Indicates JEDEC registered data

*operating characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	2N3962 2N3963 MAX	2N3964 2N3965 MAX	UNIT
NF Spot Noise Figure	$V_{CE} = -5$ V, $I_C = -20$ μA, $R_G = 10$ kΩ, f = 10 Hz, Noise Bandwidth = 2 Hz		8	dB
	$V_{CE} = -5$ V, $I_C = -20$ μA, $R_G = 10$ kΩ, f = 100 Hz, Noise Bandwidth = 15 Hz	10	4	dB
	$V_{CE} = -5$ V, $I_C = -20$ μA, $R_G = 10$ kΩ, f = 1 kHz, Noise Bandwidth = 150 Hz	3	2	dB
	$V_{CE} = -5$ V, $I_C = -20$ μA, $R_G = 10$ kΩ, f = 10 kHz, Noise Bandwidth = 1.5 kHz	3	2	dB
$\overline{NF}$ Average Noise Figure	$V_{CE} = -5$ V, $I_C = -20$ μA, $R_G = 10$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 5	3	2	dB

NOTE 5: Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*Indicates JEDEC registered data

THERMAL INFORMATION

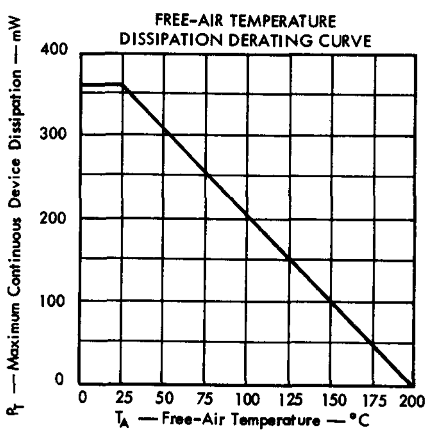


FIGURE 1

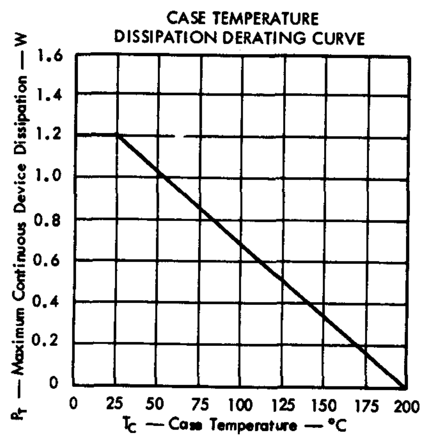


FIGURE 2

TYPE 2N3966
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

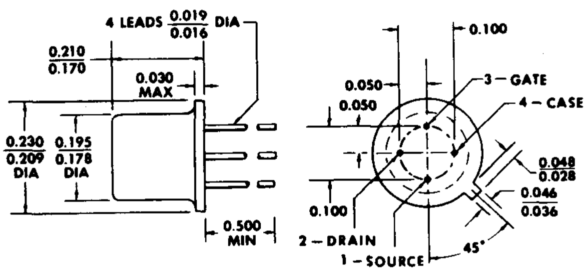
BULLETIN NO. DL-S 7011356, AUGUST 1970

FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

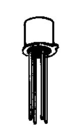
- Low $r_{ds(on)}$ . . . 220 Ω Max
- Low $I_{D(off)}$ . . . 1 nA Max
- Low C_{rss} . . . 1.5 pF Max

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	30 V
Drain-Source Voltage	30 V
Reverse Gate-Source Voltage	−30 V
Continuous Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	−55°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−0.1	nA
I_{DGO}	Drain Reverse Current	$V_{DG} = 20$ V, $I_S = 0$		0.1	nA
		$V_{DG} = 20$ V, $I_S = 0$, $T_A = 150°C$		0.2	μA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 10$ V, $V_{GS} = -7$ V		1	nA
		$V_{DS} = 10$ V, $V_{GS} = -7$ V, $T_A = 150°C$		2	μA
$V_{GS(off)}$	Gate-Source Voltage	$V_{DS} = 10$ V, $I_D = 10$ nA	−4	−6	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 20$ V, $V_{GS} = 0$	2		mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$V_{GS} = 0$, $I_D = 1$ mA		0.25	V
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, f = 1 kHz		220	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 20$ V, $V_{GS} = 0$, f = 1 MHz		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -7$ V, f = 1 MHz		1.5	pF

NOTE 1: Derate linearly to 200°C free-air temperature at the rate of 1.71 mW/°C.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†The fourth lead (case) is connected to the source for all measurements.

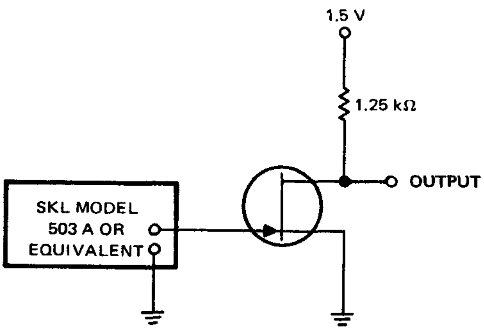
USES CHIP JN51

*switching characteristics at 25°C free-air temperature

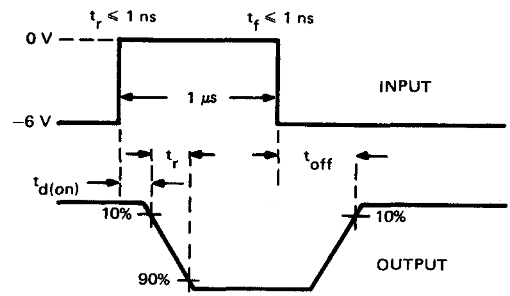
PARAMETER		TEST CONDITIONS†	MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 1.5$ V, $I_{D(on)} \approx 1$ mA,	20	ns
t_r	Rise Time	$V_{GS(on)} = 0$, $V_{GS(off)} = -6$ V,	100	ns
t_{off}	Turn-Off Time	See Figure 1	100	ns

†The fourth lead (case) is connected to the source for all measurements.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1–SWITCHING TIMES

NOTES: A. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, duty cycle $\leq 50\%$.
B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 10$ ns, $R_{in} \geq 5\ M\Omega$, $C_{in} \leq 10$ pF.

*JEDEC registered data

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TYPES 2N3970 THRU 2N3972
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

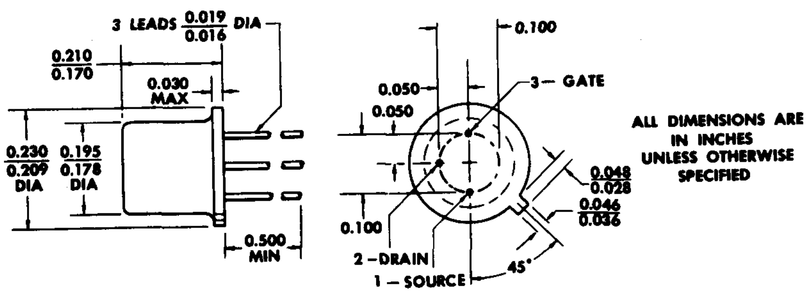
BULLETIN NO. DL-S 7311913, MARCH 1973

SYMMETRICAL N-CHANNEL FIELD-EFFECT TRANSISTORS FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

- Low $I_{D(off)}$ . . . 0.25 nA Max
- Low $r_{ds(on)}$ C_{iss} Product

*mechanical data

THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	40 V
Drain-Source Voltage	40 V
Reverse Gate-Source Voltage	–40 V
Continuous Forward Gate Current	50 mA
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 1)	1.8 W
Storage Temperature Range	–65°C to 200°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300°C

NOTE 1: Derate linearly to 200°C case temperature at the rate of 10.3 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN52

TEXAS INSTRUMENTS
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POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3970 MIN	2N3970 MAX	2N3971 MIN	2N3971 MAX	2N3972 MIN	2N3972 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−40		−40		−40		V
I_{DGO}	Drain Reverse Current	$V_{DG} = 20\ V$, $I_S = 0$		0.25		0.25		0.25	nA
		$V_{DG} = 20\ V$, $I_S = 0$, $T_A = 150°C$		0.5		0.5		0.5	μA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 20\ V$, $V_{GS} = -12\ V$		0.25		0.25		0.25	nA
		$V_{DS} = 20\ V$, $V_{GS} = -12\ V$, $T_A = 150°C$		0.5		0.5		0.5	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 20\ V$, $I_D = 1\ nA$	−4	−10	−2	−5	−0.5	−3	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 20\ V$, $V_{GS} = 0$, See Note 2	50	150	25	75	5	30	mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$V_{GS} = 0$, $I_D = 20\ mA$		1					V
		$V_{GS} = 0$, $I_D = 10\ mA$				1.5			
		$V_{GS} = 0$, $I_D = 5\ mA$						2	
$r_{DS(on)}$	Static Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 1\ mA$		30		60		100	Ω
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, $f = 1\ kHz$		30		60		100	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 20\ V$, $V_{GS} = 0$, $f = 1\ MHz$, See Note 3		25		25		25	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -12\ V$, $f = 1\ MHz$		6		6		6	pF

4

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N3970 TYP	2N3970 MAX	2N3971 TYP	2N3971 MAX	2N3972 TYP	2N3972 MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 10\ V$, $I_{D(on)}$† = 20 mA (2N3970), 10 mA (2N3971), 5 mA (2N3972); $V_{GS(on)} = 0$, $V_{GS(off)}$ = −10 V (2N3970), −5 V (2N3971), −3 V (2N3972); See Figure 1		10		15		40	ns
t_r	Rise Time			10		15		40	ns
t_{off}	Turn-Off Time			30		60		100	ns
t_r	Rise Time	$V_{DD} = 10\ V$, $I_{D(on)}$† = 12 mA (2N3970), 6 mA (2N3971), 3 mA (2N3972); $V_{GS(on)} = 0$, $V_{GS(off)}$ = −12 V (2N3970), −7 V (2N3971), −5 V (2N3972); See Figure 2	2		3		4		ns
t_{on}	Turn-On Time		5.5		6.5		8		ns
t_f	Fall Time		7		13		27		ns
t_{off}	Turn-Off Time		10		18		31		ns

NOTES: 2. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 3%.
3. This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.

†These are nominal values; exact values vary slightly with transistor parameters.

*JEDEC registered data (typical data excluded).

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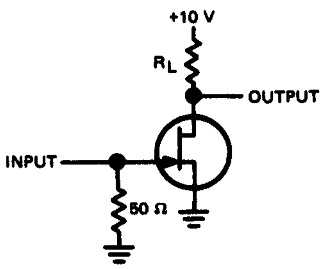
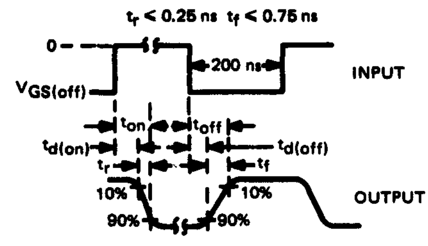
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

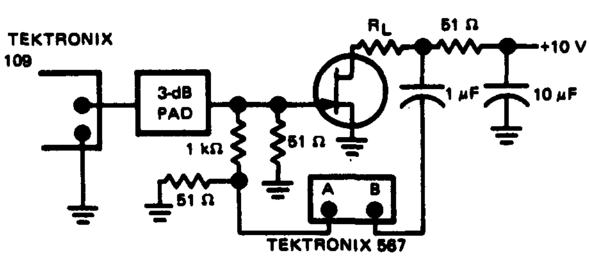


(See Notes a and b)
VOLTAGE WAVEFORMS

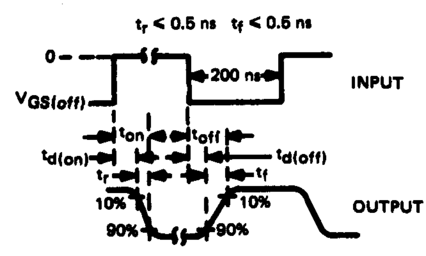
TYPE	R_L	$V_{GS(off)}$
2N3970	453 Ω	−10 V
2N3971	845 Ω	−5 V
2N3972	1.62 kΩ	−3 V

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, duty cycle ≈ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r < 0.4 ns, R_{in} = 10 MΩ, C_{in} = 1.5 pF.

FIGURE 1



TEST CIRCUIT



(See Note a)
VOLTAGE WAVEFORMS

TYPE	R_L	$V_{GS(off)}$
2N3970	750 Ω	−12 V
2N3971	1.54 kΩ	−7 V
2N3972	3.16 kΩ	−5 V

NOTE a: An equivalent generator and oscilloscope may be used. The oscilloscope must have a 50-Ω input impedance.

FIGURE 2

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 739565, MARCH 1967—REVISED MARCH 1973

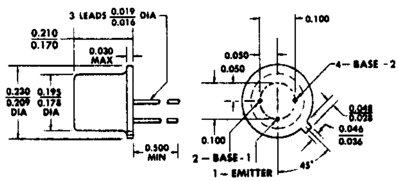
PLANAR UNIJUNCTION TRANSISTORS SPECIFICALLY CHARACTERIZED FOR A WIDE RANGE OF MILITARY, SPACE, AND INDUSTRIAL APPLICATIONS:

2N3980 for General-Purpose UJT Applications
2N4947 for High-Frequency Relaxation-Oscillator Circuits
2N4948 for Thyristor (SCR) Trigger Circuits
2N4949 for Long-Time-Delay Circuits

- **Planar Process Ensures Extremely Low Leakage, High Performance with Low Driving Currents, and Greatly Improved Reliability**

*mechanical data

Package outline is same as JEDEC TO-18 except for lead position. All TO-18 registration notes also apply to this outline.



BASE—2 IS IN ELECTRICAL CONTACT WITH THE CASE.

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Emitter—Base-Two Reverse Voltage	−30 V
Interbase Voltage	See Note 1
Continuous Emitter Current	50 mA
Peak Emitter Current (See Note 2)	1 A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	360 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. Interbase voltage is limited solely by power dissipation, $V_{B2\text{-}B1} = \sqrt{r_{BB} \cdot P_T}$
2. This value applies for a capacitor discharge through the emitter—base-one diode. Current must fall to 0.37 A within 3 ms and pulse-repetition rate must not exceed 10 pps.
3. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/deg.

*Indicates JEDEC registered data

USES CHIP U42

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3980		2N4947		2N4948		2N4949		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
r_{BB}	Static Interbase Resistance	$V_{B2-B1} = 3$ V, $I_E = 0$	4	8	4	9.1	4	12	4	12	kΩ
α_{rBB}	Interbase Resistance Temperature Coefficient	$V_{B2-B1} = 3$ V, $I_E = 0$, $T_A = -65°C$ to 100°C, See Note 4	0.4	0.9	0.1	0.9	0.1	0.9	0.1	0.9	%/deg
η	Intrinsic Standoff Ratio	$V_{B2-B1} = 10$ V, See Figure 1	0.68	0.82	0.51	0.69	0.55	0.82	0.74	0.86	
$I_{B2(mod)}$	Modulated Interbase Current	$V_{B2-B1} = 10$ V, $I_E = 50$ mA, See Note 5	12		12		12		12		mA
I_{EB2O}	*Emitter Reverse Current*	$V_{EB2} = -30$ V, $I_{B1} = 0$		−10		−10		−10		−10	nA
		$V_{EB2} = -30$ V, $I_{B1} = 0$, $T_A = 125°C$		−1		−1		−1		−1	μA
I_P	Peak-Point Emitter Current	$V_{B2-B1} = 25$ V		2		2		2		1	μA
$V_{EB1(sat)}$	Emitter — Base-One Saturation Voltage	$V_{B2-B1} = 10$ V, $I_E = 50$ mA, See Note 5		3		3		3		3	V
I_V	Valley-Point Emitter Current	$V_{B2-B1} = 20$ V	1	10	4		2		2		mA
V_{OB1}	Base-One Peak Pulse Voltage	See Figure 2	6		3		6		3		V

NOTES: 4. Temperature coefficient α_{rBB} is determined by the following formula:

$$\alpha_{rBB} = \left[\frac{(r_{BB} @ 100°C) - (r_{BB} @ -65°C)}{(r_{BB} @ 25°C)}\right]\frac{100\%}{165 \text{ deg}}$$

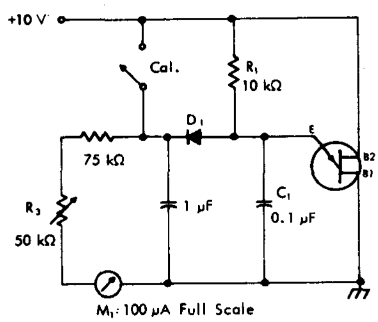
To obtain r_{BB} for a given temperature $T_{A(2)}$, use the following formula:

$$r_{BB(2)} = [r_{BB} @ 25°C]\,[1 + (\alpha_{rBB}/100\%)(T_{A(2)} - 25°C)]$$

5. *These parameters are measured using pulse techniques.* $t_p = 300$ μs, duty cycle $\leq 2\%$.

4

*PARAMETER MEASUREMENT INFORMATION



η — Intrinsic Standoff Ratio — This parameter is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.56 volt at 25°C and decreases with temperature at about 2 millivolts/deg.

The circuit used to measure η is shown in the figure. In this circuit, R_1, C_1 and the unijunction transistor form a relaxation oscillator, and the remainder of the circuit serves as a peak-voltage detector with the diode D_1 automatically subtracting the voltage V_F. To use the circuit, the "cal" button is pushed, and R_3 is adjusted to make the current meter M_1 read full scale. The "cal" button then is released and the value of η is read directly from the meter, with $\eta = 1$ corresponding to full-scale deflection of 100 μA.

D_1: 1N457, or equivalent, with the following characteristics:
$V_F = 0.565$ V at $I_F = 50$ μA,
$I_R \leq 2$ μA at $V_R = 20$ V

FIGURE 1 — TEST CIRCUIT FOR INTRINSIC STANDOFF RATIO (η)

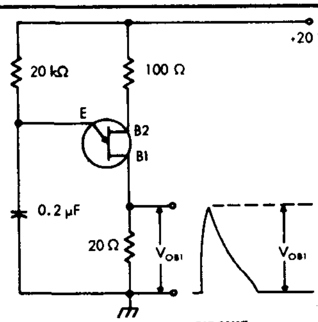


FIGURE 2 — V_{OB1} TEST CIRCUIT

EMITTER—BASE-ONE VOLTAGE
vs
EMITTER CURRENT

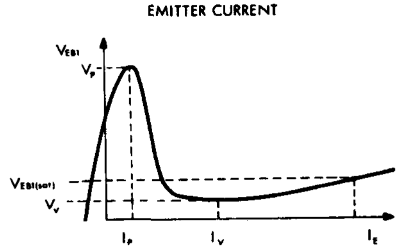


FIGURE 3 — GENERAL STATIC EMITTER CHARACTERISTIC CURVE

*Indicates JEDEC registered data

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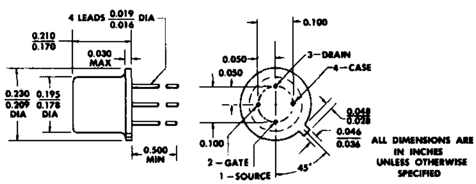
TYPES 2N3993, 2N3993A, 2N3994, 2N3994A
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 6811115, OCTOBER 1968

FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

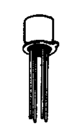
- Low $r_{ds(on)}$ . . . 150 Ω Max (2N3993, 2N3993A)
- High $|y_{fs}|/C_{iss}$ Ratio (High-Frequency Figure-of-Merit)
- Low Leakage
- Low C_{rss} . . . 3 pF Max (2N3993A)

*mechanical data



THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	-25 V
Drain-Source Voltage	-25 V
Reverse Gate-Source Voltage	25 V
Continuous Forward Gate Current	-10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	-65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE: 1. Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.

*Indicates JEDEC registered data

USES CHIP JP72

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POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		2N3993 MIN	2N3993 MAX	2N3993A MIN	2N3993A MAX	2N3994 MIN	2N3994 MAX	2N3994A MIN	2N3994A MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 1\ \mu A$,	$V_{DS} = 0$	25		25		25		25		V
I_{DGO}	Drain Reverse Current	$V_{DG} = -15$ V,	$I_s = 0$		-1.2		-1.2		-1.2		-1.2	nA
		$V_{DG} = -15$ V,	$I_s = 0$, $T_A = 150°C$		-1.2		-1.2		-1.2		-1.2	µA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -10$ V,	$V_{GS} = 0$, See Note 2	-10		-10		-2		-2		mA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = -10$ V,	$V_{GS} = 6$ V						-1.2		-1.2	nA
		$V_{DS} = -10$ V,	$V_{GS} = 6$ V, $T_A = 150°C$						-1		-1	µA
		$V_{DS} = -10$ V,	$V_{GS} = 10$ V		-1.2		-1.2					nA
		$V_{DS} = -10$ V,	$V_{GS} = 10$ V, $T_A = 150°C$		-1		-1					µA
V_{GS}	Gate-Source Voltage	$V_{DS} = -10$ V,	$I_D = -1\ \mu A$	4	9.5	4	9.5	1	5.5	1	5.5	V
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, f = 1 kHz	$I_D = 0$,		150		150		300		300	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ V, f = 1 kHz,	$V_{GS} = 0$, See Note 2	6	12	7	12	4	10	5	10	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -10$ V, f = 1 MHz,	$V_{GS} = 0$, See Note 3		16		12		16		12	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, f = 1 MHz	$V_{GS} = 6$ V,						5		3.5	pF
		$V_{DS} = 0$, f = 1 MHz	$V_{GS} = 10$ V,		4.5		3					pF

NOTES: 2. These parameters must be measured using pulse techniques. $t_p = 100$ ms, duty cycle $\leq 10\%$.

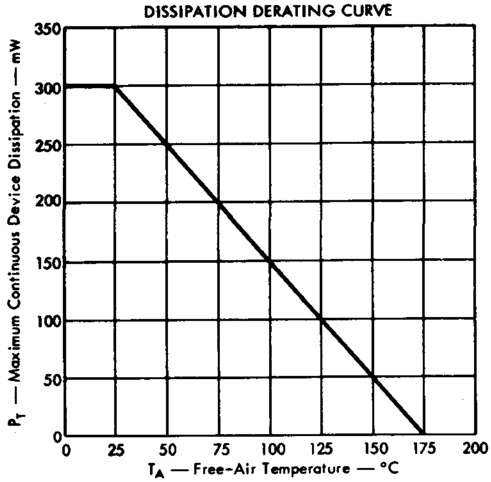
3. This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.

*Indicates JEDEC registered data

†The fourth lead (case) is connected to the source for all measurements.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



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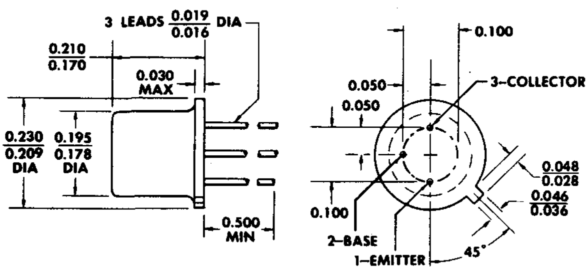
BULLETIN NO. DL-S 7311917, MARCH 1973

FAST, HIGH-VOLTAGE, HIGH-CURRENT CORE DRIVERS

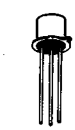
- h_{FE} Guaranteed from 10 mA to 1 A
- Guaranteed Switching Times at 500 mA
- Also Available in TO-39 as 2N3724, 2N3725

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N4013	2N4014	UNIT
Collector-Base Voltage	50	80	V
Collector-Emitter Voltage (See Note 1)	30	50	V
Emitter-Base Voltage	6	6	V
Continuous Collector Current	0.5	0.5	A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360	360	mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2	1.2	W
Storage Temperature Range	−65 to 200	−65 to 200	°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300	300	°C

NOTES: 1. These values apply between 0.01 mA and 500 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 2.06 mW/°C.
3. Derate linearly to 200°C case temperature at the rate of 6.85 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP N13

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POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		2N4013 MIN	2N4013 MAX	2N4014 MIN	2N4014 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		50		80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$,	See Note 4	30		50		V
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ \mu A$, $V_{BE} = 0$		50		80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40\ V$, $I_E = 0$			1.7			μA
		$V_{CB} = 40\ V$, $I_E = 0$, $T_A = 100°C$			120			
		$V_{CB} = 60\ V$, $I_E = 0$					1.7	
		$V_{CB} = 60\ V$, $I_E = 0$, $T_A = 100°C$					120	
I_{CES}	Collector Cutoff Current	$V_{CE} = 50\ V$, $V_{BE} = 0$			10			μA
		$V_{CE} = 80\ V$, $V_{BE} = 0$					10	
I_B	Base Current	$V_{CE} = 50\ V$, $V_{BE} = 0$			−10			μA
		$V_{CE} = 80\ V$, $V_{BE} = 0$					−10	
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1\ V$, $I_C = 10\ mA$	See Note 4	30		30		
		$V_{CE} = 1\ V$, $I_C = 100\ mA$		60	150	60	150	
		$V_{CE} = 1\ V$, $I_C = 100\ mA$, $T_A = -55°C$		30		30		
		$V_{CE} = 1\ V$, $I_C = 300\ mA$		40		40		
		$V_{CE} = 1\ V$, $I_C = 500\ mA$		35		35		
		$V_{CE} = 1\ V$, $I_C = 500\ mA$, $T_A = -55°C$		20		20		
		$V_{CE} = 2\ V$, $I_C = 800\ mA$		25		20		
		$V_{CE} = 5\ V$, $I_C = 1\ A$		30		25		
V_{BE}	Base-Emitter Voltage	$I_B = 1\ mA$, $I_C = 10\ mA$	See Note 4		0.76		0.76	V
		$I_B = 10\ mA$, $I_C = 100\ mA$			0.86		0.86	
		$I_B = 30\ mA$, $I_C = 300\ mA$			1.1		1.1	
		$I_B = 50\ mA$, $I_C = 500\ mA$		0.8	1.1	0.8	1.1	
		$I_B = 80\ mA$, $I_C = 800\ mA$			1.5		1.5	
		$I_B = 100\ mA$, $I_C = 1\ A$			1.7		1.7	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1\ mA$, $I_C = 10\ mA$	See Note 4		0.25		0.25	V
		$I_B = 10\ mA$, $I_C = 100\ mA$			0.2		0.26	
		$I_B = 30\ mA$, $I_C = 300\ mA$			0.32		0.4	
		$I_B = 50\ mA$, $I_C = 500\ mA$			0.42		0.52	
		$I_B = 80\ mA$, $I_C = 800\ mA$			0.65		0.8	
		$I_B = 100\ mA$, $I_C = 1\ A$			0.75		0.95	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 50\ mA$, $f = 100\ MHz$		3		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$, $f = 1\ MHz$			12		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$, $f = 1\ MHz$			55		55	pF

NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 1\%$.
*JEDEC registered data

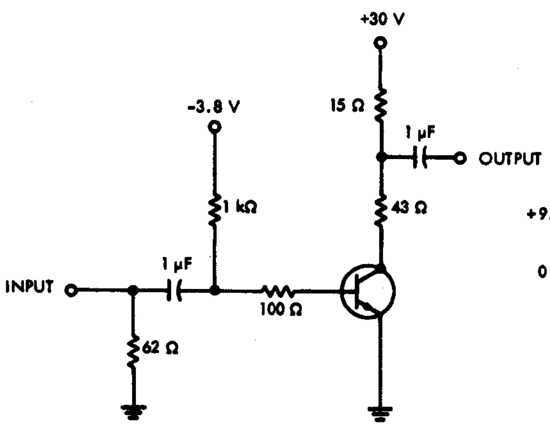
4

***switching characteristics at 25°C free-air temperature**

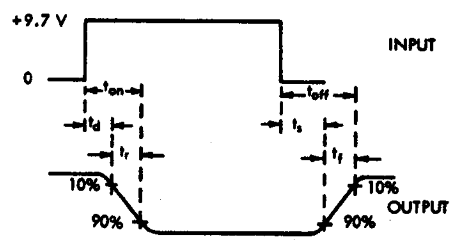
PARAMETER		TEST CONDITIONS†		2N4013 MAX	2N4014 MAX	UNIT
t_d	Delay Time	$V_{CC} = 30$ V,	$I_C = 500$ mA,	10	10	ns
t_r	Rise Time	$I_{B(1)} = 50$ mA,	$V_{BE(off)} = -3.8$ V,	30	30	ns
t_{on}	Turn-On Time	See Figure 1		35	35	ns
t_s	Storage Time	$V_{CC} = 30$ V,	$I_C = 500$ mA,	50	50	ns
t_f	Fall Time	$I_{B(1)} = 50$ mA,	$I_{B(2)} = -50$ mA,	25	30	ns
t_{off}	Turn-Off Time	See Figure 1		60	60	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1 — 500-mA SWITCHING TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r < 1$ ns, $t_f < 1$ ns, $t_w \approx 1\ \mu s$, duty cycle < 2%.

b. The output waveforms are monitored on an oscilloscope with the following characteristics: $t_r < 1$ ns, $R_{in} > 100\ k\Omega$, $C_{in} < 7$ pF.

*JEDEC registered data

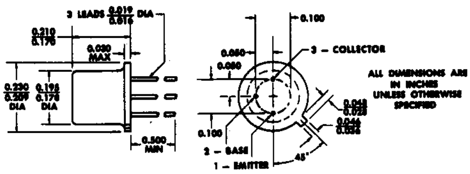
BULLETIN NO. DLS 7311982, MARCH 1973

MEDIUM POWER P-N-P TRANSISTORS FOR COMPUTER MEMORY APPLICATIONS

- Increased Dissipation at 25°C Case Temperature . . . 10 W Max (2N4030 thru 2N4033)
- High $V_{(BR)CEO}$ . . . 80 V Min (2N4027, 2N4029, 2N4031, 2N4033)

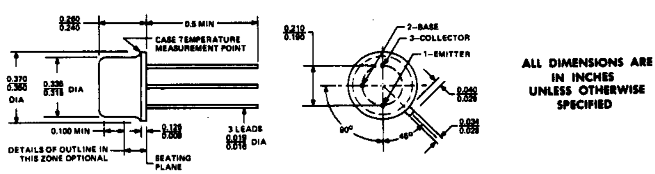
mechanical data

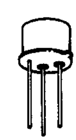
2N4026 THRU 2N4029
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE*

2N4030 THRU 2N4033
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N4026 2N4028	2N4027 2N4029	2N4030 2N4032	2N4031 2N4033	UNIT
Collector-Base Voltage	−60*	−80*	−60*	−80*	V
Collector-Emitter Voltage (See Note 1)	−60*	−80*	−60*	−80*	V
Emitter-Base Voltage	−5*		−5*		V
Continuous Collector Current	−1*		−1*		A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.5*		0.8*		W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	2*		10† 4*		W
Storage Temperature Range	−65 to 200*		−65 to 200*		°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300*		300*		°C

NOTES: 1. These values apply between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rates of 2.86 mW/°C for 2N4026 through 2N4029 and 4.56 mW/°C for 2N4030 through 2N4033.
3. Derate linearly to 200°C case temperature at the following rates: 11.4 mW/°C for the 2-watt rating, 57.1 mW/°C for the 10-watt rating, and 22.8 mW/°C for the 4-watt rating.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N4026 2N4030 MIN	2N4026 2N4030 MAX	2N4027 2N4031 MIN	2N4027 2N4031 MAX	2N4028 2N4032 MIN	2N4028 2N4032 MAX	2N4029 2N4033 MIN	2N4029 2N4033 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−60		−80		−60		−80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ mA$, $I_B = 0$, See Note 4		−60		−80		−60		−80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−5		−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50\ V$, $I_E = 0$			−50				−50			nA
		$V_{CB} = -60\ V$, $I_E = 0$					−50				−50	nA
		$V_{CB} = -50\ V$, $I_E = 0$, $T_A = 150°C$			−50				−50			μA
		$V_{CB} = -60\ V$, $I_E = 0$, $T_A = 150°C$					−50				−50	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5\ V$, $I_C = 0$			−10		−10		−10		−10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5\ V$, $I_C = -100\ \mu A$		30		30		75		75		
		$V_{CE} = -5\ V$, $I_C = -100\ mA$	See Note 4	40	120	40	120	100	300	100	300	
		$V_{CE} = -5\ V$, $I_C = -100\ mA$, $T_A = -55°C$	See Note 4	15		15		40		40		
		$V_{CE} = -5\ V$, $I_C = -500\ mA$	See Note 4	25		25		70		70		
		$V_{CE} = -5\ V$, $I_C = -1\ A$	See Note 4	15		10		40		25		
V_{BE}	Base-Emitter Voltage	$I_B = -15\ mA$, $I_C = -150\ mA$	See Note 4		−0.9		−0.9		−0.9		−0.9	V
		$V_{CE} = -0.5\ V$, $I_C = -500\ mA$	See Note 4		−1.1		−1.1		−1.1		−1.1	V
		$V_{CE} = -1\ V$, $I_C = -1\ A$	See Note 4		−1.2				−1.2			V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15\ mA$, $I_C = -150\ mA$	See Note 4		−0.15		−0.15		−0.15		−0.15	V
		$I_B = -50\ mA$, $I_C = -500\ mA$	See Note 4		−0.5		−0.5		−0.5		−0.5	V
		$I_B = -100\ mA$, $I_C = -1\ A$	See Note 4		−1				−1			V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10\ V$, $I_C = -50\ mA$, $f = 100\ MHz$		1	4	1	4	1.5	5	1.5	5	
C_{cb}	Collector-Base Capacitance	$V_{CB} = -10\ V$, $I_E = 0$, $f = 1\ MHz$, See Note 5			20		20		20		20	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5\ V$, $I_C = 0$, $f = 1\ MHz$			110		110		110		110	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 1%.

5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*JEDEC registered data

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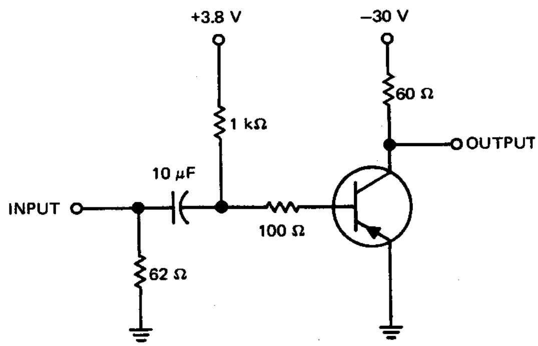
4

switching characteristics at 25°C free-air temperature

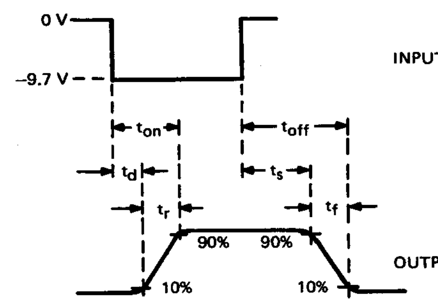
PARAMETER		TEST CONDITIONS†		MAX	UNIT
t_{on}	Turn-On Time	$V_{CC} = -30$ V,	$I_C = -500$ mA,	100	ns
t_s	Storage Time	$I_{B(1)} = -50$ mA,	$I_{B(2)} = 50$ mA,	350	ns
t_f	Fall Time	$V_{BE(off)} = 3.8$ V,	See Figure 1	50	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.
*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 20$ ns, $t_f \leq 20$ ns, $t_w \approx 10\ \mu s$, duty cycle ≤ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \approx 10$ ns, $R_{in} \geq 100\ k\Omega$.

FIGURE 1—500-mA SWITCHING TIMES

THERMAL INFORMATION

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

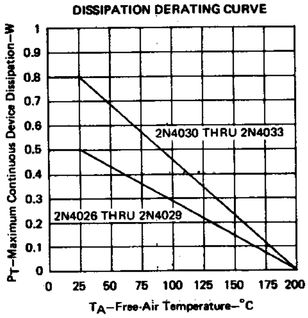


FIGURE 2

2N4026 THRU 2N4029
CASE TEMPERATURE
DISSIPATION DERATING CURVE

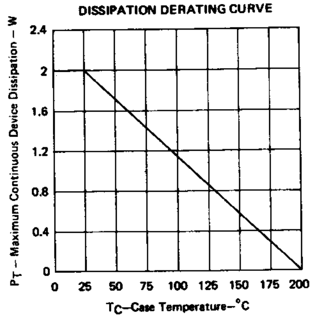


FIGURE 3

2N4030 THRU 2N4033
CASE TEMPERATURE
DISSIPATION DERATING CURVE

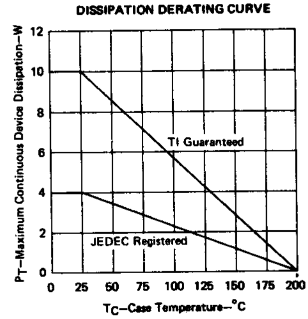


FIGURE 4

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7312002, MARCH 1973

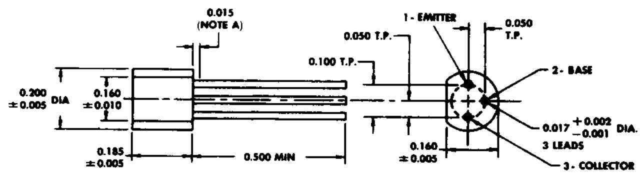
SILECT† TRANSISTORS‡
FOR GENERAL PURPOSE APPLICATIONS

- High $V_{(BR)CEO}$ . . . 80 V Min (A5T4027, A5T4029, A8T4027, A8T4029)
- High Current Capability . . . 1 A
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circule Configuration

mechanical data

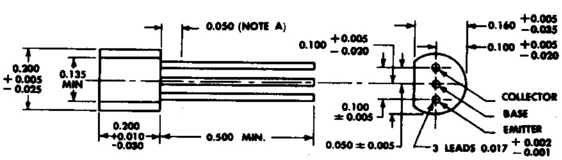
These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. This case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

A5T4026 THRU A5T4029



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

A8T4026 THRU A8T4028



EBC

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T4026 A5T4028 A8T4026 A8T4028	A5T4027 A5T4029 A8T4027 A8T4029
Collector-Base Voltage	−60 V	−80 V
Collector-Emitter Voltage (See Note 1)	−60 V	−80 V
Emitter-Base Voltage	−5 V	−5 V
Continuous Collector Current	←−1 A→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←625 mW→	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	←1.25 W→	
Storage Temperature Range	←−65°C to 150°C→	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←260°C→	

NOTES: 1. These values apply between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP P16

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	A5T4026 A8T4026 MIN	A5T4026 A8T4026 MAX	A5T4027 A8T4027 MIN	A5T4027 A8T4027 MAX	A5T4028 A8T4028 MIN	A5T4028 A8T4028 MAX	A5T4029 A8T4029 MIN	A5T4029 A8T4029 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−60		−80		−60		−80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 4	−60		−80		−60		−80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−5		−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V, $I_E = 0$		−50				−50			nA
		$V_{CB} = -60$ V, $I_E = 0$				−50				−50	nA
		$V_{CB} = -50$ V, $I_E = 0$, $T_A = 100°C$		−5				−5			μA
		$V_{CB} = -60$ V, $I_E = 0$, $T_A = 100°C$				−5				−5	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -5$ V, $I_C = 0$		−10		−10		−10		−10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -100\ \mu A$	30		30		75		75		
		$V_{CE} = -5$ V, $I_C = -100$ mA, See Note 4	40	120	40	120	100	300	100	300	
		$V_{CE} = -5$ V, $I_C = -100$ mA, $T_A = -55°C$, See Note 4	15		15		40		40		
		$V_{CE} = -5$ V, $I_C = -500$ mA, See Note 4	25		25		70		70		
		$V_{CE} = -5$ V, $I_C = -1$ A, See Note 4	15		10		40		25		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 4		−0.9		−0.9		−0.9		−0.9	V
		$V_{CE} = -0.5$ V, $I_C = -500$ mA, See Note 4		−1.1		−1.1		−1.1		−1.1	V
		$V_{CE} = -1$ V, $I_C = -1$ A, See Note 4		−1.2				−1.2			V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 4		−0.15		−0.15		−0.15		−0.15	V
		$I_B = -50$ mA, $I_C = -500$ mA, See Note 4		−0.5		−0.5		−0.5		−0.5	V
		$I_B = -100$ mA, $I_C = -1$ A, See Note 4		−1				−1			V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -50$ mA, f = 100 MHz	1	4	1	4	1.5	5	1.5	5	
C_{cb}	Collector-Base Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 1 MHz, See Note 5		20		20		20		20	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 1 MHz		110		110		110		110	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $< 2\%$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

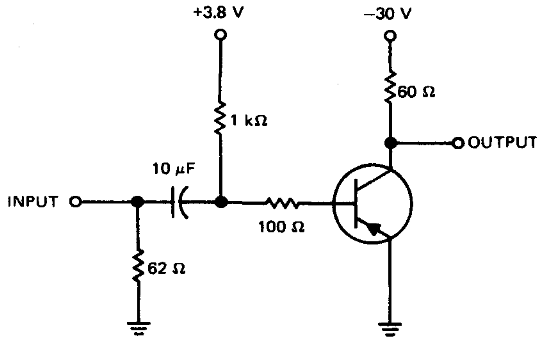
4

switching characteristics at 25°C free-air temperature

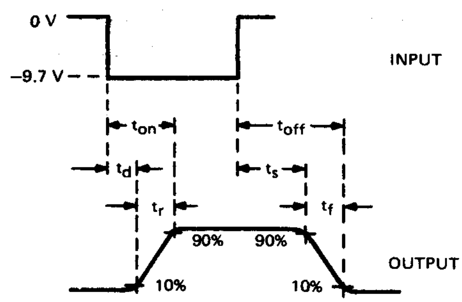
PARAMETER		TEST CONDITIONS†		MAX	UNIT
t_{on}	Turn-On Time	$V_{CC} = -30$ V,	$I_C = -500$ mA,	100	ns
t_s	Storage Time	$I_{B(1)} = -50$ mA,	$I_{B(2)} = 50$ mA,	350	ns
t_f	Fall Time	$V_{BE(off)} = 3.8$ V,	See Figure 1	50	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 20$ ns, $t_f \leq 20$ ns, $t_w \approx 10\ \mu s$, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \approx 10$ ns, $R_{in} \geq 100$ kΩ.

FIGURE 1—500-mA SWITCHING TIMES

THERMAL INFORMATION

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

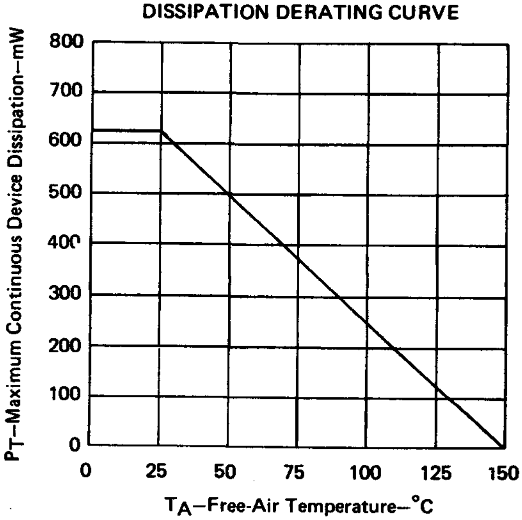


FIGURE 2

LEAD TEMPERATURE
DISSIPATION DERATING CURVE

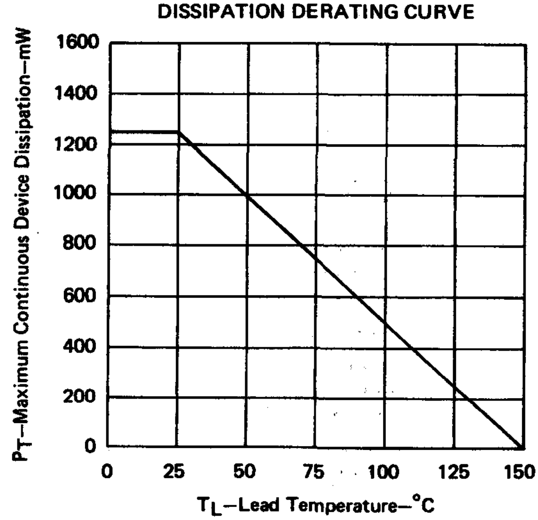


FIGURE 3

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311962, MARCH 1973

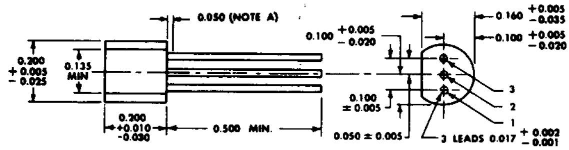
SILECT† TRANSISTORS‡

- **Ideal for Low-Level Amplifier Applications**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**
- **Recommended for Complementary Use with 2N3707 thru 2N3711, A5T3707 thru A5T3711, or A8T3707 thru A8T3711**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N4058 THRU 2N4062, A8T4058 THRU A8T4062
*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

DEVICE	LEAD 1	LEAD 2	LEAD 3
2N4058 thru 2N4062	Emitter	Collector	Base
A8T4058 thru A8T4062	Emitter	Base	Collector

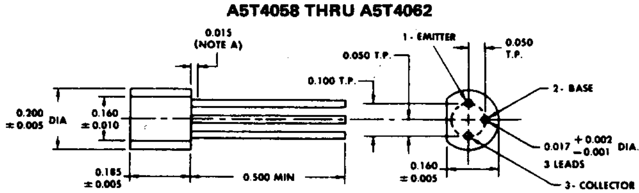
2N4058 thru 2N4062

ECB

A8T4058 thru A8T4062

EBC

A5T4058 THRU A5T4062



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−30 V*
Collector-Emitter Voltage (See Note 1)	−30 V*
Emitter-Base Voltage	−6 V*
Continuous Collector Current	−30 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ / 360 mW*
Storage Temperature Range	−65°C to 150°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 360-mW (JEDEC registered) rating linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N4058 through 2N4062 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees this value in addition to the JEDEC registered value which is also shown.

USES CHIP P18

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N4058 A5T4058 A8T4058		2N4059 A5T4059 A8T4059		2N4060 A5T4060 A8T4060		2N4061 A5T4061 A8T4061		2N4062 A5T4062 A8T4062		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 3	−30		−30		−30		−30		−30		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -20$ V, $I_E = 0$		−100		−100		−100		−100		−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -6$ V, $I_C = 0$		−100		−100		−100		−100		−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -100$ µA	100	400									
		$V_{CE} = -5$ V, $I_C = -1$ mA			45	660	45	165	90	330	180	660	
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -1$ mA	−0.5	−1	−0.5	−1	−0.5	−1	−0.5	−1	−0.5	−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.5$ mA, $I_C = -10$ mA		−0.7		−0.7		−0.7		−0.7		−0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -100$ µA, f = 1 kHz	100	550									
		$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz			45	800	45	250	90	450	180	800	

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N4058, A5T4058, A8T4058			UNIT
			MIN	TYP	MAX	
$\overline{F}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -100$ µA, $R_G = 5$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 4		1.7	5	dB

NOTES: 3. This parameter must be measured using pulse techniques: $t_w = 300$ µs, duty cycle ≤ 2%.
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*The asterisk identifies JEDEC registered data for 2N4058 through 2N4062 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

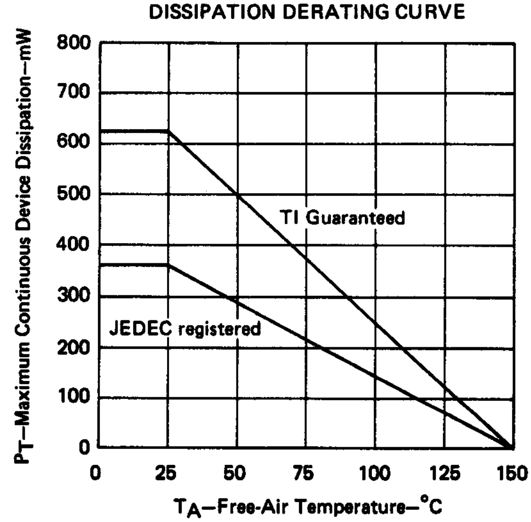


FIGURE 1

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N4091 THRU 2N4093
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

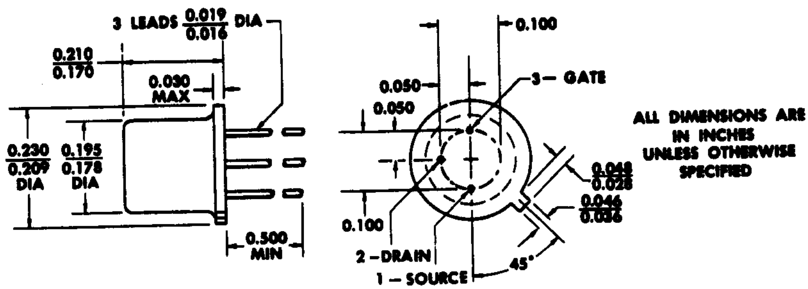
BULLETIN NO. DL-S 7311914, MARCH 1973

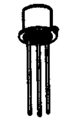
SYMMETRICAL N-CHANNEL FIELD-EFFECT TRANSISTORS FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

- Low $I_{D(off)}$ . . . 0.25 nA Max
- Low $r_{ds(on)}$ C_{iss} Product

*mechanical data

THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	40 V
Drain-Source Voltage	40 V
Reverse Gate-Source Voltage	−40 V
Continuous Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 1)	1.8 W
Storage Temperature Range	−55°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE 1: Derate linearly to 200°C case temperature at the rate of 10.3 mW/°C.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN52

4

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4091 MIN	2N4091 MAX	2N4092 MIN	2N4092 MAX	2N4093 MIN	2N4093 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−40		−40		−40		V
I_{DGO}	Drain Reverse Current	$V_{DG} = 20\ V$, $I_S = 0$		0.2		0.2		0.2	nA
		$V_{DG} = 20\ V$, $I_S = 0$, $T_A = 150°C$		0.4		0.4		0.4	μA
I_{SGO}	Source Reverse Current	$V_{SG} = 20\ V$, $I_D = 0$		0.2		0.2		0.2	nA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 20\ V$, $V_{GS} = -12\ V$		0.2					nA
		$V_{DS} = 20\ V$, $V_{GS} = -8\ V$				0.2			
		$V_{DS} = 20\ V$, $V_{GS} = -6\ V$						0.2	
		$V_{DS} = 20\ V$, $V_{GS} = -12\ V$, $T_A = 150°C$		0.4					μA
		$V_{DS} = 20\ V$, $V_{GS} = -8\ V$, $T_A = 150°C$				0.4			
		$V_{DS} = 20\ V$, $V_{GS} = -6\ V$, $T_A = 150°C$						0.4	
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 20\ V$, $I_D = 1\ nA$	−5	−10	−2	−7	−1	−5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 20\ V$, $V_{GS} = 0$, See Note 2	30		15		8		mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$V_{GS} = 0$, $I_D = 6.6\ mA$		0.2					V
		$V_{GS} = 0$, $I_D = 4\ mA$				0.2			
		$V_{GS} = 0$, $I_D = 2.5\ mA$						0.2	
$r_{DS(on)}$	Static Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 1\ mA$		30		50		80	Ω
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, $f = 1\ kHz$		30		50		80	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 20\ V$, $V_{GS} = 0$, $f = 1\ MHz$, See Note 3		16		16		16	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -20\ V$, $f = 1\ MHz$		5		5		5	pF

*switching characteristics at 25°C free-air temperature

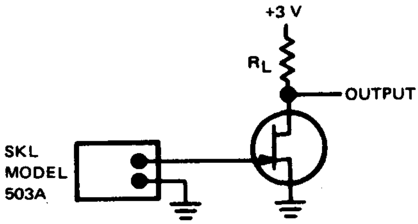
PARAMETER		TEST CONDITIONS	2N4091 TYP	2N4091 MAX	2N4092 TYP	2N4092 MAX	2N4093 TYP	2N4093 MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 3\ V$, $I_{D(on)}$† = 6.6 mA (2N4091), 4 mA (2N4092), 2.5 mA (2N4093); $V_{GS(on)} = 0$, $V_{GS(off)}$ = −12 V (2N4091), −8 V (2N4092), −6 V (2N4093); See Figure 1		15		15		20	ns
t_r	Rise Time			10		20		40	ns
t_{off}	Turn-Off Time			40		60		80	ns
t_r	Rise Time	$V_{DD} = 10\ V$, $I_{D(on)}$† = 12 mA (2N4091), 6 mA (2N4092), 3 mA (2N4093); $V_{GS(on)} = 0$, $V_{GS(off)}$ = −12 V (2N4091), −7 V (2N4092), −5 V (2N4093); See Figure 2	2		3		4		ns
t_{on}	Turn-On Time		5.5		6.5		8		ns
t_f	Fall Time		7		13		27		ns
t_{off}	Turn-Off Time		10		18		31		ns

NOTES: 2. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 3%.
3. This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.

†These are nominal values; exact values vary slightly with transistor parameters.

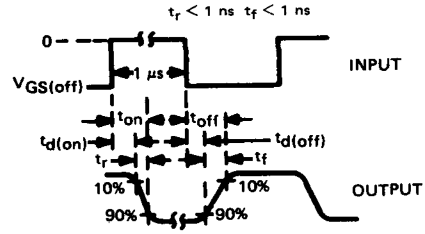
*JEDEC registered data (typical data excluded).

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

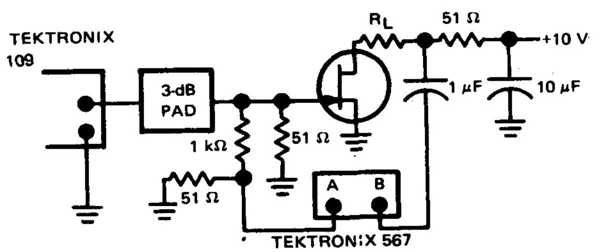
TYPE	R_L	$V_{GS(off)}$
2N4091	422 Ω	−12 V
2N4092	698 Ω	−8 V
2N4093	1.13 kΩ	−6 V



(See Notes a and b)
VOLTAGE WAVEFORMS

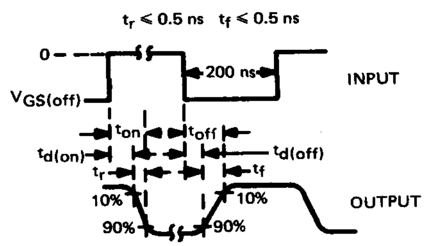
NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, duty cycle ≈ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 0.4$ ns, $R_{in} = 10\ M\Omega$, $C_{in} = 1.5$ pF.

FIGURE 1



TEST CIRCUIT

TYPE	R_L	$V_{GS(off)}$
2N4091	750 Ω	−12 V
2N4092	1.54 kΩ	−7 V
2N4093	3.16 kΩ	−5 V



(See Note a)
VOLTAGE WAVEFORMS

NOTE a. An equivalent generator and oscilloscope may be used. The oscilloscope must have a 50-Ω input impedance.

FIGURE 2

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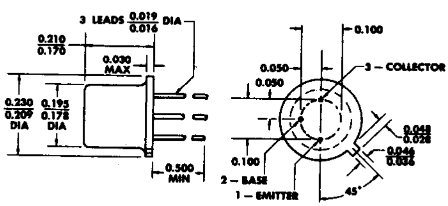
BULLETIN NO. DL-S 668315, JANUARY 1966

DESIGNED FOR USE IN LOW-LEVEL, LOW-NOISE AMPLIFIERS

- **Guaranteed Low-Noise Characteristics at 10 Hz, 100 Hz, 1 kHz and 10 kHz**
- **Very High Guaranteed h_{FE} at $I_C = 10\ \mu A$: 400 Minimum**
- **High Rated V_{EBO} : 10 V**

4

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE

ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	60 V
Collector-Emitter Voltage (See Note 1)	60 V
Emitter-Base Voltage	10 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	0.3 W
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. This value applies between 0 and 10 mA when the base-emitter diode is open-circuited.

2. Derate linearly to 175°C free-air temperature at the rate of 2 mw/°C.

3. Derate linearly to 175°C case temperature at the rate of 8 mw/°C.

*JEDEC registered data

USES CHIP N11

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 4	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	10		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45$ V, $I_E = 0$		10	nA
		$V_{CB} = 45$ V, $I_E = 0$, $T_A = 150°C$		10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1\ \mu A$	150		
		$V_{CE} = 5$ V, $I_C = 10\ \mu A$	400	800	
		$V_{CE} = 5$ V, $I_C = 100\ \mu A$	450		
		$V_{CE} = 5$ V, $I_C = 1$ mA	500		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 100\ \mu A$		0.7	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.1$ mA, $I_C = 1$ mA		0.3	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ V, $I_C = 1$ mA, $f = 1$ kHz	12	42	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		500	1400	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			8×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance		8	60	μmho
$\lvert h_{fe}\rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 0.5$ mA, $f = 30$ MHz	3	18	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_E = 0$, $f = 1$ MHz		4.5	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 1$ MHz		6	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
NF	Spot Noise Figure	$V_{CE} = 5$ V, $I_C = 30\ \mu A$, $R_G = 10$ kΩ, $f = 10$ Hz		15	dB
		$V_{CE} = 5$ V, $I_C = 30\ \mu A$, $R_G = 10$ kΩ, $f = 100$ Hz		4	dB
		$V_{CE} = 5$ V, $I_C = 5\ \mu A$, $R_G = 50$ kΩ, $f = 1$ kHz		1	dB
		$V_{CE} = 5$ V, $I_C = 5\ \mu A$, $R_G = 50$ kΩ, $f = 10$ kHz		1	dB

NOTE 4: This parameter must be measured using pulse techniques: $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

*JEDEC registered data

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INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311471, NOVEMBER 1971—REVISED MARCH 1973

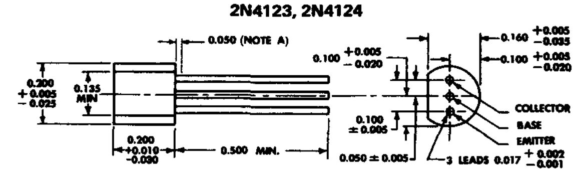
SILECT† TRANSISTORS‡
DESIGNED FOR GENERAL PURPOSE SATURATED SWITCHING AND AMPLIFIER APPLICATIONS

- **For Complementary Use with P-N-P Types 2N4125, 2N4126, A5T4125, and A5T4126**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. This case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N4123, 2N4124

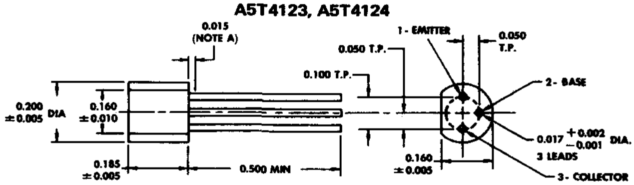


*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

A5T4123, A5T4124



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N4123 A5T4123	2N4124 A5T4124
Collector-Base Voltage	40 V*	30 V*
Collector-Emitter Voltage (See Note 1)	30 V*	25 V*
Emitter-Base Voltage	5 V*	5 V*
Continuous Collector Current	200 mA*	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ / 310 mW*	
Storage Temperature Range	−65°C to 150°C§ / −55°C to 135°C*	
Lead Temperature 1/16 Inch from Case for 60 Seconds	230°C*	

NOTES: 1. These values apply between 10 μA and 200 mA collector current when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.81 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N4123 and 2N4124 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			2N4123 A5T4123 MIN	2N4123 A5T4123 MAX	2N4124 A5T4124 MIN	2N4124 A5T4124 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$		40		30		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA,	$I_B = 0$,	See Note 3	30		25		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$		5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20$ V,	$I_E = 0$			50		50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V,	$I_C = 0$			50		50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V,	$I_C = 2$ mA	See Note 3	50	150	120	360	
		$V_{CE} = 1$ V,	$I_C = 50$ mA		25		60		
V_{BE}	Base-Emitter Voltage	$I_B = 5$ mA,	$I_C = 50$ mA,	See Note 3		0.95		0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ mA,	$I_C = 50$ mA,	See Note 3		0.3		0.3	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 2$ mA,	f = 1 kHz	50	200	120	480	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 20$ V,	$I_C = 10$ mA,	f = 100 MHz	2.5		3		
f_T	Transition Frequency	$V_{CE} = 20$ V,	$I_C = 10$ mA,	See Note 4	250		300		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V,	$I_E = 0$,	f = 100 kHz		4		4	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V,	$I_C = 0$,	f = 100 kHz		8		8	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
4. To obtain f_T, the $\lvert h_{fe} \rvert$ response is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N4123 A5T4123 MIN	2N4123 A5T4123 MAX	2N4124 A5T4124 MIN	2N4124 A5T4124 MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, $R_G = 1$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 5		6		5	dB

NOTE 5: Average noise figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*The asterisk identifies JEDEC registered data for the 2N4123 and 2N4124 only.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	$I_C = 10$ mA, $I_{B(1)} = 1$ mA, $V_{BE(off)} = -0.5$ V,	14	ns
t_r	Rise Time	$R_L = 275\ \Omega$, See Figure 1	8	ns
t_s	Storage Time	$I_C = 10$ mA, $I_{B(1)} = 1$ mA, $I_{B(2)} = -1$ mA,	22	ns
t_f	Fall Time	$R_L = 275\ \Omega$, See Figure 2	10	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters. Nominal base current for delay and rise times is calculated using the minimum value of V_{BE}. Nominal base currents for storage and fall times are calculated using the maximum value of V_{BE}.

PARAMETER MEASUREMENT INFORMATION

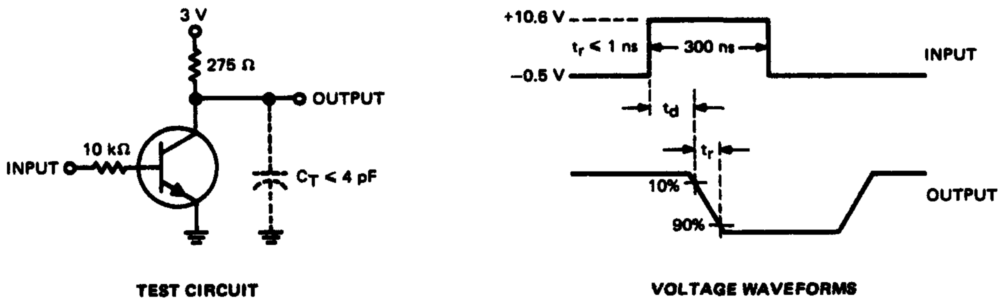

FIGURE 1–DELAY AND RISE TIMES

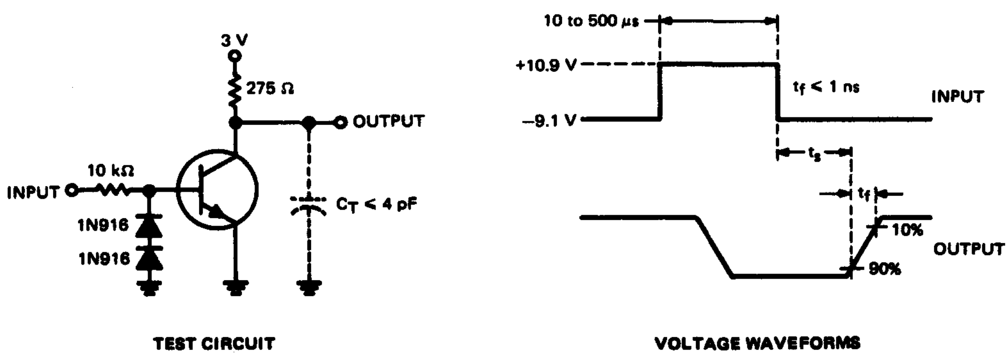

FIGURE 2–STORAGE AND FALL TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, duty cycle = 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r < 1 ns, R_{in} = 10 MΩ, C_{in} < 4 pF.

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INCORPORATED
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PRINTED IN U.S.A. 1071

BULLETIN NO. DL-S 7311472, JULY 1971–REVISED MARCH 1973

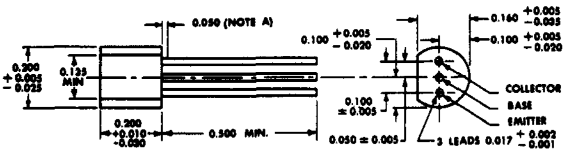
SILECT† TRANSISTORS‡
FOR GENERAL PURPOSE SATURATED-SWITCHING AND AMPLIFIER APPLICATIONS

- **For Complementary Use with N-P-N Types 2N4123, 2N4124, A5T4123, and A5T4124**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N4125, 2N4126

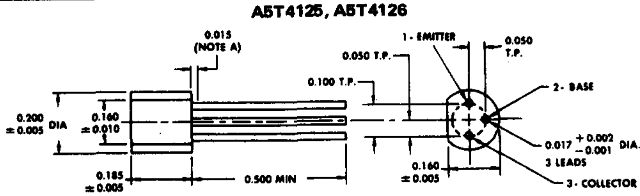


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T4125, A5T4126



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N4125 A5T4125	2N4126 A5T4126
Collector-Base Voltage	–30 V*	–25 V*
Collector-Emitter Voltage (See Note 1)	–30 V*	–25 V*
Emitter-Base Voltage	–4 V*	–4 V*
Continuous Collector Current	–200 mA*	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ / 310 mW*	
Storage Temperature Range	–65°C to 150°C§ / –55°C to 135°C*	
Lead Temperature 1/16 Inch from Case for 60 Seconds	230°C*	

NOTES: 1. These values apply between 10 μA and 200 mA collector current when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.81 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N4125 and 2N4126 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		2N4125 A5T4125 MIN	2N4125 A5T4125 MAX	2N4126 A5T4126 MIN	2N4126 A5T4126 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−30		−25		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$,	See Note 3	−30		−25		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$		−4		−4		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -20$ V, $I_E = 0$			−50		−50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$			−50		−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -2$ mA	See Note 3	50	150	120	360	
		$V_{CE} = -1$ V, $I_C = -50$ mA		25		60		
V_{BE}	Base-Emitter Voltage	$I_B = -5$ mA, $I_C = -50$ mA,	See Note 3		−0.95		−0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -5$ mA, $I_C = -50$ mA,	See Note 3		−0.4		−0.4	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -2$ mA,	f = 1 kHz	50	200	120	480	
$\lvert h_{fe}\rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -20$ V, $I_C = -10$ mA,	f = 100 MHz	2		2.5		
f_T	Transition Frequency	$V_{CE} = -20$ V, $I_C = -10$ mA,	See Note 4	200		250		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$,	f = 100 kHz		4.5		4.5	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$,	f = 100 kHz		10		10	pF

NOTES: 3. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
4. To obtain f_T, the $\lvert h_{fe}\rvert$ response is extrpolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe}\rvert = 1$.

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N4125 A5T4125 MIN	2N4125 A5T4125 MAX	2N4126 A5T4126 MIN	2N4126 A5T4126 MAX	UNIT
$\overline{NF}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -100\ \mu A$, $R_G = 1\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 5		5		4	dB

NOTE 5: Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

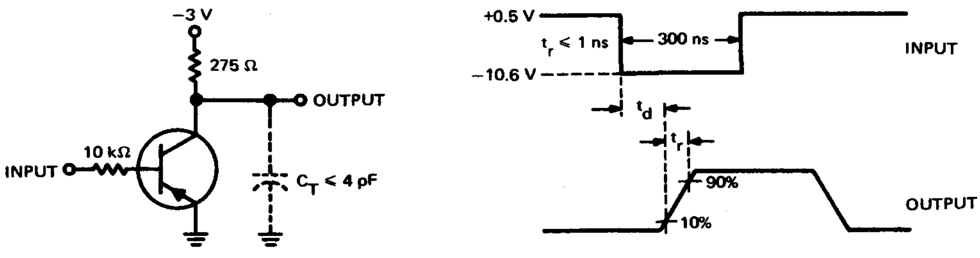
*The asterisk identifies JEDEC registered data for the 2N4125 and 2N4126 only.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	TYP	UNIT
t_d	Delay Time	$I_C = -10$ mA, $I_{B(1)} = -1$ mA, $V_{BE(off)} = 0.5$ V, $R_L = 275\ \Omega$, See Figure 1	13	ns
t_r	Rise Time		13	ns
t_s	Storage Time	$I_C = -10$ mA, $I_{B(1)} = -1$ mA, $I_{B(2)} = 1$ mA, $R_L = 275\ \Omega$, See Figure 2	60	ns
t_f	Fall Time		22	ns

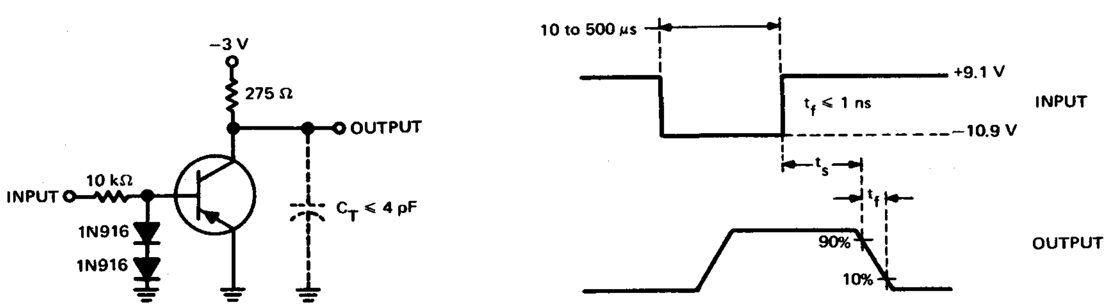
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters. Nominal base current for delay and rise times is calculated using the minimum value of V_{BE}. Nominal base currents for storage and fall times are calculated using the maximum value of V_{BE}.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT   VOLTAGE WAVEFORMS

FIGURE 1—DELAY AND RISE TIMES



TEST CIRCUIT   VOLTAGE WAVEFORMS

FIGURE 2—STORAGE AND FALL TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, duty cycle = 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, R_{in} = 10 MΩ, $C_{in} \leq 4$ pF.

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N2432, 2N2432A, 2N4138
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 689079, OCTOBER 1966—REVISED JANUARY 1968

FOR LOW-LEVEL, HIGH-SPEED CHOPPER APPLICATIONS IN INVERTED CONNECTION

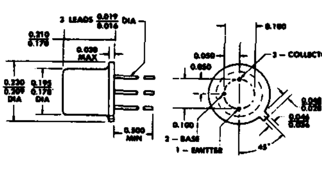
- **Low Offset Voltage . . . 0.4 mV Max (2N2432A)**
- **Low I_{ECS} . . . 2 nA Max**
- **High Rated V_{ECO} for Inverted Connection**

ALSO USEFUL FOR LOW-LEVEL AMPLIFIER APPLICATIONS

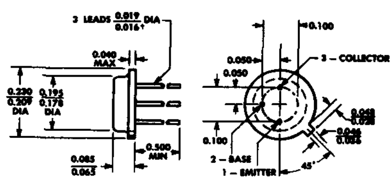
- **h_{FE} . . . 30 Min at 10 μA**

*mechanical data

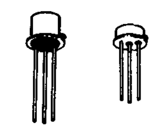
THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



2N2432 AND 2N2432A
ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE.



2N4138
ALL JEDEC TO-46 DIMENSIONS AND NOTES ARE APPLICABLE.



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

†TI guaranteed minimum. The JEDEC registered minimum lead diameter for the TO-46 is 0.012.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N2432 2N4138	2N2432A
Collector-Base Voltage	30 V	45 V
Collector-Emitter Voltage (See Note 1)	30 V	45 V
Emitter-Collector Voltage (See Note 2)	15 V	18 V
Emitter-Base Voltage	15 V	18 V
Continuous Collector Current	← 100 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	← 300 mW →	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	← 600 mW →	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTES: 1. This value applies between 0 and 10 mA collector current when the emitter-base diode is open-circuited.
2. This value applies between 0 and 100 μA emitter current when the collector-base diode is open-circuited.
3. Derate linearly to 175°C free-air temperature at the rate of 2 mW/deg.
4. Derate linearly to 175°C case temperature at the rate of 4 mW/deg.

*Indicates JEDEC registered data.

USES CHIP N18

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	2N2432 2N4138 MIN	2N2432 2N4138 MAX	2N2432A MIN	2N2432A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A, I_E = 0$	30		45		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 5	30		45		V
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	$I_E = 100\ \mu A$, $I_B = 0$	15		18		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 25$ V, $I_E = 0$		10			nA
		$V_{CB} = 40$ V, $I_E = 0$				10	nA
I_{CES}	Collector Cutoff Current	$V_{CE} = 25$ V, $V_{BE} = 0$		10			nA
		$V_{CE} = 25$ V, $V_{BE} = 0$, $T_A = 125°C$		250			nA
		$V_{CE} = 40$ V, $V_{BE} = 0$				10	nA
		$V_{CE} = 40$ V, $V_{BE} = 0$, $T_A = 125°C$				250	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 15$ V, $I_C = 0$		2		2	nA
I_{ECS}	Emitter Cutoff Current	$V_{EC} = 15$ V, $V_{BC} = 0$		2		2	nA
		$V_{EC} = 15$ V, $V_{BC} = 0$, $T_A = 125°C$		200		200	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 10\ \mu A$	30		30		
		$V_{CE} = 5$ V, $I_C = 1$ mA	50		50		
$h_{FE(inv)}$	Static Forward Current Transfer Ratio (Inverted Connection)	$V_{EC} = 5$ V, $I_E = 0.2$ mA	2		3		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ mA, $I_C = 10$ mA		0.15		0.15	V
$V_{EC(ofs)}$	Offset Voltage (Inverted Connection)	$I_B = 200\ \mu A$, $I_E = 0$, See Figure 1		0.5		0.4	mV
		$I_B = 1$ mA, $I_E = 0$, See Figure 1		1		0.7	mV
$r_{ec(on)}$	Small-Signal Emitter-Collector On-State Resistance	$I_B = 1$ mA, $I_E = 0$, $I_e = 100\ \mu A$, $f = 1$ kHz, See Figure 2		20		15	Ω
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ mA, $f = 20$ MHz	1		1		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 0$, $I_E = 0$, $f = 140$ kHz		12		12	pF
C_{cb}	Collector-Base Capacitance	$V_{CB} = 0$, $I_E = 0$, $f = 1$ MHz, See Note 6		12		12	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0$, $I_C = 0$, $f = 140$ kHz		12		12	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0$, $I_C = 0$, $f = 1$ MHz, See Note 6		12		12	pF

NOTES: 5. This parameter must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

6. C_{cb} and C_{eb} are measured using three-terminal measurement techniques with the third electrode (emitter or collector respectively) guarded.

PARAMETER MEASUREMENT INFORMATION

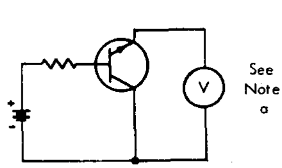
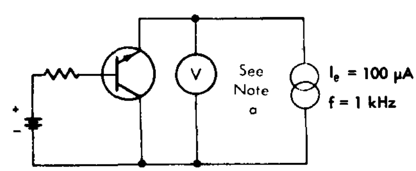


FIGURE 1

MEASUREMENT CIRCUIT FOR OFFSET VOLTAGE



$$r_{ec(on)} = \frac{V_{ec}}{I_e}$$

FIGURE 2

MEASUREMENT CIRCUIT FOR EMITTER-COLLECTOR ON-STATE RESISTANCE

NOTE a: The voltmeter must have high enough impedance that halving the value of the voltmeter impedance does not change the measured value.

*Indicates JEDEC registered data.

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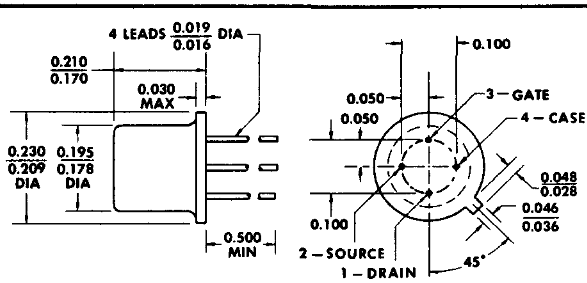
TYPES 2N4220, 2N4221, 2N4222, 2N4220A, 2N4221A, 2N4222A
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7011340, JULY 1970

N-CHANNEL FIELD-EFFECT TRANSISTORS

- Designed for General Purpose Amplifier and Switching Applications
- Low I_{GSS} . . . 100 pA Max
- Low Input Capacitance . . . 6 pF Max
- High $|y_{fs}|/C_{iss}$ Ratio

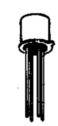
*mechanical data



THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	30 V
Drain-Source Voltage	30 V
Reverse Gate-Source Voltage	−30 V
Continuous Forward Gate Current	10 mA
Continuous Drain Current	15 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE 1: Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN51

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		2N4220 2N4220A MIN	2N4220 2N4220A MAX	2N4221 2N4221A MIN	2N4221 2N4221A MAX	2N4222 2N4222A MIN	2N4222 2N4222A MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 10\ \mu A$,	$V_{DS} = 0$	−30*		−30*		−30*		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -15$ V,	$V_{DS} = 0$		−0.1*		−0.1*		−0.1*	nA
		$V_{GS} = -15$ V, $T_A = 150°C$	$V_{DS} = 0$,		−0.1*		−0.1*		−0.1*	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V,	$I_D = 0.1$ nA		−4*		−6*		−8*	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V,	$I_D = 50\ \mu A$	−0.5*	−2.5*					V
		$V_{DS} = 15$ V,	$I_D = 200\ \mu A$			−1*	−5*			
		$V_{DS} = 15$ V,	$I_D = 500\ \mu A$					−2*	−6*	
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, See Note 2	$V_{GS} = 0$,	0.5*	3*	2*	6*	5*	15*	mA
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $f = 1$ kHz,	$V_{GS} = 0$, See Note 2	1*	4*	2*	5*	2.5*	6*	mmho
$\lvert y_{os}\rvert$	Small-Signal Common-Source Output Admittance				10*		20*		40*	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $f = 1$ MHz	$V_{GS} = 0$,		6*		6*		6*	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance				2*		2*		2*	pF
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $f = 100$ MHz	$V_{GS} = 0$,	0.75*		1.5§ 0.75*		2§ 0.75*		mmho

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N4220A 2N4221A 2N4222A MIN	2N4220A 2N4221A 2N4222A MAX	UNIT
NF	Common-Source Spot Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 100$ Hz, $R_G = 1$ MΩ		2.5*	dB

NOTE 2: These parameters must be measured using pulse techniques. $t_w = 100$ ms, duty cycle ≤ 10%.
†The fourth lead (case) is connected to the source for all measurements.
*JEDEC registered data
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N4223, 2N4224
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

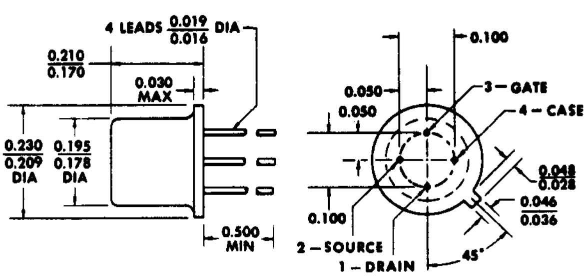
BULLETIN NO. DL-S 7311350, JULY 1970—REVISED MARCH 1973

FOR VHF AMPLIFIER AND MIXER APPLICATIONS

- Low C_{rss} . . . 2 pF Max
- High $|y_{fs}|/C_{iss}$ Ratio (High-Frequency Figure-of-Merit)
- Cross Modulation Minimized by Square-Law Transfer Characteristic
- Low Noise Figure . . . 5 dB Max at 200 MHz

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	30 V
Drain-Source Voltage	30 V
Reverse Gate-Source Voltage	–30 V
Continuous Drain Current	20 mA
Continuous Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	–65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE 1: Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN51

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

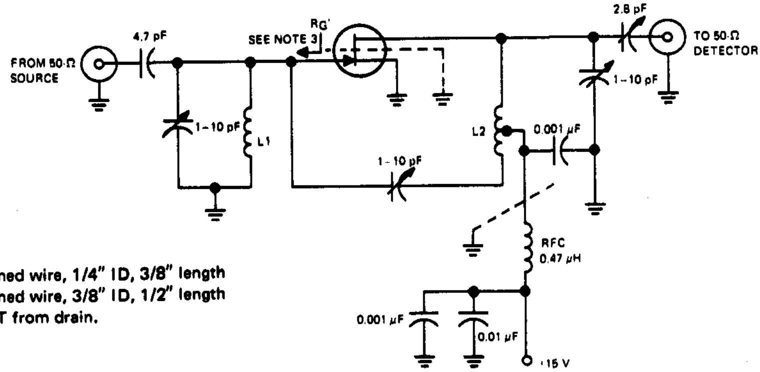
PARAMETER		TEST CONDITIONS†	2N4223 MIN	2N4223 MAX	2N4224 MIN	2N4224 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -10\ \mu A$, $V_{DS} = 0$	−30		−30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−0.25		−0.5	nA
		$V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 100°C$		−0.25		−0.5	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 0.25$ nA	−1.2	−8			V
		$V_{DS} = 15$ V, $I_D = 0.5$ nA			−1.2	−8	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 0.3$ mA	−1	−7			V
		$V_{DS} = 15$ V, $I_D = 0.2$ mA			−1	−7.5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2	3	18	2	20	mA
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 2	3	7	2	7.5	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		6		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		2		2	pF
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 200 MHz, See Note 2		800		800	μmho
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 200 MHz, See Note 2	2.7		1.7		mmho
g_{os}	Small-Signal Common-Source Output Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 200 MHz, See Note 2		200		200	μmho

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N4223 MIN	2N4223 MAX	UNIT
F	Common-Source Spot Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 200 MHz, $R_G' = 1\ k\Omega$, See Figure 1		5	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 200 MHz, See Figure 1	10		dB

NOTE 2: These parameters must be measured using pulse techniques. $t_w \leq 630$ ms, duty cycle $\leq 10\%$.
†The fourth lead (case) is connected to the source for all measurements.
*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



COIL INFORMATION:
L1: 1 1/2 T, #20 tinned wire, 1/4" ID, 3/8" length
L2: 3 1/2 T, #18 tinned wire, 3/8" ID, 1/2" length tapped at 1 1/4 T from drain.

FIGURE 1—NOISE FIGURE AND POWER GAIN TEST CIRCUIT

NOTE 3: Transformed equivalent source resistance (R_G') is 1 kΩ at 200 MHz.

TEXAS INSTRUMENTS
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BULLETIN NO. DL-S 7311972, MARCH 1973

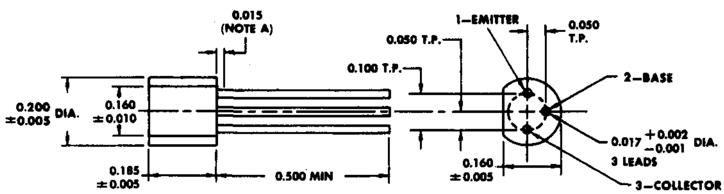
4

SILECT† TRANSISTORS‡
FOR LOW-LEVEL, LOW-NOISE AMPLIFIER APPLICATIONS

- h_{FE} Guaranteed at 100 μA
- Low Noise Figure . . . 2 dB Max (A5T4250)
- Plug-In Replacements for 2N4248, 2N4249, 2N4250 (TO-106)

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T4248 A5T4250	A5T4249
Collector-Base Voltage	−40 V	−60 V
Collector-Emitter Voltage (See Note 1)	−40 V	−60 V
Emitter-Base Voltage	−5 V	−5 V
Continuous Collector Current	−100 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP P18

TEXAS INSTRUMENTS
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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T4248 MIN	A5T4248 MAX	A5T4249 MIN	A5T4249 MAX	A5T4250 MIN	A5T4250 MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -5$ mA, $I_B = 0$, See Note 3	−40		−60		−40		V
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ \mu A$, $V_{BE} = 0$	−40		−60		−40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−5		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -40$ V, $I_E = 0$		−10		−10		−10	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$		−20		−20		−20	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -100\ \mu A$	50		100	300	250	700	
		$V_{CE} = -5$ V, $I_C = -1$ mA	50		100		250		
		$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 3	50		100		250		
V_{BE}	Base-Emitter Voltage	$I_B = -0.5$ mA, $I_C = -10$ mA, See Note 3		−0.9		−0.9		−0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.5$ mA, $I_C = -10$ mA, See Note 3		−0.25		−0.25		−0.25	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz			2.5	17	6	20	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		50	1000	100	550	250	800	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio					10×10^{-4}		10×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance				5	40	5	50	µmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -0.5$ mA, f = 20 MHz	2		2		2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 1 MHz		6		6		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 1 MHz		16		16		16	pF

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T4248 MIN	A5T4248 MAX	A5T4249 MIN	A5T4249 MAX	A5T4250 MIN	A5T4250 MAX	UNIT
F	Spot Noise Figure	$V_{CE} = -5$ V, $I_C = -20\ \mu A$, $R_G = 10$ kΩ, f = 1 kHz				3		2	dB
		$V_{CE} = -5$ V, $I_C = -250\ \mu A$, $R_G = 1$ kΩ, f = 1 kHz				3		2	dB
$\bar{F}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -20\ \mu A$, $R_G = 10$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 4				3		2	dB

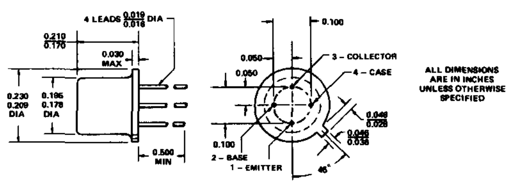
NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

4

BULLETIN NO. DL-S 668575, APRIL 1966

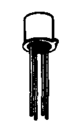
HIGH-FREQUENCY TRANSISTORS FOR TUNER AND IF-AMPLIFIER STAGES IN FM AND AM/FM STEREO-MULTIPLEX RECEIVERS

*mechanical data



THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE



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*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	30 V
Collector-Emitter Voltage (See Note 1)	18 V
Emitter-Base Voltage	4 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	200 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4252		2N4253		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	30		30		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 2$ mA, $I_B = 0$, See Note 3	18		18		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	4		4		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ V, $I_E = 0$		50		50	nA
		$V_{CB} = 15$ V, $I_E = 0$, $T_A = 85°C$		5		5	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 2$ mA	50		30	150	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 2$ mA, $f = 100$ MHz	6	14	6	14	
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz, See Note 4	0.1	0.45	0.1	0.45	pF
r_{oep}	Parallel-Equivalent Common-Emitter Short-Circuit Output Resistance	$V_{CE} = 10$ V, $I_C = 2$ mA, $f = 10$ MHz			50		kΩ
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 10$ V, $I_E = -2$ mA, $f = 79.8$ MHz		12		12	ps

NOTES: 1. *This value applies when base-emitter diode is open-circuited.*
2. Derate linearly to 175°C free-air temperature at the rate of 1.33 mW/°C.
3. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.
4. Collector-Base Capacitance is measured using three-terminal measurement techniques with the case and emitter guarded.

*JEDEC registered data

USES CHIP N16

PRINTED IN U.S.A.

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

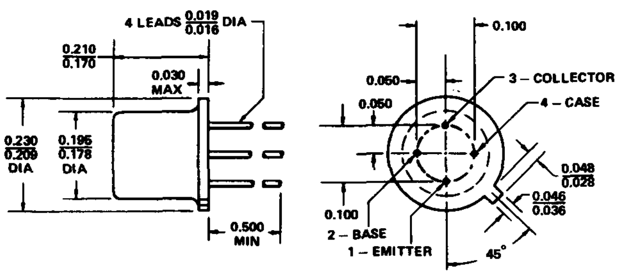
BULLETIN NO. DL-S 7311933, JUNE 1973

DESIGNED FOR VHF AND UHF AMPLIFIER APPLICATIONS

- **High f_T . . . 2 GHz Min (2N4261)**
- **Low Capacitances . . . 2.5 pF Max C_{cb} and C_{eb}**
- **Calculated f_{max}† . . . 1.27 GHz Min (2N4261)**

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−15 V
Collector-Emitter Voltage (See Note 1)	−15 V
Emitter-Base Voltage	−4.5 V
Continuous Collector Current	−30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	200 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

NOTES: 1. This value applies between 0 and 30 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 200°C free-air temperature at the rate of 1.14 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†Maximum Frequency of Oscillation may be calculated from the equation: $f_{max}\ (\mathrm{MHz}) = 200\sqrt{\dfrac{f_T\ (\mathrm{MHz})}{r_b'C_c\ (\mathrm{ps})}}$

USES CHIP P27

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4260 MIN	2N4260 MAX	2N4261 MIN	2N4261 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−15		−15		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ mA$, $I_B = 0$, See Note 3	−15		−15		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−4.5		−4.5		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = -10\ V$, $V_{BE} = 2\ V$		−5		−5	nA
		$V_{CE} = -5\ V$, $V_{BE} = 0.4\ V$		−50		−50	nA
		$V_{CE} = -10\ V$, $V_{BE} = 2\ V$, $T_A = 150°C$		−5		−5	µA
I_{BEV}	Base Cutoff Current	$V_{CE} = -10\ V$, $V_{BE} = 2\ V$		5		5	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1\ V$, $I_C = -1\ mA$	25		25		
		$V_{CE} = -1\ V$, $I_C = -10\ mA$, See Note 3	30	150	30	150	
		$V_{CE} = -2\ V$, $I_C = -30\ mA$, See Note 3	20		20		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -1\ V$, $I_C = -1\ mA$		−0.8		−0.8	V
		$V_{CE} = -1\ V$, $I_C = -10\ mA$, See Note 3		−1		−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.1\ mA$, $I_C = -1\ mA$		−0.15		−0.15	V
		$I_B = -1\ mA$, $I_C = -10\ mA$, See Note 3		−0.35		−0.35	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4\ V$, $I_C = -5\ mA$, $f = 100\ MHz$	12		15		
		$V_{CE} = -10\ V$, $I_C = -10\ mA$, $f = 100\ MHz$	16		20		
f_T	Transition Frequency	$V_{CE} = -4\ V$, $I_C = -5\ mA$, See Note 4	1.2		1.5		GHz
		$V_{CE} = -10\ V$, $I_C = -10\ mA$, See Note 4	1.6		2		GHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -4\ V$, $I_E = 0$, $f = 100\ kHz$ to $1\ MHz$, See Note 5		2.5		2.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5\ V$, $I_C = 0$, $f = 100\ kHz$ to $1\ MHz$, See Note 5		2.5		2.5	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CE} = -4\ V$, $I_C = -5\ mA$, $f = 31.8\ MHz$		35		60	ps
		$V_{CE} = -10\ V$, $I_C = -10\ mA$, $f = 31.8\ MHz$		30		50	ps

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. To obtain f_T, the $|h_{fe}|$ response is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) and the case are connected to the guard terminal of the bridge.

*JEDEC registered data

4

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

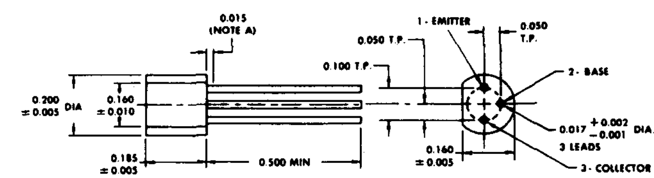
SILECT† TRANSISTORS‡

DESIGNED FOR VHF AND UHF AMPLIFIER APPLICATIONS

- **High f_T . . . 2 GHz Min (A5T4261)**
- **Low Capacitances . . . 2.5 pF Max C_{cb} and C_{eb}**
- **Calculated f_{max}§ . . . 1.27 GHz Min (A5T4261)**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−15 V
Collector-Emitter Voltage (See Note 1)	−15 V
Emitter-Base Voltage	−4.5 V
Continuous Collector Current	−30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies between 0 and 30 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 4 mW/°C.

†Trademark of Texas Instruments

‡U.S. Patent No. 3,439,238

§Maximum Frequency of Oscillation may be calculated from the equation: $f_{max}\ (\text{MHz}) = 200\sqrt{\dfrac{f_T\ (\text{MHz})}{r_b'C_c\,(\text{ps})}}$.

USES CHIP P27

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	A5T4260 MIN	A5T4260 MAX	A5T4261 MIN	A5T4261 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−15		−15		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 3	−15		−15		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−4.5		−4.5		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = -10$ V, $V_{BE} = 2$ V		−5		−5	nA
		$V_{CE} = -5$ V, $V_{BE} = 0.4$ V		−50		−50	
		$V_{CE} = -10$ V, $V_{BE} = 2$ V, $T_A = 85°C$		−200		−200	
I_{BEV}	Base Cutoff Current	$V_{CE} = -10$ V, $V_{BE} = 2$ V		5		5	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -1$ mA	25		25		
		$V_{CE} = -1$ V, $I_C = -10$ mA, See Note 3	30	150	30	150	
		$V_{CE} = -2$ V, $I_C = -30$ mA, See Note 3	20		20		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -1$ V, $I_C = -1$ mA		−0.8		−0.8	V
		$V_{CE} = -1$ V, $I_C = -10$ mA, See Note 3		−1		−1	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.1$ mA, $I_C = -1$ mA		−0.15		−0.15	V
		$I_B = -1$ mA, $I_C = -10$ mA, See Note 3		−0.35		−0.35	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -4$ V, $I_C = -5$ mA, f = 100 MHz	12		15		
		$V_{CE} = -10$ V, $I_C = -10$ mA, f = 100 MHz	16		20		
f_T	Transition Frequency	$V_{CE} = -4$ V, $I_C = -5$ mA, See Note 4	1.2		1.5		GHz
		$V_{CE} = -10$ V, $I_C = -10$ mA, See Note 4	1.6		2		
C_{cb}	Collector-Base Capacitance	$V_{CB} = -4$ V, $I_E = 0$, f = 1 MHz, See Note 5		2.5		2.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 1 MHz, See Note 5		2.5		2.5	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CE} = -4$ V, $I_C = -5$ mA, f = 31.8 MHz		35		60	ps
		$V_{CE} = -10$ V, $I_C = -10$ mA, f = 31.8 MHz		30		50	

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

4. To obtain f_T, the $|h_{fe}|$ response is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

5. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

*JEDEC registered data

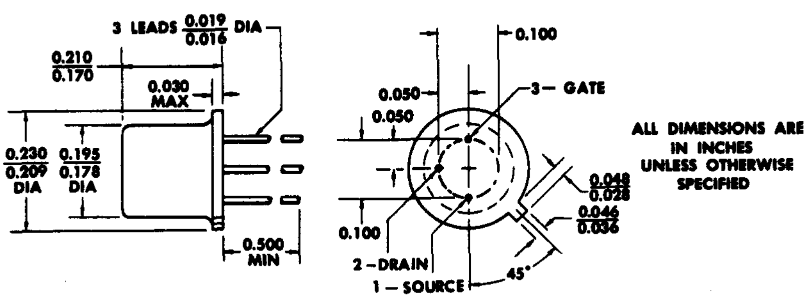
4

SYMMETRICAL N-CHANNEL FIELD-EFFECT TRANSISTORS FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

- Low $I_{D(off)}$ . . . 0.25 nA Max
- Low $r_{ds(on)}$ C_{iss} Product

*mechanical data

THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	40 V
Drain-Source Voltage	40 V
Reverse Gate-Source Voltage	−40 V
Continuous Forward Gate Current	50 mA
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 1)	1.8 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	300°C

NOTE 1: Derate linearly to 200°C case temperrature at the rate of 10.3 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN52

TYPES 2N4391 THRU 2N4393
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	2N4391		2N4392		2N4393		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−40		−40		−40		V
V_{GSF}	Gate-Source Forward Voltage	$I_G = 1$ mA, $V_{DS} = 0$		1		1		1	V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−0.1		−0.1		−0.1	nA
		$V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.2		−0.2		−0.2	μA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 20$ V, $V_{GS} = -12$ V		0.1					nA
		$V_{DS} = 20$ V, $V_{GS} = -7$ V				0.1			
		$V_{DS} = 20$ V, $V_{GS} = -5$ V						0.1	
		$V_{DS} = 20$ V, $V_{GS} = -12$ V, $T_A = 150°C$		0.2					μA
		$V_{DS} = 20$ V, $V_{GS} = -7$ V, $T_A = 150°C$				0.2			
		$V_{DS} = 20$ V, $V_{GS} = -5$ V, $T_A = 150°C$						0.2	
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 20$ V, $I_D = 1$ nA	−4	−10	−2	−5	−0.5	−3	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 20$ V, $V_{GS} = 0$, See Note 2	50	150	25	75	5	30	mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$V_{GS} = 0$, $I_D = 12$ mA		0.4					V
		$V_{GS} = 0$, $I_D = 6$ mA				0.4			
		$V_{GS} = 0$, $I_D = 3$ mA						0.4	
$r_{DS(on)}$	Static Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 1$ mA		30		60		100	Ω
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, $f = 1$ kHz		30		60		100	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 20$ V, $V_{GS} = 0$, $f = 1$ MHz, See Note 3		14		14		14	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -12$ V, $f = 1$ MHz		3.5					pF
		$V_{DS} = 0$, $V_{GS} = -7$ V, $f = 1$ MHz				3.5			
		$V_{DS} = 0$, $V_{GS} = -5$ V, $f = 1$ MHz						3.5	

*** switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	2N4391		2N4392		2N4393		UNIT
			TYP	MAX	TYP	MAX	TYP	MAX	
t_r	Rise Time	$V_{DD} = 10$ V, $I_{D(on)}$† = 12 mA (2N4391), 6 mA (2N4392), 3 mA (2N4393)	2	5	3	5	4	5	ns
t_{on}	Turn-On Time	$V_{GS(on)} = 0$,	5.5	15	6.5	15	8	15	ns
t_f	Fall Time	See Figure 1, $V_{GS(off)}$ = −12 V (2N4391), −7 V (2N4392), −5 V (2N4393)	7	15	13	20	27	30	ns
t_{off}	Turn-Off Time		10	20	18	35	31	50	ns

NOTES: 2. This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.

3. This parameter must be measured using pulse techniques. $t_w = 100\ \mu s$, duty cycle $\leq 1\%$.

†These are nominal values; exact values vary slightly with transistor parameters.

* JEDEC registered data.

TEXAS INSTRUMENTS
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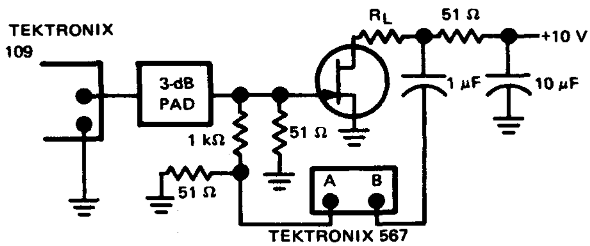
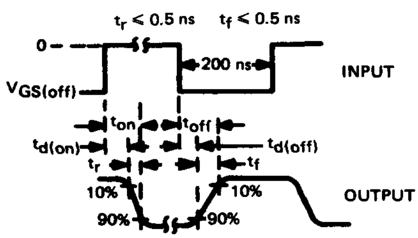
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Note a)

VOLTAGE WAVEFORMS

TYPES	R_L	$V_{GS(off)}$
2N4391	750 Ω	−12 V
2N4392	1.54 kΩ	−7 V
2N4393	3.16 kΩ	−5 V

NOTE a: An equivalent generator and oscilloscope may be used. The oscilloscope must have a 50-Ω input impedance.

FIGURE 1

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N4402, 2N4403, A5T4402, A5T4403
P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 7311973, MARCH 1973

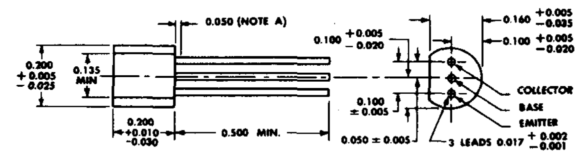
SILECT† TRANSISTORS‡

- For Low-Level, Small-Signal, General Purpose Amplifier and Switching Applications
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N4402, 2N4403

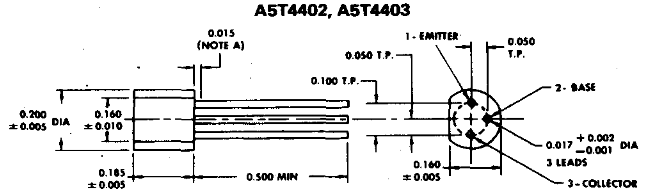


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

***ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE**

A5T4402, A5T4403



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured *in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.*
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−40 V*
Collector-Emitter Voltage (See Note 1)	−40 V*
Emitter-Base Voltage	−5 V*
Continuous Collector Current	−600 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C§ 230°C*

NOTES: 1. This value applies between 0 and 50 mA when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N4402 and 2N4403 only. This data sheet contains all applicable registered data in effect at the time of publication.

†Trademark of Texas Instruments

‡U.S. Patent No. 3,439,238

§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP P20

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N4402 A5T4402 MIN	2N4402 A5T4402 MAX	2N4403 A5T4403 MIN	2N4403 A5T4403 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−40		−40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 3	−40		−40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−5		−5		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = -35$ V, $V_{BE} = 0.4$ V		−100		−100	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -35$ V, $V_{BE} = 0.4$ V		100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -100\ \mu A$			30		
		$V_{CE} = -1$ V, $I_C = -1$ mA	30		60		
		$V_{CE} = -1$ V, $I_C = -10$ mA, See Note 3	50		100		
		$V_{CE} = -2$ V, $I_C = -150$ mA, See Note 3	50	150	100	300	
		$V_{CE} = -2$ V, $I_C = -500$ mA, See Note 3	20		20		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 3	−0.75	−0.95	−0.75	−0.95	V
		$I_B = -50$ mA, $I_C = -500$ mA, See Note 3		−1.3		−1.3	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 3		−0.4		−0.4	V
		$I_B = -50$ mA, $I_C = -500$ mA, See Note 3		−0.75		−0.75	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	0.75	7.5	1.5	15	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	30	250	60	500	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	0.1×10^{-4}	8×10^{-4}	0.1×10^{-4}	8×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	1	100	1	100	µmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -20$ mA, f = 100 MHz	1.5		2		
C_{cb}	Collector-Base Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 140 kHz, See Note 4		8.5		8.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 140 kHz, See Note 4		30		30	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N4402 and 2N4403 only.

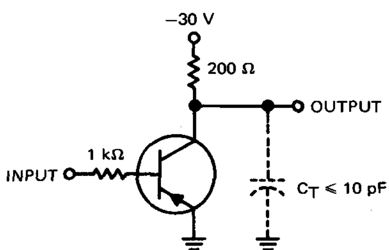
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MAX	UNIT
t_d	Delay Time	$V_{CC} = -30$ V, $I_C = -150$ mA, $I_{B(1)} = -15$ mA,	15	ns
t_r	Rise Time	$V_{BE(off)} = 2$ V, See Figure 1	20	ns
t_s	Storage Time	$V_{CC} = -30$ V, $I_C = -150$ mA, $I_{B(1)} = -15$ mA,	225	ns
t_f	Fall Time	$I_{B(2)} = 15$ mA, See Figure 2	30	ns

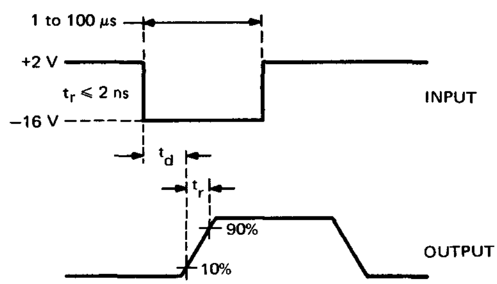
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*The asterisk identifies JEDEC registered data for the 2N4402 and 2N4403 only.

PARAMETER MEASUREMENT INFORMATION

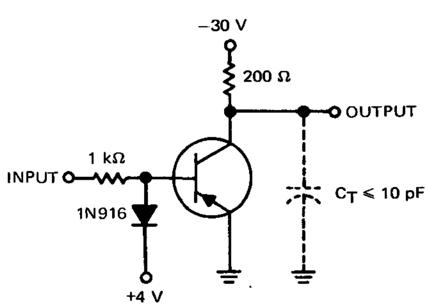


TEST CIRCUIT

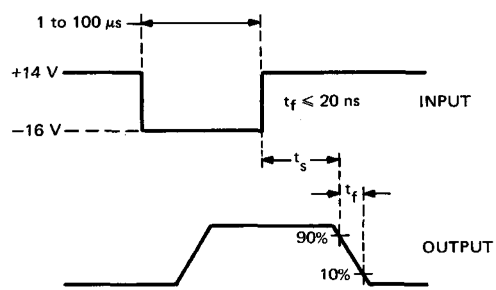


VOLTAGE WAVEFORMS

FIGURE 1–DELAY AND RISE TIMES



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 2–STORAGE AND FALL TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, duty cycle = 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 4$ ns, $R_{in} = 10\ M\Omega$.
c. C_T includes capacitance of test jig, connectors, and oscilloscope.

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

PRINTED IN U.S.A.

BULLETIN NO. DL-S 7311974, MARCH 1973

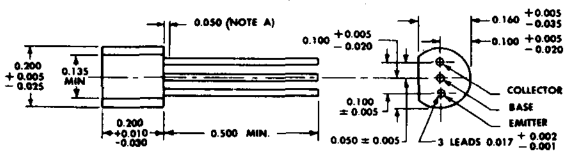
SILECT† TRANSISTORS‡
FOR MEDIUM-CURRENT AMPLIFIER APPLICATIONS

- High-Voltage Indicator and Display Control
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N4409, 2N4410

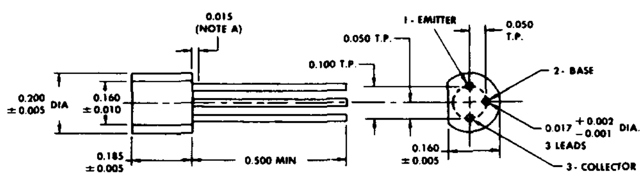


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T4409, A5T4410



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N4409 A5T4409	2N4410 A5T4410
Collector-Base Voltage	80 V*	120 V*
Collector-Emitter Voltage (See Note 1)	50 V*	80 V*
Emitter-Base Voltage	5 V*	5 V*
Continuous Collector Current	250 mA*	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ / 310 mW*	
Storage Temperature Range	−65°C to 150°C§ / −55°C to 135°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C§ / 230°C*	

NOTES: 1. These values apply between 0 and 50 mA when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N4409 and 2N4410 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP N23

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4409 A5T4409 MIN	2N4409 A5T4409 MAX	2N4410 A5T4410 MIN	2N4410 A5T4410 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	80		120		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1\ mA$, $I_B = 0$, See Note 3	50		80		V
$V_{(BR)CEX}$	Collector-Emitter Breakdown Voltage	$I_C = 500\ \mu A$, $R_B = 8.2\ k\Omega$ to $-5\ V$	80		120		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 60\ V$, $I_E = 0$		10			nA
		$V_{CB} = 100\ V$, $I_E = 0$				10	nA
		$V_{CB} = 60\ V$, $I_E = 0$, $T_A = 100°C$		1			μA
		$V_{CB} = 100\ V$, $I_E = 0$, $T_A = 100°C$				1	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4\ V$, $I_C = 0$		100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1\ V$, $I_C = 1\ mA$	60		60		
		$V_{CE} = 1\ V$, $I_C = 10\ mA$, See Note 3	60	400	60	400	
V_{BE}	Base-Emitter Voltage	$I_B = 0.1\ mA$, $I_C = 1\ mA$		0.8		0.8	V
		$V_{CE} = 5\ V$, $I_C = 1\ mA$		0.8		0.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.1\ mA$, $I_C = 1\ mA$		0.2		0.2	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 10\ mA$, $f = 30\ MHz$	2	10	2	10	
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10\ V$, $I_E = 0$, $f = 140\ kHz$, See Note 4		12		12	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

4. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N4409 and 2N4410 only.

4

THERMAL INFORMATION

DISSIPATION DERATING CURVE

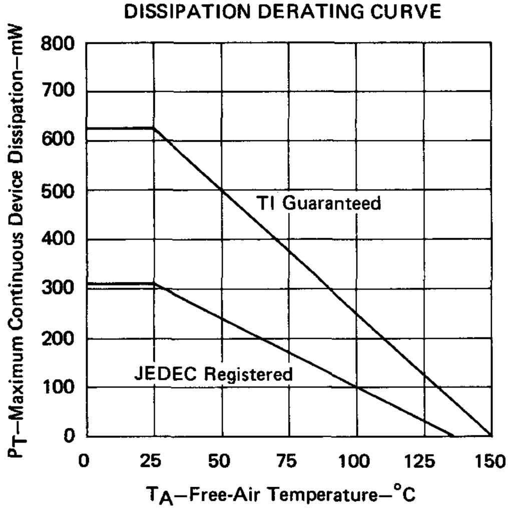


FIGURE 1

TYPES 2N4416, 2N4416A
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 6810649, JANUARY 1968

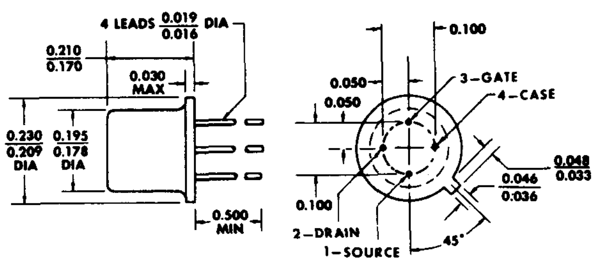
FOR VHF AMPLIFIER AND MIXER APPLICATIONS

- **High Power Gain . . . 10 dB Min at 400 MHz**
- **Low Noise Figure . . . 4 dB Max at 400 MHz**
- **High Transconductance . . . 4000 μmho Min at 400 MHz**
- **Low C_{rss} . . . 0.8 pF Max**
- **High $|y_{fs}|/C_{iss}$ Ratio (High-Frequency Figure-of-Merit)**
- **Cross-Modulation Minimized by Square-Law Transfer Characteristic**
- **Recommended for Use in VHF-UHF Bandpass Amplifiers**
- **Excellent for General Purpose Amplifier and Chopper Applications**

4

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N4416	2N4416A
*Drain-Gate Voltage	30 V	35 V
*Drain-Source Voltage	30 V	35 V
*Reverse Gate-Source Voltage	−30 V	−35 V
*Continuous Forward Gate Current	← 10 mA →	
*Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	← 300 mW →	
Continuous Device Dissipation at (or below) 125°C Case Temperature (See Note 2)	← 450 mW →	
*Storage Temperature Range	−65°C to 200°C	
*Lead Temperature 1/16 Inch from Case for 60 Seconds	← 300°C →	

NOTES: 1. Derate linearly to 200°C free-air temperature at the rate of 1.7 mW/°C.
2. Derate linearly to 200°C case temperature at the rate of 6 mW/°C.

*Indicates JEDEC registered data

USES CHIP JN53

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TYPES 2N4416, 2N4416A
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	2N4416 MIN	2N4416 MAX	2N4416A MIN	2N4416A MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−30*		−35*		V
V_{GSF}	Gate-Source Forward Voltage	$I_G = 1$ mA, $V_{DS} = 0$		1*		1*	V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−0.1*		−0.1*	nA
		$V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.2* −0.1†		−0.2* −0.1†	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 1$ nA		−6*	−2.5*	−6*	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 0.5$ mA	−1*	−5.5*	−1*	−5.5*	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	5*	15*	5*	15*	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 1$ kHz	4.5*	7.5*	4.5*	7.5*	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			0.05*		0.05*	
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 1$ MHz		4*		4*	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			0.8*		0.8*	
C_{oss}	Common-Source Short-Circuit Output Capacitance			2*		2*	
$Re(y_{is})$	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 100$ MHz		0.1*		0.1*	mmho
$Im(y_{is})$	Small-Signal Common-Source Input Susceptance			2.5*		2.5*	
$Re(y_{os})$	Small-Signal Common-Source Output Conductance			0.075*		0.075*	
$Im(y_{os})$	Small-Signal Common-Source Output Susceptance			1*		1*	
$Re(y_{is})$	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 400$ MHz		1*		1*	mmho
$Im(y_{is})$	Small-Signal Common-Source Input Susceptance			10*		10*	
$Re(y_{fs})$	Small-Signal Common-Source Forward Transfer Conductance		4*		4*		
$Re(y_{os})$	Small-Signal Common-Source Output Conductance			0.1*		0.1*	
$Im(y_{os})$	Small-Signal Common-Source Output Susceptance			4*		4*	

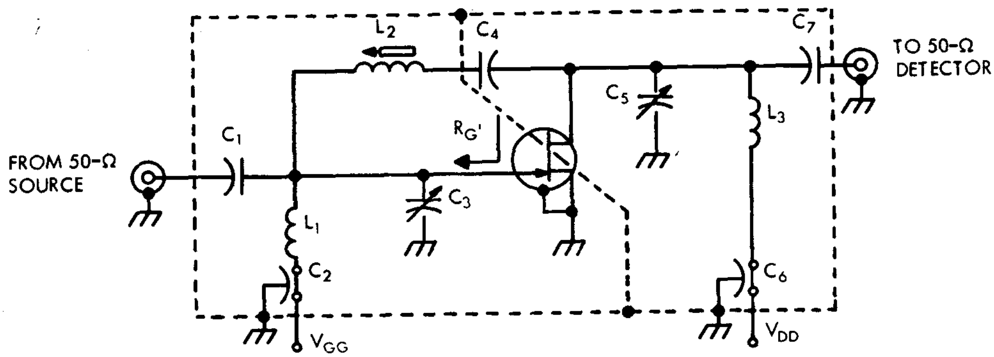
NOTE 3: This parameter must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 1\%$.
†Texas Instruments guarantees this value in addition to the JEDEC registered value, which is also shown.

***operating characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS‡	MIN	MAX	UNIT
G_{ps}	Small-Signal Common-Source Neutralized Insertion Power Gain	$V_{DS} = 15$ V, $I_D = 5$ mA, $f = 100$ MHz, $R_G' = 1\ k\Omega$, See Figure 1	18		dB
		$V_{DS} = 15$ V, $I_D = 5$ mA, $f = 400$ MHz, $R_G' = 1\ k\Omega$, See Figure 1	10		
NF	Spot Noise Figure	$V_{DS} = 15$ V, $I_D = 5$ mA, $f = 100$ MHz, $R_G' = 1\ k\Omega$, See Figure 1		2	dB
		$V_{DS} = 15$ V, $I_D = 5$ mA, $f = 400$ MHz, $R_G' = 1\ k\Omega$, See Figure 1		4	

‡The fourth lead (case) is connected to the source for all measurements.
*Indicates JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION (See Note 4)					
CAPACITORS			COILS		
	100 MHz	400 MHz		100 MHz	400 MHz
C_1	7 pF	1.8 pF	L_1	0.14 μH, 3.5 T, #18 enameled copper wire, 3/8" I.D., 1/4" long	0.022 μH, 5/8" of #16 copper wire formed to 0.5 T, 1/4" I.D.
C_2	0.0015 μF	0.001 μF			
C_3	1–12 pF	0.8–8 pF	L_2	3 μH, 17 T, #28 enameled copper wire, close wound, 9/32" I.D., powdered iron slug	0.2 μH, 6 T, #24 enameled copper wire, close wound, 7/32" I.D., aluminum slug
C_4	1000 pF	27 pF			
C_5	1–12 pF	0.8–8 pF			
C_6	0.0015 μF	0.001 μF	L_3	0.25 μH, 4.5 T, #18 enameled copper wire, 3/8" I.D., 5/16" long	0.03 μH, 1½" of #16 enameled copper wire formed to 1 T, 3/8" I.D.
C_7	3 pF	1 pF			

FIGURE 1—NEUTRALIZED POWER GAIN AND SPOT NOISE FIGURE TEST CIRCUIT

NOTE 4: Transformed equivalent source resistance (R_G') is 1000 Ω at 100 MHz for 100-MHz amplifier, and 1000 Ω at 400 MHz for 400-MHz amplifier.

THERMAL INFORMATION

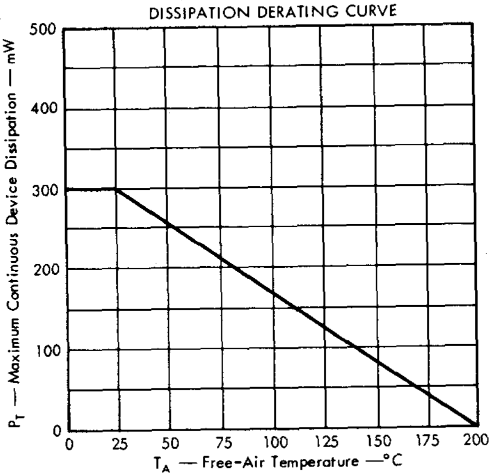


FIGURE 2

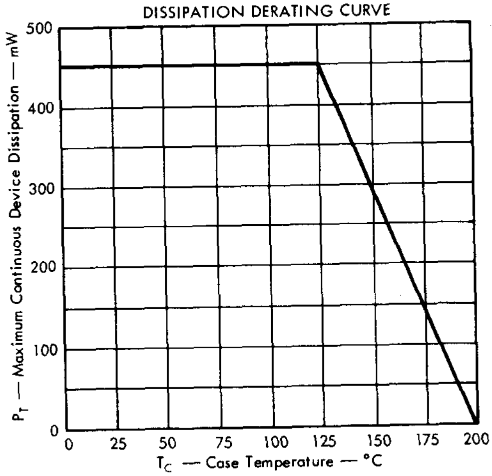


FIGURE 3

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE 2N4423
P-N-P SILICON TRANSISTOR

BULLETIN NO. DL-S 689124, AUGUST 1966—REVISED MAY 1968

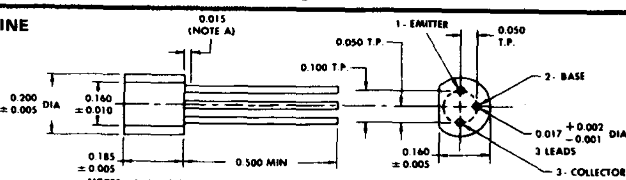
SILECT† TRANSISTOR FOR HIGH-SPEED SWITCHING APPLICATIONS

- **Electrically Similar to the 2N2894**
- **Rugged, One-Piece Construction with Standard TO-18 100-mil Pin Circle**

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.

*CASE OUTLINE



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−12 V
Collector-Emitter Voltage (See Note 1)	−12 V
Collector-Emitter Voltage (See Note 2)	−12 V
Emitter-Base Voltage	−4 V
Continuous Collector Current	−200 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	360 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 4)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$		−12		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA,	$I_B = 0$,	See Note 5	−12		V
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ \mu A$,	$V_{BE} = 0$		−12		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$,	$I_C = 0$		−4		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -6$ V,	$I_E = 0$,	$T_A = 70°C$		−1	μA
I_{CES}	Collector Cutoff Current	$V_{CE} = -6$ V,	$V_{BE} = 0$			−80	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V,	$I_C = 0$			−20	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.3$ V,	$I_C = -10$ mA	See Note 5	30		
		$V_{CE} = -0.5$ V,	$I_C = -30$ mA		40	150	
		$V_{CE} = -1$ V,	$I_C = -100$ mA		20		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA,	$I_C = -10$ mA	See Note 5	−0.76	−0.98	V
		$I_B = -3$ mA,	$I_C = -30$ mA		−0.82	−1.2	
		$I_B = -10$ mA,	$I_C = -100$ mA			−1.7	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA,	$I_C = -10$ mA	See Note 5		−0.15	V
		$I_B = -3$ mA,	$I_C = -30$ mA			−0.2	
		$I_B = -10$ mA,	$I_C = -100$ mA			−0.5	

NOTES: 1. This value applies when the base-emitter diode is short-circuited.
2. This value applies between 0 and 200 mA collector current when the base-emitter diode is open-circuited. Maximum rated voltage and 200 mA collector current may be simultaneously applied provided the time of application is 10 μs or less and the duty cycle is 2% or less.
3. Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/deg.
4. Derate linearly to 150°C lead temperature at the rate of 4 mW/deg. Lead temperature is measured on the collector lead 1/16 inch from the case.
5. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

*Indicates JEDEC registered data
†Trademark of Texas Instruments

USES CHIP **P11**

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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -30$ mA, $f = 100$ MHz		4		
C_{cb}	Collector-Base Capacitance	$V_{CB} = -5$ V, $I_E = 0$,	$f = 1$ MHz, See Note 6		6	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$,	$f = 1$ MHz, See Note 6		6	pF

NOTE 6: C_{cb} and C_{eb} are measured using three-terminal measurement techniques with the third electrode (emitter or collector respectively) guarded.

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†		MAX	UNIT
t_d	Delay Time	$I_C = -30$ mA, $I_{B(1)} = -3$ mA, $R_L = 93\ \Omega$,	$V_{BE(off)} = 0$, See Figure 1	15	ns
t_r	Rise Time			30	ns
t_{on}	Turn-On Time			40	ns
t_s	Storage Time	$I_C = -30$ mA, $I_{B(1)} = -3$ mA, $R_L = 93\ \Omega$,	$I_{B(2)} = 3$ mA, See Figure 2	40	ns
t_f	Fall Time			15	ns
t_{off}	Turn-Off Time			50	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

*PARAMETER MEASUREMENT INFORMATION

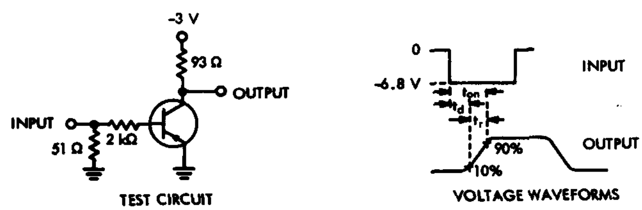

FIGURE 1

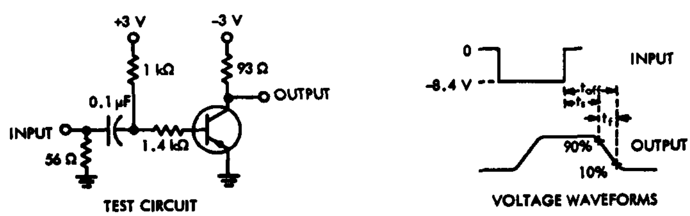

FIGURE 2

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 1$ ns, $t_p \geq 200$ ns, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 10$ pF.

*Indicates JEDEC registered data

TEXAS INSTRUMENTS INCORPORATED
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TYPES 2N4851, 2N4852, 2N4853
P-N UNIJUNCTION SILICON TRANSISTORS

BULLETIN NO. DL-S 7311967, MARCH 1973

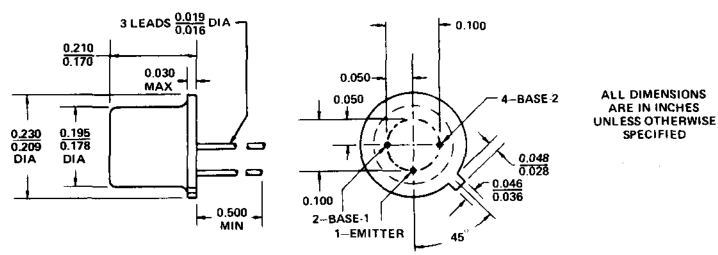
PLANAR UNIJUNCTION TRANSISTORS SPECIFICALLY CHARACTERIZED FOR A WIDE RANGE OF MILITARY, SPACE, AND INDUSTRIAL APPLICATIONS

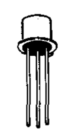
- **Planar Process Ensures Low Leakage, High-Performance With Low Driving Currents, and Greatly Improved Reliability**

*mechanical data

Package outline is same as JEDEC TO-18 except for lead position. All TO-18 registration notes also apply to this outline.

BASE-2 IS IN ELECTRICAL CONTACT WITH THE CASE





*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Emitter–Base-Two Reverse Voltage	–30 V
Interbase Voltage (See Note 1)	35 V
Continuous Emitter Current	50 mA
Peak Emitter Current (See Note 2)	1.5 A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	300 mW
Storage Temperature Range	–65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		2N4851		2N4852		2N4853		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
r_{BB}	Static Interbase Resistance	$V_{B2B1} = 3$ V,	I_E 0	4.7	9.1	4.7	9.1	4.7	9.1	kΩ
α_{rBB}	Interbase Resistance Temperature Coefficient	$V_{B2B1} = 3$ V, $T_A = -65°C$ to 125°C,	$I_E = 0$, See Note 4	0.2	0.8	0.2	0.8	0.2	0.8	%/°C
η	Intrinsic Standoff Ratio	$V_{B2B1} = 10$ V,	See Figure 3	0.56	0.75	0.7	0.85	0.7	0.85	
I_{EB2O}	Emitter Reverse Current	$V_{EB2} = 30$ V,	$I_{B1} = 0$		100		100		50	nA
I_P	Peak-Point Emitter Current	$V_{B2B1} = 25$ V			2		2		0.4	µA
I_V	Valley-Point Emitter Current	$V_{B2B1} = 25$ V		2		4		6		mA
V_{OB1}	Base-One Peak Pulse Voltage	See Figure 4		3		5		6		V
f_{max}	*Maximum Frequency of Oscillation*	*See Figure 5*		1		1		1		MHz

NOTES:
1. The interbase voltage rating is based upon allowable power dissipation: $V_{B2B1} = \sqrt{r_{BB} \cdot P_T}$.
2. The peak emitter current rating is based on the capability of the transistor to operate safely in the circuit of Figure 4.
3. *Derate linearly to 125°C free-air temperature at the rate of 3 mW/°C.*
4. Temperature coefficient α_{rBB} is determined by the following formula:

$$\alpha_{rBB} = \left[\frac{(r_{BB} @ 125°C) - (r_{BB} @ -65°C)}{r_{BB} @ 25°C}\right] \frac{100\%}{190°C}.$$

To obtain r_{BB} for a given temperature $T_{A(2)}$, use the following formula:

$$r_{BB(2)} = [r_{BB} @ 25°C]\ [1 + (\alpha_{rBB}/100\%)(T_{A(2)} - 25°C)].$$

*JEDEC registered data. This data sheet contains all applicable data in effect at the time of publication.

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*PARAMETER MEASUREMENT INFORMATION

EMITTER–BASE-ONE VOLTAGE
vs
EMITTER CURRENT

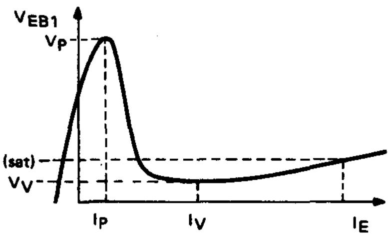


FIGURE 1—GENERAL STATIC EMITTER CHARACTERISTIC CURVE

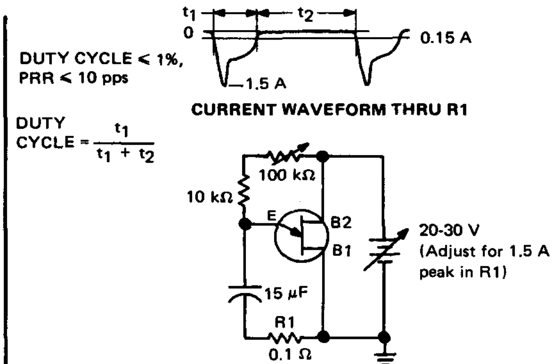
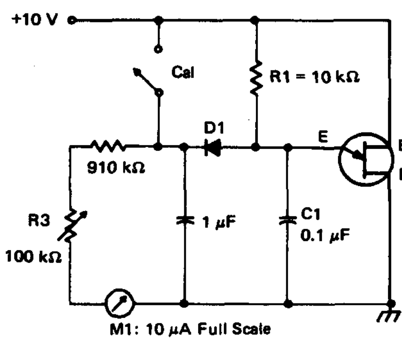


FIGURE 2—PEAK-EMITTER-CURRENT TEST CIRCUIT AND WAVEFORM



η—Intrinsic Standoff Ratio—This parameter is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25°C and decreases with temperature at about 2 millivolts/°C.

The circuit used to measure η is shown in the figure. In this circuit, R1, C1 and the unijunction transistor form a relaxation oscillator, and the remainder of the circuit serves as a peak-voltage detector with the diode D1 automatically subtracting the voltage V_P. To use the circuit, the "cal" button is pushed, and R3 is adjusted to make the current meter M1 read full scale. The "cal" button then is released and the value of η is read directly from the meter, with N = 1 corresponding to full-scale deflection of 10 µA.

D1: 1N457, or equivalent, with the following characteristics:
$V_F = 0.49$ V at $I_F = 10$ µA
$I_R < 2$ µA at $V_R = 20$ V

FIGURE 3—TEST CIRCUIT FOR INTRINSIC STANDOFF RATIO (η)

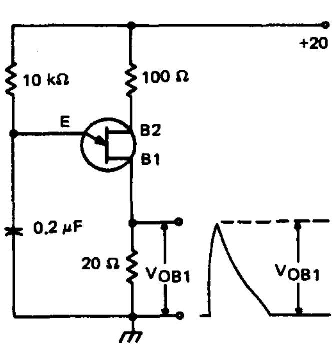
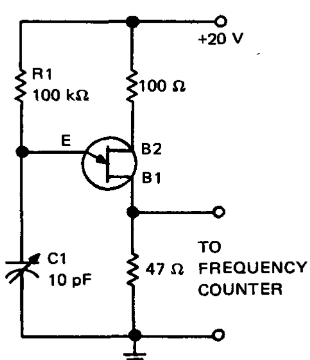


FIGURE 4—V_{OB1} TEST CIRCUIT



R1 and C1 are adjusted to maximize the frequency of oscillation.

FIGURE 5—f_{max} TEST CIRCUIT

*JEDEC registered data

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TYPES 2N4854, 2N4855
N-P-N, P-N-P DUAL SILICON TRANSISTORS

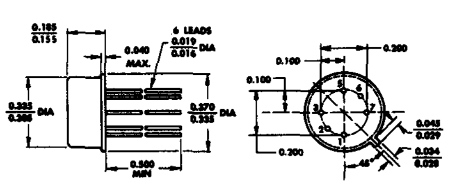
BULLETIN NO. DL-S 7211694, MARCH 1972

DESIGNED FOR COMPLEMENTARY MEDIUM-POWER HIGH-SPEED SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **2N4854 Electrically Similar to 2N2222/2N2907**
- **2N4855 Electrically Similar to 2N2221/2N2906**
- **h_{FE}—Guaranteed from 100 μA to 300 mA**
- **Low-Profile Case**

*mechanical data

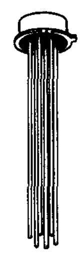
ALL LEADS INSULATED FROM CASE



Dimensions without tolerance designate true position. Leads having maximum diameter (0.019″) measured in gaging plane 0.054″ +0.001″ −0.000″ below the seating plane of the device shall be within 0.007″ of their true positions relative to a maximum-width tab.

1. N-P-N COLLECTOR
2. N-P-N BASE
3. N-P-N EMITTER
5. P-N-P EMITTER
6. P-N-P BASE
7. P-N-P COLLECTOR

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted) †

	EACH TRIODE	TOTAL DEVICE
Collector-Base Voltage	60 V	
Collector-Emitter Voltage (See Note 1)	40 V	
Emitter-Base Voltage	5 V	
Collector-1—Collector-2 Voltage		±120 V
Lead-to-Case Voltage		±120 V
Continuous Collector Current	600 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	300 mW	600 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1 W	2 W
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTES: 1. This value applies between 0 and 600 mA collector current when the base-emitter diode is open-circuited. 40 V and 600 mA collector current may be simultaneously applied provided the time of application is 10 μs or less and the duty cycle is 2% or less.
2. Derate linearly to 175°C free-air temperature at the rates of 2 mW/°C for each triode and 4 mW/°C for total device.
3. Derate linearly to 175°C case temperature at the rates of 6.67 mW/°C for each triode and 13.33 mW/°C for total device.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†Voltages and currents apply to the N-P-N triode. For the P-N-P triode the values are the same, but the signs are reversed.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)†

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS			2N4854 MIN	2N4854 MAX	2N4855 MIN	2N4855 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA,	$I_B = 0$,	See Note 5	40		40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$		5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50$ V,	$I_E = 0$			10		10	nA
		$V_{CB} = 50$ V,	$I_E = 0$,	$T_A = 150°C$		10		10	µA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V,	$I_C = 0$			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V,	$I_C = 150$ mA,	See Note 5	50		20		
		$V_{CE} = 10$ V,	$I_C = 100\ \mu A$		35		20		
		$V_{CE} = 10$ V,	$I_C = 1$ mA		50		25		
		$V_{CE} = 10$ V,	$I_C = 10$ mA,	See Note 5	75		35		
		$V_{CE} = 10$ V,	$I_C = 150$ mA,	See Note 5	100	300	40	120	
		$V_{CE} = 10$ V,	$I_C = 300$ mA,	See Note 5	35		20		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ mA,	$I_C = 150$ mA,	See Note 5	0.75	1.2	0.75	1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ mA,	$I_C = 150$ mA,	See Note 5		0.4		0.4	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ V,	$I_C = 1$ mA,	f = 1 kHz	1.5	9	0.75	4.5	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio				60	300	30	150	
h_{oe}	Small-Signal Common-Emitter Output Admittance					50		25	µmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 20$ mA,	f = 100 MHz	2		2		
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V,	$I_E = 0$,	f = 1 MHz, See Note 6		8		8	pF

*operating characteristics at 25°C free-air temperature†

individual triode characteristics (see note 4)

PARAMETER		TEST CONDITIONS	MAX	UNIT
t_d	Delay Time	$I_C = 150$ mA, $I_{B(1)} = 15$ mA, $V_{BE(off)} = -0.5$ V,	20	ns
t_r	Rise Time	$R_L = 200\ \Omega$, See Note 7 and Figure 1	40	ns
t_s	Storage Time	$I_C = 150$ mA, $I_{B(1)} = 15$ mA, $I_{B(2)} = -15$ mA,	280	ns
t_f	Fall Time	$R_L = 200\ \Omega$, See Note 7 and Figure 2	70	ns
F	Spot Noise Figure	$V_{CE} = 10$ V, $I_C = 100\ \mu A$, $R_G = 1\ k\Omega$, f = 1 kHz	8	dB

NOTES: 4. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
6. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter and case are connected to the guard terminal of the bridge.
7. Voltages and current values shown are nominal; exact values vary with device parameters.

*JEDEC registered data
†Voltages and currents apply to the N-P-N triode. For the P-N-P triode the values are the same, but the signs are reversed.

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*PARAMETER MEASUREMENT INFORMATION

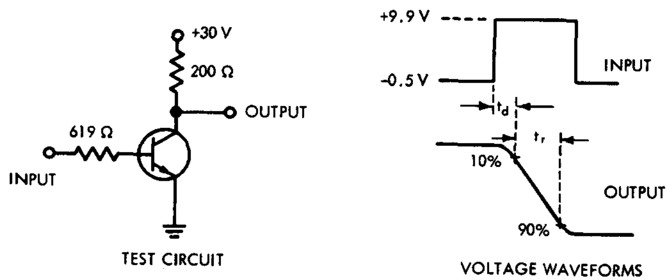


FIGURE 1—DELAY AND RISE TIMES

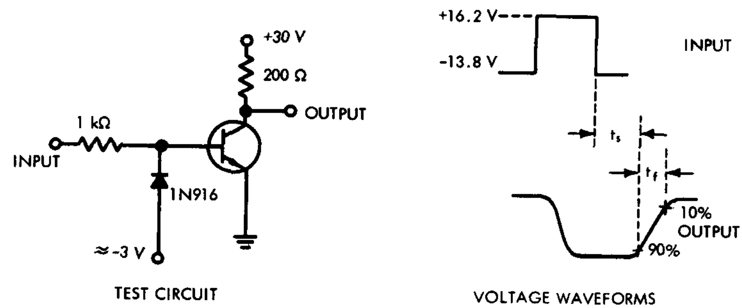


FIGURE 2—STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: For figure 1, $t_r \leq 2$ ns, $t_w = 200$ ns, duty cycle $\leq 2\%$; for figure 2, $t_f \leq 5$ ns, $t_w = 10\ \mu s$, duty cycle $\leq 2\%$.
b. All waveforms are monitored on an oscilloscope with the following characteristics; $t_r \leq 5$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 12$ pF.
c. The signs and polarity symbols shown are for the N-P-N triode; for the P-N-P triode the signs and polarity symbols are reversed.

*JEDEC registered data

TYPES 2N4856 THRU 2N4861, 2N4856A THRU 2N4861A
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

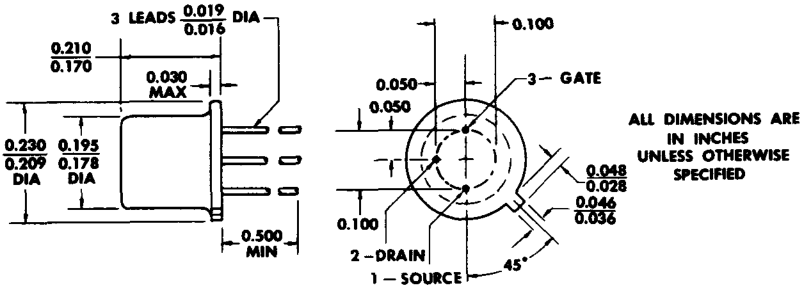
BULLETIN NO. DL-S 7311911, JUNE 1973

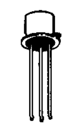
SYMMETRICAL N-CHANNEL FIELD-EFFECT TRANSISTORS FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

- Low $r_{ds(on)}$ . . . 25 Ω Max (2N4856, 2N4856A, 2N4859, 2N4859A)
- Low $I_{D(off)}$ . . . 0.25 nA Max
- Low $r_{ds(on)}$ C_{iss} Product

*mechanical data

THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

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*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N4856 2N4857 2N4858 2N4856A 2N4857A 2N4858A	2N4859 2N4860 2N4861 2N4859A 2N4860A 2N4861A
Drain-Gate Voltage	40 V	30 V
Drain-Source Voltage	40 V	30 V
Reverse Gate-Source Voltage	−40 V	−30 V
Continuous Forward Gate Current	← 50 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	← 360 mW →	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	← 1.8 W →	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 60 Seconds	← 300°C →	

NOTES: 1. Derate linearly to 200°C free-air temperature at the rate of 2.06 mW/°C.
2. Derate linearly to 200°C case temperature at the rate of 10.3 mW/°C.

USES CHIP JN52

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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TYPES 2N4856 THRU 2N4861, 2N4856A THRU 2N4861A
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

2N4856 THRU 2N4861

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4856		2N4857		2N4858		2N4859		2N4860		2N4861		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−40		−40		−40		−30		−30		−30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20\ V$, $V_{DS} = 0$		−0.25		−0.25		−0.25							nA
		$V_{GS} = -20\ V$, $V_{DS} = 0$, $T_A = 150°C$		−0.5		−0.5		−0.5							µA
		$V_{GS} = -15\ V$, $V_{DS} = 0$								−0.25		−0.25		−0.25	nA
		$V_{GS} = -15\ V$, $V_{DS} = 0$, $T_A = 150°C$								−0.5		−0.5		−0.5	µA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 15\ V$, $V_{GS} = -10\ V$		0.25		0.25		0.25		0.25		0.25		0.25	nA
		$V_{DS} = 15\ V$, $V_{GS} = -10\ V$, $T_A = 150°C$		0.5		0.5		0.5		0.5		0.5		0.5	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15\ V$, $I_D = 0.5\ nA$	−4	−10	−2	−6	−0.8	−4	−4	−10	−2	−6	−0.8	−4	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15\ V$, $V_{GS} = 0$, See Note 3	50		20	100	8	80	50		20	100	8	80	mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$I_D = 20\ mA$, $V_{GS} = 0$		0.75						0.75					V
		$I_D = 10\ mA$, $V_{GS} = 0$				0.5						0.5			
		$I_D = 5\ mA$, $V_{GS} = 0$						0.5						0.5	
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, $f = 1\ kHz$		25		40		60		25		40		60	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 0$, $V_{GS} = -10\ V$, $f = 1\ MHz$		18		18		18		18		18		18	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -10\ V$, $f = 1\ MHz$		8		8		8		8		8		8	pF

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N4856 2N4859	2N4857 2N4860	2N4858 2N4861	UNIT
			MAX	MAX	MAX	
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 10\ V$, $I_{D(on)}$† = 20 mA (2N4856, 2N4859), 10 mA (2N4857, 2N4860), 5 mA (2N4858, 2N4861)	6	6	10	ns
t_r	Rise Time	$V_{GS(on)} = 0$, $V_{GS(off)}$ = −10 V (2N4856, 2N4859), −6 V (2N4857, 2N4860), −4 V (2N4858, 2N4861)	3	4	10	ns
t_{off}	Turn-Off Time	See Figure 1	25	50	100	ns

NOTE 3: This parameter must be measured using pulse techniques. $t_w \approx 100$ ms, duty cycle $\leq 10\%$.

†These are nominal values; exact values vary slightly with transistor parameters.

*JEDEC registered data

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2N4856A THRU 2N4861A

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4856A MIN	2N4856A MAX	2N4857A MIN	2N4857A MAX	2N4858A MIN	2N4858A MAX	2N4859A MIN	2N4859A MAX	2N4860A MIN	2N4860A MAX	2N4861A MIN	2N4861A MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−40		−40		−40		−30		−30		−30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20\ V$, $V_{DS} = 0$		−0.25		−0.25		−0.25							nA
		$V_{GS} = -20\ V$, $V_{DS} = 0$, $T_A = 150°C$		−0.5		−0.5		−0.5							µA
		$V_{GS} = -15\ V$, $V_{DS} = 0$								−0.25		−0.25		−0.25	nA
		$V_{GS} = -15\ V$, $V_{DS} = 0$, $T_A = 150°C$								−0.5		−0.5		−0.5	µA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 15\ V$, $V_{GS} = -10\ V$		0.25		0.25		0.25		0.25		0.25		0.25	nA
		$V_{DS} = 15\ V$, $V_{GS} = -10\ V$, $T_A = 150°C$		0.5		0.5		0.5		0.5		0.5		0.5	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15\ V$, $I_D = 0.5\ nA$	−4	−10	−2	−6	−0.8	−4	−4	−10	−2	−6	−0.8	−4	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15\ V$, $V_{GS} = 0$, See Note 3	50		20	100	8	80	50		20	100	8	80	mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$I_D = 20\ mA$, $V_{GS} = 0$		0.75						0.75					V
		$I_D = 10\ mA$, $V_{GS} = 0$				0.5						0.5			
		$I_D = 5\ mA$, $V_{GS} = 0$						0.5						0.5	
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, $f = 1\ kHz$		25		40		60		25		40		60	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 0$, $V_{GS} = -10\ V$, $f = 1\ MHz$		10		10		10		10		10		10	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -10\ V$, $f = 1\ MHz$		4		3.5		3.5		4		3.5		3.5	pF

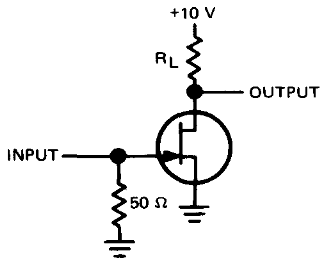
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N4856A 2N4859A TYP	2N4856A 2N4859A MAX	2N4857A 2N4860A TYP	2N4857A 2N4860A MAX	2N4858A 2N4861A TYP	2N4858A 2N4861A MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 10\ V$, $I_{D(on)}$† = 20 mA (2N4856A, 2N4859A), 10 mA (2N4857A, 2N4860A), 5 mA (2N4858A, 2N4861A)		5		6		8	ns
t_r	Rise Time	$V_{GS(on)} = 0$, $V_{GS(off)}$ = −10 V (2N4856A, 2N4859A), −6 V (2N4857A, 2N4860A), −4 V (2N4858A, 2N4861A)		3		4		8	ns
t_{off}	Turn-Off Time	See Figure 1,		20		40		80	ns
t_r	Rise Time	$V_{DD} = 10\ V$, $I_{D(on)}$† = 12 mA (2N4856A, 2N4859A), 6 mA (2N4857A, 2N4860A), 3 mA (2N4858A, 2N4861A)	2		3		4		ns
t_{on}	Turn-On Time	$V_{GS(on)} = 0$,	5.5		6.5		8		ns
t_f	Fall Time	$V_{GS(off)}$ = −12 V (2N4856A, 2N4859A), −7 (2N4857A, 2N4860A), −5 V (2N4858A, 2N4861A)	7		13		27		ns
t_{off}	Turn-Off Time	See Figure 2,	10		18		31		ns

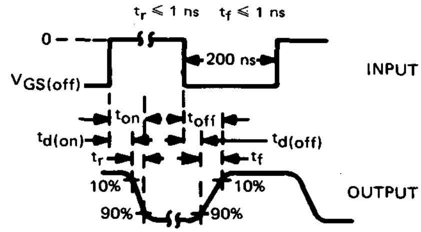
NOTE 3: This parameter must be measured using pulse techniques. $t_w \approx 100$ ms, duty cycle $\leq 10\%$.
*JEDEC registered data (typical data excluded).
†These are nominal values; exact values vary slightly with transistor parameters.

4

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

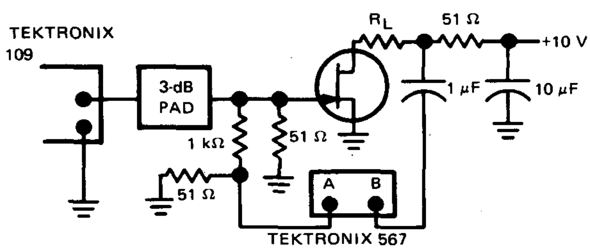


(See Notes a and b)
VOLTAGE WAVEFORMS

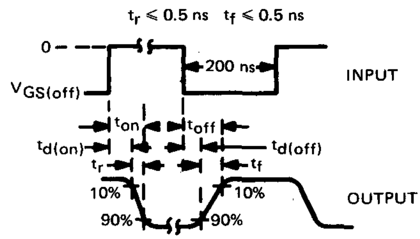
TYPES	R_L	$V_{GS(off)}$
2N4856A, 2N4859A	464 Ω	−10 V
2N4857A, 2N4860A	953 Ω	−6 V
2N4858A, 2N4861A	1910 Ω	−4 V

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, duty cycle ≈ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leqslant$ 0.75 ns, $R_{in} \geqslant$ 1 MΩ, $C_{in} \leqslant$ 2.5 pF.

FIGURE 1



TEST CIRCUIT



(See Note a)
VOLTAGE WAVEFORMS

TYPES	R_L	$V_{GS(off)}$
2N4856, 2N4856A, 2N4859, 2N4859A	750 Ω	−12 V
2N4857, 2N4857A, 2N4860, 2N4860A	1.54 kΩ	−7 V
2N4858, 2N4848A, 2N4861, 2N4861A	3.16 kΩ	−5 V

NOTE a: An equivalent generator and oscilloscope may be used. The oscilloscope must have a 50-Ω input impedance.

FIGURE 2

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6

TYPES 2N4891 THRU 2N4894
P-N PLANAR SILICON UNIJUNCTION TRANSISTORS

BULLETIN NO. DL-S 689776, JANUARY 1967

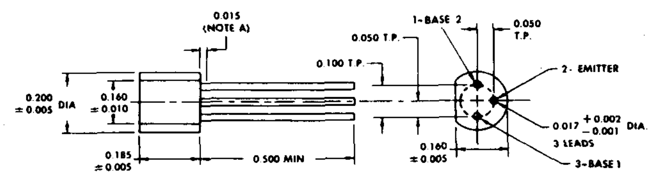
PLANAR UNIJUNCTION SILECT† TRANSISTORS‡ FOR APPLICATION IN SCR DRIVERS, MOTOR-SPEED CONTROLS, TIMERS, WAVEFORM GENERATORS, MULTIVIBRATORS, RING COUNTERS, ELECTRONIC ORGANS, AND MILITARY FUZES

- **Low Leakage Allows More Accurate Timing Circuit Design**
- **High Performance Capability at Low Drive Currents**
- **Provides Wider Range of Design Applications than Bar-Type Unijunction Transistors**
- **Rugged, One-Piece Construction Features Standard 100-mil TO-18 Pin-Circle**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

***CASE OUTLINE**



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Emitter—Base-Two Reverse Voltage	−30 V
Interbase Voltage	See Note 1
Continuous Emitter Current	50 mA
Peak Emitter Current (See Note 2)	1 A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	300 mW
Storage Temperature Range	−55°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. Intervase voltage is limited solely by power dissipation, $V_{B2\text{-}B1} = \sqrt{r_{BB} \cdot P_T}$.
2. This value applies for a capacitor discharge through the emitter—base-one diode. Current must fall to 0.37 A within 3 ms and pulse-repetition rate must not exceed 10 pps.
3. Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.

*JEDEC registered data
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP U42

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS		2N4891 MIN	2N4891 MAX	2N4892 MIN	2N4892 MAX	2N4893 MIN	2N4893 MAX	2N4894 MIN	2N4894 MAX	UNIT
r_{BB}	Static Interbase Resistance	$V_{B2\text{-}B1} = 3$ V, $I_E = 0$		4	9.1	4	9.1	4	12	4	12	kΩ
α_{rBB}	Interbase Resistance Temperature Coefficient	$V_{B2\text{-}B1} = 3$ V, $I_E = 0$, $T_A = -55°C$ to $100°C$,	See Note 4	0.1	0.9	0.1	0.9	0.1	0.9	0.1	0.9	%/deg
η	Intrinsic Standoff Ratio	$V_{B2\text{-}B1} = 10$ V,	See Figure 1	0.55	0.82	0.51	0.69	0.55	0.82	0.74	0.86	
$I_{B2(mod)}$	Modulated Interbase Current	$V_{B2\text{-}B1} = 10$ V, $I_E = 50$ mA,	See Note 5	10		10		10		10		mA
I_{EB2O}	Emitter Reverse Current	$V_{EB2} = -30$ V, $I_{B1} = 0$			−10		−10		−10		−10	nA
I_P	Peak-Point Emitter Current	$V_{B2\text{-}B1} = 25$ V			5		2		2		1	μA
$V_{EB1(sat)}$	Emitter – Base-One Saturation Voltage	$V_{B2\text{-}B1} = 10$ V, $I_E = 50$ mA,	See Note 5		4		4		4		4	V
I_V	Valley-Point Emitter Current	$V_{B2\text{-}B1} = 20$ V		2		4		2		2		mA
V_{OB1}	Base-One Peak Pulse Voltage	See Figure 2		3		3		6		3		V

NOTES: 4. Temperature coefficient, α_{rBB}, is determined by the following formula:

$$\alpha_{rBB} = \left[\frac{(r_{BB} @ 100°C) - (r_{BB} @ -55°C)}{(r_{BB} @ 25°C)}\right]\frac{100\%}{155\ \text{deg}}$$

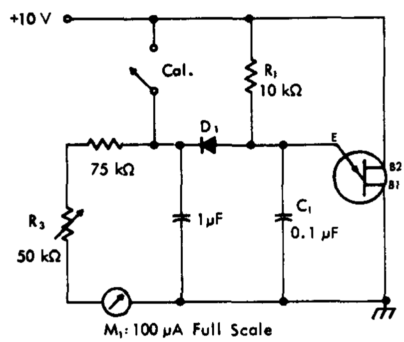
To obtain r_{BB} for a given temperature $T_{A(2)}$, use the following formula: $r_{BB(2)} = [r_{BB} @ 25°C]\,[1 + (\alpha_{rBB}/100)\,(T_{A(2)} - 25°C)]$

5. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

*JEDEC registered data

4

PARAMETER MEASUREMENT INFORMATION



η — Intrinsic Standoff Ratio — This parameter is defined in terms of the peak-point voltage, V_p, by means of the equation: $V_p = \eta V_{B2B1} + V_F$, where V_F is about 0.56 volt at 25°C and decreases with temperature at about 2 millivolts/deg.

The circuit used to measure η is shown in the figure. In this circuit, R_1, C_1 and the unijunction transistor form a relaxation oscillator, and the remainder of the circuit serves as a peak-voltage detector with the diode D_1 automatically subtracting the voltage V_F. To use the circuit, the "cal" button is pushed, and R_3 is adjusted to make the current meter M_1 read full scale. The "cal" button then is released and the value of η is read directly from the meter, with $\eta = 1$ corresponding to full-scale deflection of 100 μA.

D_1: 1N457, or equivalent, with the following characteristics:
$V_F = 0.565$ V at $I_F = 50\ \mu A$,
$I_R \leq 2\ \mu A$ at $V_R = 20$ V

FIGURE 1 — TEST CIRCUIT FOR INTRINSIC STANDOFF RATIO (η)

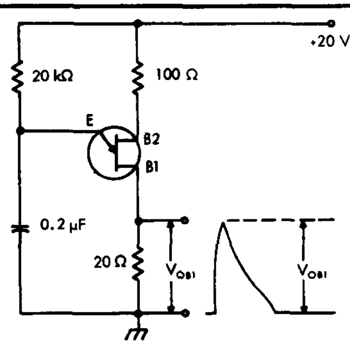


FIGURE 2 — V_{OB1} TEST CIRCUIT

EMITTER—BASE-ONE VOLTAGE
vs
EMITTER CURRENT

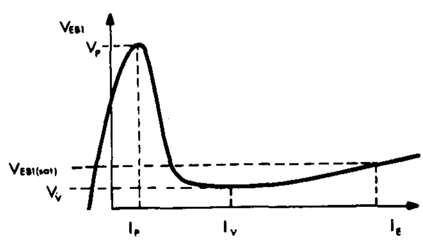


FIGURE 3 — GENERAL STATIC EMITTER CHARACTERISTIC CURVE

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3

TYPES 2N3980, 2N4947 THRU 2N4949
P-N PLANAR SILICON UNIJUNCTION TRANSISTORS

BULLETIN NO. DL-S 739565, MARCH 1967–REVISED MARCH 1973

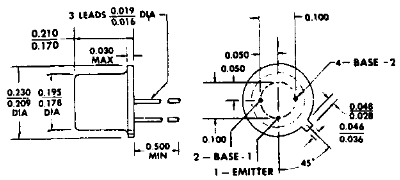
PLANAR UNIJUNCTION TRANSISTORS SPECIFICALLY CHARACTERIZED FOR A WIDE RANGE OF MILITARY, SPACE, AND INDUSTRIAL APPLICATIONS:

2N3980 for General-Purpose UJT Applications
2N4947 for High-Frequency Relaxation-Oscillator Circuits
2N4948 for Thyristor (SCR) Trigger Circuits
2N4949 for Long-Time-Delay Circuits

- **Planar Process Ensures Extremely Low Leakage, High Performance with Low Driving Currents, and Greatly Improved Reliability**

*mechanical data

Package outline is same as JEDEC TO-18 except for lead position. All TO-18 registration notes also apply to this outline.



BASE – 2 IS IN ELECTRICAL CONTACT WITH THE CASE.

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Emitter—Base-Two Reverse Voltage	–30 V
Interbase Voltage	See Note 1
Continuous Emitter Current	50 mA
Peak Emitter Current (See Note 2)	1 A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	360 mW
Storage Temperature Range	–65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. Interbase voltage is limited solely by power dissipation, $V_{B2-B1} = \sqrt{r_{BB} \cdot P_T}$

2. This value applies for a capacitor discharge through the emitter—base-one diode. Current must fall to 0.37 A within 3 ms and pulse-repetition rate must not exceed 10 pps.

3. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/deg.

*Indicates JEDEC registered data

USES CHIP U42

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N3980 MIN	2N3980 MAX	2N4947 MIN	2N4947 MAX	2N4948 MIN	2N4948 MAX	2N4949 MIN	2N4949 MAX	UNIT
r_{BB}	Static Interbase Resistance	$V_{B2-B1} = 3\text{ V}$, $I_E = 0$	4	8	4	9.1	4	12	4	12	kΩ
α_{rBB}	Interbase Resistance Temperature Coefficient	$V_{B2-B1} = 3\text{ V}$, $I_E = 0$, $T_A = -65°\text{C}$ to $100°\text{C}$, See Note 4	0.4	0.9	0.1	0.9	0.1	0.9	0.1	0.9	%/deg
η	Intrinsic Standoff Ratio	$V_{B2-B1} = 10\text{ V}$, See Figure 1	0.68	0.82	0.51	0.69	0.55	0.82	0.74	0.86	
$I_{B2(mod)}$	Modulated Interbase Current	$V_{B2-B1} = 10\text{ V}$, $I_E = 50\text{ mA}$, See Note 5	12		12		12		12		mA
I_{EB2O}	Emitter Reverse Current	$V_{EB2} = -30\text{ V}$, $I_{B1} = 0$		−10		−10		−10		−10	nA
		$V_{EB2} = -30\text{ V}$, $I_{B1} = 0$, $T_A = 125°\text{C}$		−1		−1		−1		−1	μA
I_P	Peak-Point Emitter Current	$V_{B2-B1} = 25\text{ V}$		2		2		2		1	μA
$V_{EB1(sat)}$	Emitter — Base-One Saturation Voltage	$V_{B2-B1} = 10\text{ V}$, $I_E = 50\text{ mA}$, See Note 5		3		3		3		3	V
I_V	Valley-Point Emitter Current	$V_{B2-B1} = 20\text{ V}$	1	10	4		2		2		mA
V_{OB1}	Base-One Peak Pulse Voltage	See Figure 2	6		3		6		3		V

NOTES: 4. Temperature coefficient α_{rBB} is determined by the following formula:

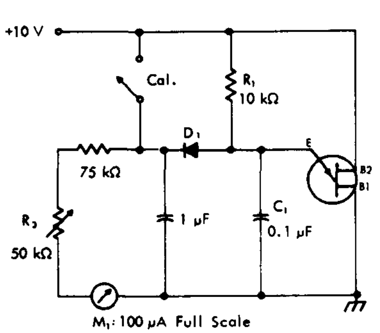
$$\alpha_{rBB} = \left[\frac{(r_{BB} @ 100°\text{C}) - (r_{BB} @ -65°\text{C})}{(r_{BB} @ 25°\text{C})}\right]\frac{100\%}{165\text{ deg}}$$

To obtain r_{BB} for a given temperature $T_{A(2)}$, use the following formula:

$$r_{BB(2)} = \left[r_{BB} @ 25°\text{C}\right]\left[1 + (\alpha_{rBB}/100\%)(T_{A(2)} - 25°\text{C})\right]$$

5. These parameters are measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

*PARAMETER MEASUREMENT INFORMATION



η — Intrinsic Standoff Ratio — This parameter is defined in terms of the peak-point voltage, V_p, by means of the equation: $V_p = \eta V_{B2B1} + V_F$, where V_F is about 0.56 volt at 25°C and decreases with temperature at about 2 millivolts/deg.

The circuit used to measure η is shown in the figure. In this circuit, R_1, C_1 and the unijunction transistor form a relaxation oscillator, and the remainder of the circuit serves as a peak-voltage detector with the diode D_1 automatically subtracting the voltage V_F. To use the circuit, the "cal" button is pushed, and R_2 is adjusted to make the current meter M_1 read full scale. The "cal" button then is released and the value of η is read directly from the meter, with $\eta = 1$ corresponding to full-scale deflection of 100 μA.

D_1: 1N457, or equivalent, with the following characteristics:
$V_F = 0.565\text{ V}$ at $I_F = 50\ \mu A$,
$I_R \leq 2\ \mu A$ at $V_R = 20\text{ V}$

FIGURE 1 — TEST CIRCUIT FOR INTRINSIC STANDOFF RATIO (η)

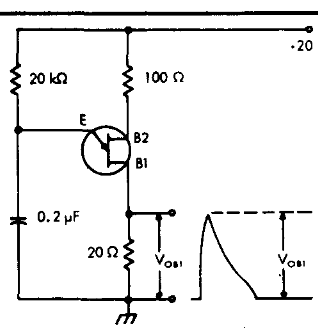


FIGURE 2 — V_{OB1} TEST CIRCUIT

EMITTER—BASE-ONE VOLTAGE
vs
EMITTER CURRENT

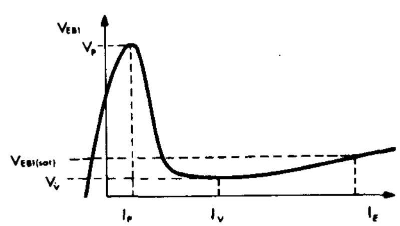


FIGURE 3 — GENERAL STATIC EMITTER CHARACTERISTIC CURVE

*Indicates JEDEC registered data

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INCORPORATED
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PRINTED IN U.S.A.

BULLETIN NO. DL-S 6911249, AUGUST 1969

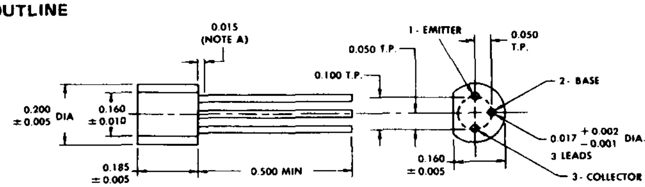
HIGH-FREQUENCY SILECT† TRANSISTORS‡ FOR TUNER AND IF-AMPLIFIER STAGES IN FM AND AM/FM STEREO-MULTIPLEX RECEIVERS

- **Rugged, One-Piece Construction with Standard TO-18 100-mil Pin-Circle**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

***CASE OUTLINE**



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	30 V
Collector-Emitter Voltage (See Note 1)	18 V
Emitter-Base Voltage	4 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 2 mW/°C.

*JEDEC registered data
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N16

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N4996 MIN	2N4996 TYP	2N4996 MAX	2N4997 MIN	2N4997 TYP	2N4997 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	30			30			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 2$ mA, $I_B = 0$, See Note 3	18			18			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	4			4			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ V, $I_E = 0$			100			100	nA
		$V_{CB} = 15$ V, $I_E = 0$, $T_A = 85°C$			10			10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 2$ mA	50			30		150	
$\lvert h_{fe}\rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 2$ mA, f = 100 MHz	6		14	6		14	
$\lvert y_{fe}\rvert$	Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = 10$ V, $I_C = 2$ mA, f = 10 MHz					70		mmho
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz, See Note 4	0.1		0.65	0.1		0.65	pF
r_{oep}	Parallel-Equivalent Common-Emitter Short-Circuit Output Resistance	$V_{CE} = 10$ V, $I_C = 2$ mA, f = 10 MHz				50			kΩ
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 10$ V, $I_E = -2$ mA, f = 79.8 MHz		14	20		14	20	ps

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N4996 TYP	UNIT
NF	Spot Noise Figure	$V_{CE} = 10$ V, $I_C = 2$ mA, $R_G = 100\ \Omega$, f = 100 MHz	2.5	dB

NOTES: 3. This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
4. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*JEDEC registered data

TEXAS INSTRUMENTS
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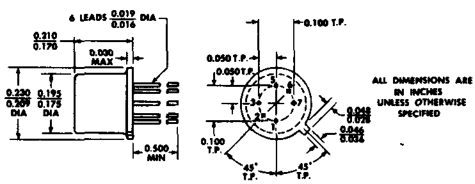
TYPES 2N5045, 2N5046, 2N5047
DUAL N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7211695, MARCH 1972

MATCHED FIELD-EFFECT TRANSISTORS

- **High $|y_{fs}|/C_{iss}$ Ratio (High-Frequency Figure-of-Merit)**
- **Low Input Capacitance C_{iss} . . . 8 pF Max**
- **Low Gate Reverse Current Differential . . . 10 nA Max at T_A = 100°C**
- **Recommended for Low-Level D-C Amplifiers, Sample-Hold Circuits, and Series-Shunt Choppers**

*mechanical data



1. SOURCE 1
2. DRAIN 1
3. GATE 1
5. SOURCE 2
6. DRAIN 2
7. GATE 2

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE

ALL JEDEC TO-71 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Drain-Gate Voltage	50 V	
Reverse Gate-Source Voltage	−50 V	
Gate-1—Gate-2 Voltage		±100 V
Lead-to-Case Voltage		±100 V
Continuous Forward Gate Current	30 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	250 mW	400 mW
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←300°C→	

NOTE 1: Derate linearly to 175°C free-air temperature at the rates of 1.67 mW/°C for each triode and 2.67 mW/°C for the total device.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN51

TYPES 2N5045, 2N5046, 2N5047
DUAL N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 2)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
I_{GSS}	Gate Reverse Current	$V_{GS} = -50$ V, $V_{DS} = 0$		−1	µA
		$V_{GS} = -30$ V, $V_{DS} = 0$		−0.25	nA
		$V_{GS} = -30$ V, $V_{DS} = 0$, $T_A = 150°C$		−250	nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 0.5$ nA	−0.5	−4.5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$	0.5	8	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz	1.5	6	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz		25	µmho
C_{iss}	Small-Signal Common-Source Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		8	pF
C_{rss}	Small-Signal Common-Source Reverse Transfer Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		4	pF
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz	1.5		mmho

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N5045		2N5046		2N5047		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$\|I_{GSS1} - I_{GSS2}\|$	Gate-Reverse-Current Differential	$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$		10		10		10	nA
$\|V_{GS1} - V_{GS2}\|$	Gate-Source-Voltage Differential	$V_{DS} = 15$ V, $I_D = 50$ µA		5		10		15	mV
		$V_{DS} = 15$ V, $I_D = 200$ µA		5		10		15	
$\|\Delta(V_{GS1} - V_{GS2}) \Delta T_A\|$	Gate-Source-Voltage-Differential Change with Temperature	$V_{DS} = 15$ V, $I_D = 200$ µA, $T_{A(1)} = 25°C$, $T_{A(2)} = -25°C$		5		10		15	mV
		$V_{DS} = 15$ V, $I_D = 200$ µA, $T_{A(1)} = 25°C$, $T_{A(2)} = 100°C$		5		10		15	
$\frac{I_{DSS1}}{I_{DSS2}}$	Zero-Gate-Voltage Drain Current Ratio	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	0.95	1	0.9	1	0.8	1	
$\frac{\|y_{fs}\|_1}{\|y_{fs}\|_2}$	Small-Signal Common-Source Forward Transfer Admittance Ratio	$V_{DS} = 15$ V, $I_D = 200$ µA, f = 1 kHz, See Note 3	0.95	1	0.9	1	0.8	1	
$\|y_{os}\|_1 - \|y_{os}\|_2$	Small-Signal Common-Source Output Admittance Differential	$V_{DS} = 15$ V, $I_D = 200$ µA, f = 1 kHz, See Note 3		1		2		3	µmho

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 2)

PARAMETER		TEST CONDITIONS	2N5045	2N5046	UNIT
			MAX	MAX	
F	Spot Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 10 Hz, $R_G = 1$ MΩ, Noise Bandwidth = 5 Hz	5	5	dB
V_n	Equivalent Input Noise Voltage	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 10 Hz, Noise Bandwidth = 5 Hz	200	200	$nV/\sqrt{Hz}$

NOTES: 2. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
3. The lower of the two characteristic readings is taken as the numerator or subtrahend.

*JEDEC registered data

4

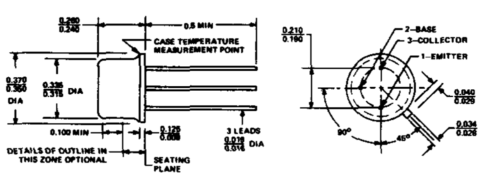
BULLETIN NO. DL-S 739699, MARCH 1967—REVISED MARCH 1973

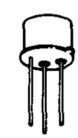
HIGH-VOLTAGE 10-WATT TRANSISTORS FOR GENERAL PURPOSE AMPLIFIER APPLICATIONS IN LINE-OPERATED CIRCUITS

- Solid-State Relays
- High-Voltage Inverters
- Voltage Regulators
- TV Sweep Circuits

mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE♦

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N5058	2N5059
Collector-Base Voltage	300 V*	250 V*
Collector-Emitter Voltage (See Note 1)	300 V*	250 V*
Emitter-Base Voltage	7 V*	6 V*
Collector Current	←150 mA*→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←1 W*→	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	←{10 W†, 5 W*}→	
Storage Temperature Range	−65°C to +200°C*	
Lead Temperature 1/16 Inch from Case for 60 Seconds	←300°C*→	

NOTES: 1. This value applies between 0 and 30 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 6.67 mW/°C.
3. Derate the 10-watt rating linearly to 175°C case temperature at the rate of 66.7 mW/°C. Derate the 5-watt (JEDEC registered) rating linearly to 175°C case temperature at the rate of 33.3 mW/°C.

♦The JEDEC registered outline for these devices is TO-5. TO-39 falls within TO-5 with the exception of lead length.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

USES CHIP N15

TYPES 2N5058, 2N5059
N-P-N SILICON TRANSISTORS

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		2N5058 MIN	2N5058 MAX	2N5059 MIN	2N5059 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$		300		250		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA, $I_B = 0$,	See Note 4	300		250		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$		7		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 100$ V, $I_E = 0$			50		50	nA
		$V_{CB} = 100$ V, $I_E = 0$,	$T_A = 125°C$		20		20	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 25$ V, $I_C = 5$ mA	See Note 4	10		10		
		$V_{CE} = 25$ V, $I_C = 30$ mA		35	150	30	150	
		$V_{CE} = 25$ V, $I_C = 100$ mA		35		30		
		$V_{CE} = 25$ V, $I_C = 30$ mA, $T_A = -55°C$		10				
V_{BE}	Base-Emitter Voltage	$V_{CE} = 25$ V, $I_C = 30$ mA,	See Note 4		0.82		0.82	V
		$I_B = 3$ mA, $I_C = 30$ mA,	See Note 4		0.85		0.85	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 3$ mA, $I_C = 30$ mA,	See Note 4		1		1	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 25$ V, $I_C = 10$ mA,	$f = 20$ MHz	1.5	8	1.5	8	
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$,	$f = 1$ MHz, See Note 5		10		10	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$,	$f = 1$ MHz, See Note 5		75		75	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

5. C_{cb} and C_{eb} are measured using three-terminal measurement techniques with the third electrode (emitter or collector respectively) guarded.

4

THERMAL INFORMATION

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

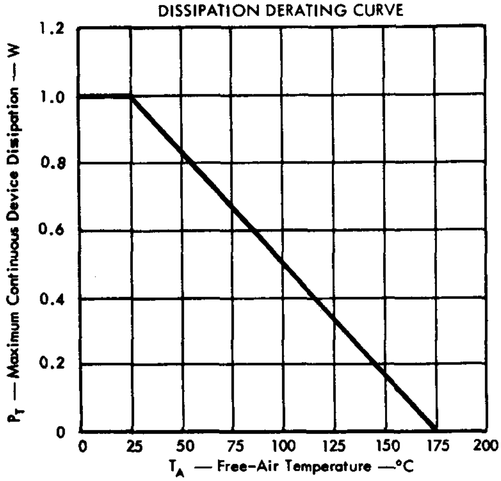


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

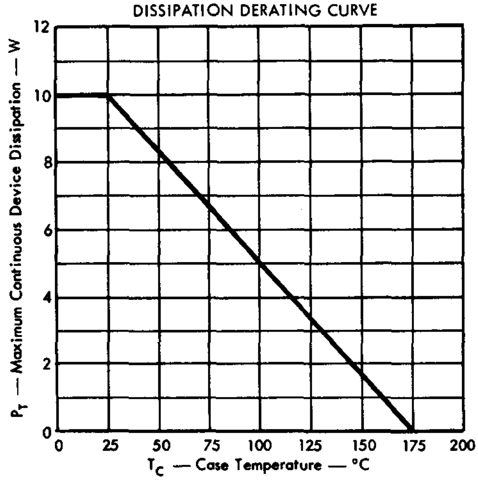


FIGURE 2

* Indicates JEDEC registered data

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

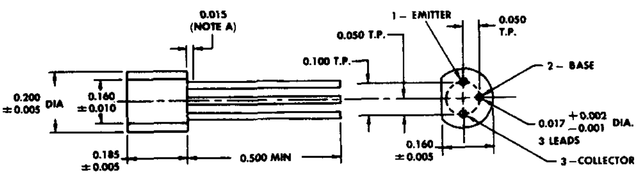
BULLETIN NO. DL-S 7011322, MAY 1970

HIGH-VOLTAGE SILECT† TRANSISTORS‡ FOR GENERAL PURPOSE AMPLIFIER APPLICATIONS IN LINE-OPERATED CIRCUITS

- Solid-State Relays
- High-Voltage Inverters
- Voltage Regulators
- High-Voltage Indicator and Display Controls

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T5058	A5T5059
Collector-Base Voltage	300 V	250 V
Collector-Emitter Voltage (See Note 1)	300 V	250 V
Emitter-Base Voltage	7 V	6 V
Continuous Collector Current	←150 mA→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←800 mW→	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	← 1.25 W →	
Continuous Device Dissipation at (or below) 25°C Case-and-Lead Temperature (See Note 4)	← 1.6 W →	
Storage Temperature Range	← −65°C to 150°C →	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←260°C→	

NOTES: 1. These values apply between 0 and 30 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 6.4 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.
4. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N15

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			A5T5058 MIN	A5T5058 MAX	A5T5059 MIN	A5T5059 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		300		250		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 30$ mA,	$I_B = 0$,	See Note 5	300		250		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$		7		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 100$ V,	$I_E = 0$			50		50	nA
		$V_{CB} = 100$ V,	$I_E = 0$,	$T_A = 75°C$		2		2	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V,	$I_C = 0$			10	·	10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 25$ V,	$I_C = 5$ mA	See Note 5	10		10		
		$V_{CE} = 25$ V,	$I_C = 30$ mA		35	150	30	150	
		$V_{CE} = 25$ V,	$I_C = 100$ mA		35		30		
		$V_{CE} = 25$ V,	$I_C = 30$ mA, $T_A = -55°C$		10				
V_{BE}	Base-Emitter Voltage	$V_{CE} = 25$ V,	$I_C = 30$ mA	See Note 5		0.82		0.82	V
		$I_B = 3$ mA,	$I_C = 30$ mA			0.85		0.85	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 3$ mA,	$I_C = 30$ mA,	See Note 5		1		1	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 25$ V,	$I_C = 10$ mA,	f = 20 MHz	1.5	8	1.5	8	
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V,	$I_E = 0$,	f = 1 MHz, See Note 6		10		10	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5$ V,	$I_C = 0$,	f = 1 MHz, See Note 6		75		75	pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

6. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

4

THERMAL INFORMATION

DISSIPATION DERATING CURVES

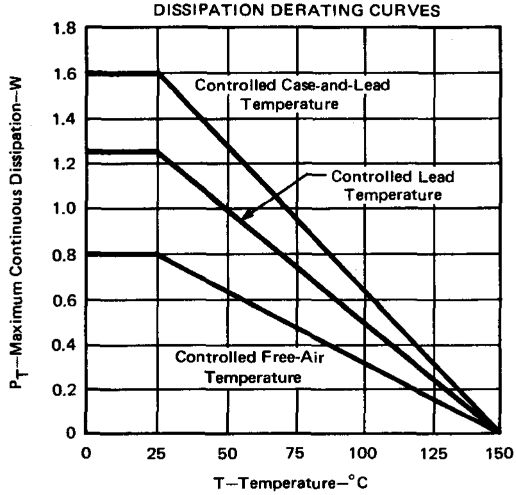


FIGURE 1

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TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311921, MARCH 1973

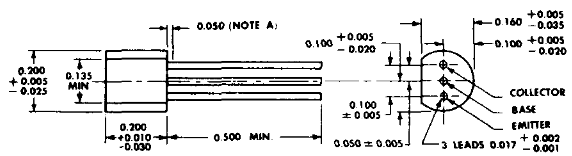
SILECT† TRANSISTORS‡
FOR LOW-LEVEL, LOW-NOISE AUDIO AMPLIFIER APPLICATIONS

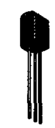
- For Complementary Use with N-P-N Types 2N5209, 2N5210, A5T5209, A5T5210
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5086, 2N5087

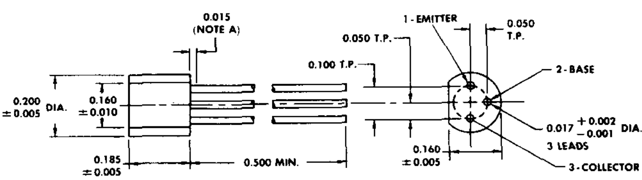


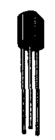


NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5086, A5T5087





NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−50 V*
Collector-Emitter Voltage (See Note 1)	−50 V*
Emitter-Base Voltage	−3 V*
Continuous Collector Current	−50 mA*
Continuous Device Dissipation at (or below) 25°C Free-air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5086 and 2N5087 only. This data sheet contains all applicable registered data in effect at the time of publication.

†Trademark of Texas Instruments ‡U.S. Patent No. 3,439,238

USES CHIP P18

§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N5086, 2N5087, A5T5086, A5T5087
P-N-P SILICON TRANSISTORS

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N5086 A5T5086 MIN	2N5086 A5T5086 MAX	2N5087 A5T5087 MIN	2N5087 A5T5087 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C 100 μA, $I_E = 0$	−50		−50		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 3	−50		−50		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -35$ V, $I_E = 0$		−50		−50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$		−50		−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -100\ \mu$A	150	500	250	800	
		$V_{CE} = -5$ V, $I_C = -1$ mA	150		250		
		$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 3	150		250		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -1$ mA		−0.85		−0.85	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 3		−0.3		−0.3	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz	150	600	250	900	
f_T	Transition Frequency	$V_{CE} = -5$ V, $I_C = -500\ \mu$A, See Note 4	40		40		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 140 kHz, See Note 5		4		4	pF

*operating characteristics at 25°C free-air temperature

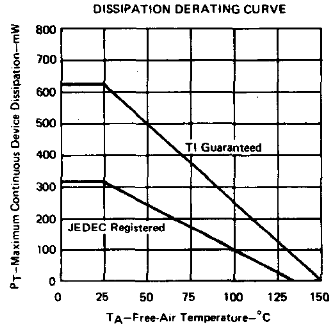
PARAMETER		TEST CONDITIONS	2N5086 A5T5086 MIN	2N5086 A5T5086 MAX	2N5087 A5T5087 MIN	2N5087 A5T5087 MAX	UNIT
F	Spot Noise Figure	$V_{CE} = -5$ V, $I_C = -100\ \mu$A, $R_G = 3\ k\Omega$, f = 1 kHz		3		2	dB
$\overline{F}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -20\ \mu$A, $R_G = 10\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 6		3		2	dB

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.
6. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*The asterisk identifies JEDEC registered data for the 2N5086 and 2N5087 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311770, FEBRUARY 1973

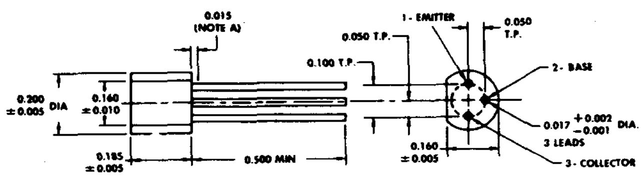
SILECT† TRANSISTORS‡
FOR LOW-COST, GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**
- **A7T5172 is Plug-in Replacement for 2N5172 (TO-98 Package)**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

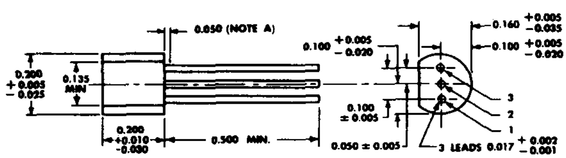
A5T5172



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

A7T5172, A8T5172

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



A7T5172

ECB

A8T5172

EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

DEVICE	LEADS 1	2	3
A7T5172	Emitter	Collector	Base
A8T5172	Emitter	Base	Collector

4

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	25 V
Collector-Emitter Voltage (See Note 1)	25 V
Emitter-Base Voltage	5 V
Continuous Collector Current	100 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N21

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 3	25		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 25$ V, $I_E = 0$		100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 3	100	500	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 3	0.5	1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA, See Note 3		0.25	V
h_{fe}	Small-Signal Common-Emitter Forward-Current Transfer Ratio	$V_{CB} = 10$ V, $I_C = 10$ mA, f = 1 kHz	100	750	
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz, See Note 4	1.6	10	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

THERMAL INFORMATION

4

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

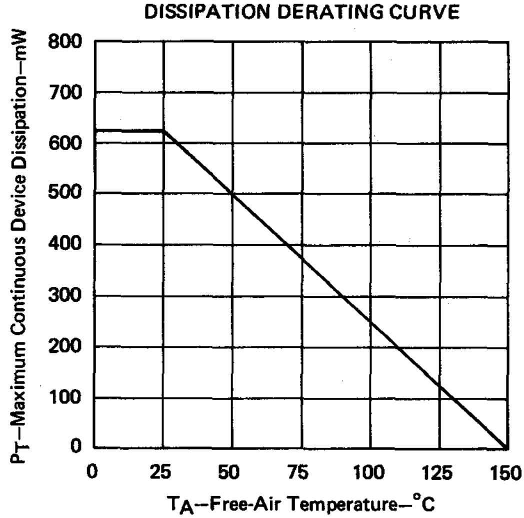


FIGURE 1

BULLETIN NO. DL-S 7311922, JUNE 1973

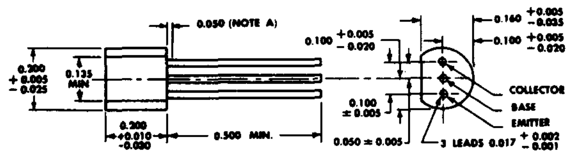
SILECT† TRANSISTORS‡
FOR LOW-LEVEL, LOW-NOISE AUDIO AMPLIFIER APPLICATIONS

- For Complementary Use with P-N-P Types 2N5086, 2N5087, A5T5086, A5T5087
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

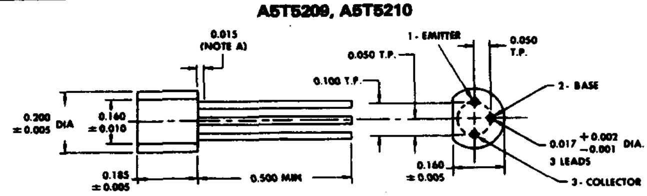
2N5209, 2N5210



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5209, A5T5210



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	50 V*
Collector-Emitter Voltage (See Note 1)	50 V*
Emitter-Base Voltage	4.5 V*
Continuous Collector Current	50 mA*
Peak Collector Current	100 mA*
Continuous Device Dissipation at (or below) 25°C Free-air Temperature (See Note 2)	625 mW§ / 310 mW*
Storage Temperature Range	−65°C to 150°C§ / −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ / 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5209 and 2N5210 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP N21

TEXAS INSTRUMENTS
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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N5209 A5T5209 MIN	2N5209 A5T5209 MAX	2N5210 A5T5210 MIN	2N5210 A5T5210 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	50		50		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA, $I_B = 0$, See Note 3	50		50		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 35$ V, $I_E = 0$		50		50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V, $I_C = 0$		50		50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 100\ \mu A$	100	300	200	600	
		$V_{CE} = 5$ V, $I_C = 1$ mA	150		250		
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 3	150		250		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 1$ mA		0.85		0.85	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA, See Note 3		0.7		0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ mA, f = 1 kHz	150	600	250	900	
f_T	Transition Frequency	$V_{CE} = 5$ V, $I_C = 500\ \mu A$, See Note 4	30		30		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 5$ V, $I_E = 0$, f = 100 kHz, See Note 5		4		4	pF

*operating characteristics at 25°C free-air temperature

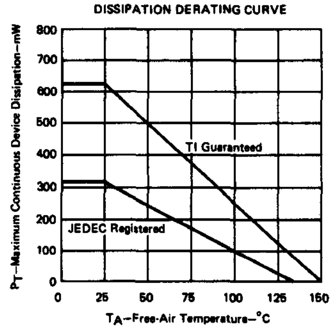
PARAMETER		TEST CONDITIONS	2N5209 A5T5209 MIN	2N5209 A5T5209 MAX	2N5210 A5T5210 MIN	2N5210 A5T5210 MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 5$ V, $I_C = 20\ \mu A$, $R_G = 10\ k\Omega$, f = 1 kHz		4		3	dB
$\bar{F}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 20\ \mu A$, $R_G = 22\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 6		3		2	dB

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.
6. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*The asterisk identifies JEDEC registered data for the 2N5209 and 2N5210 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



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BULLETIN NO. DL-S 7311928, MARCH 1973

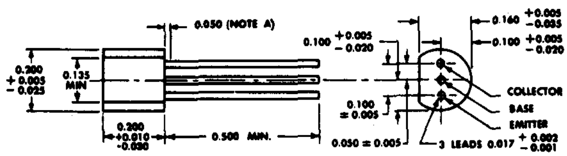
SILECT† TRANSISTORS‡

- For Low-Level, Small-Signal, General Purpose Amplifier and Oscillator Applications
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5219

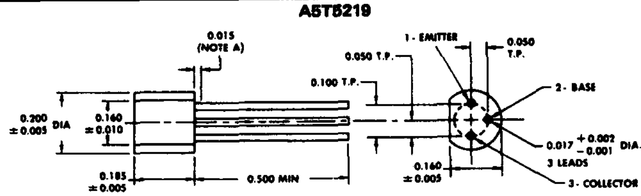


NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

EBC

A5T5219



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	20 V*
Collector-Emitter Voltage (See Note 1)	15 V*
Emitter-Base Voltage	3 V*
Continuous Collector Current	100 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5219 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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TEXAS INSTRUMENTS
INCORPORATED
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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		20		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA,	$I_B = 0$,	See Note 3	15		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$		3		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ V,	$I_E = 0$			100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 2$ V,	$I_C = 0$			500	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 2$ mA		35	500	
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA,	$I_C = 10$ mA,	See Note 3		1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA,	$I_C = 10$ mA,	See Note 3		0.4	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 2$ mA,	f = 1 kHz	35	1500	
f_T	Transition Frequency	$V_{CE} = 10$ V,	$I_C = 10$ mA,	See Note 4	150		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, See Note 5	$I_E = 0$,	f = 1 MHz,		4	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 40 MHz to the frequency at which $|h_{fe}| = 1$.

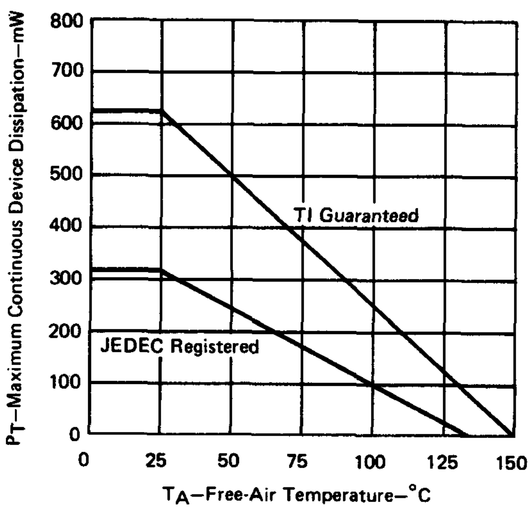
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

4

*The asterisk identifies JEDEC registered data for the 2N5219 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



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BULLETIN NO. DL-S 7311920, MARCH 1973

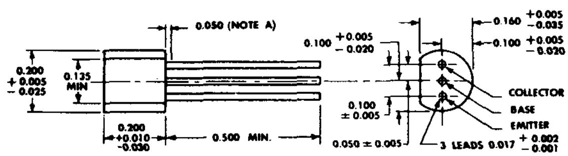
SILECT† TRANSISTORS‡
FOR GENERAL PURPOSE AMPLIFIER AND LOW-POWER AUDIO APPLICATIONS

- **For Complementary Use with P-N-P Types 2N5221, A5T5221**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5220

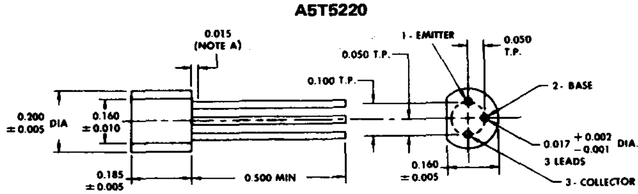


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5220



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	15 V*
Collector-Emitter Voltage (See Note 1)	15 V*
Emitter-Base Voltage	3 V*
Continuous Collector Current	500 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5220 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP N24

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		15		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$,	$I_B = 0$,	See Note 3	15		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$		3		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10\ V$,	$I_E = 0$			100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3\ V$,	$I_C = 0$			100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$,	$I_C = 10\ mA$	See Note 3	25		
		$V_{CE} = 10\ V$,	$I_C = 50\ mA$		30	600	
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$,	$I_C = 150\ mA$,	See Note 3		1.1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$,	$I_C = 150\ mA$,	See Note 3		0.5	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$,	$I_C = 50\ mA$,	$f = 1\ kHz$	30	1800	
f_T	Transition Frequency	$V_{CE} = 10\ V$,	$I_C = 20\ mA$,	See Note 4	100		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 5\ V$, See Note 5	$I_E = 0$,	$f = 1\ MHz$,		10	pF

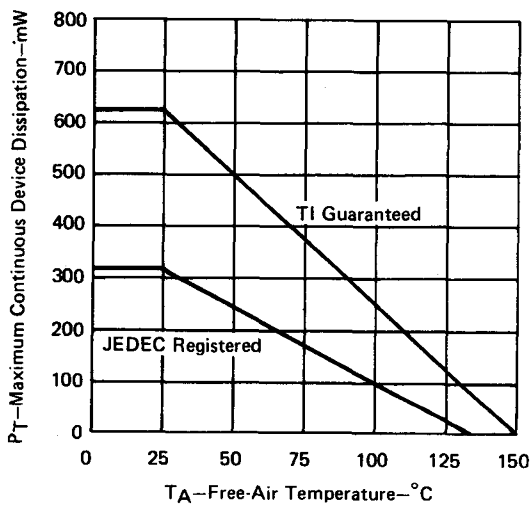
NOTES: 3. *These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.*
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N5220 only.

4

THERMAL INFORMATION

DISSIPATION DERATING CURVE



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BULLETIN NO. DL-S 7311924, MARCH 1973

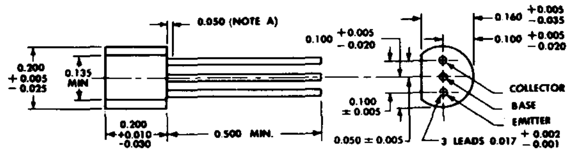
SILECT† TRANSISTORS‡
FOR GENERAL PURPOSE AMPLIFIER AND LOW-POWER AUDIO APPLICATIONS

- **For Complementary Use with N-P-N Types 2N5220, A5T5220**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

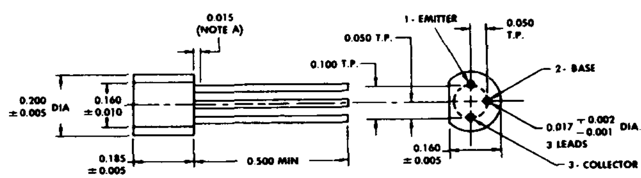
2N5221



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5221



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−15 V*
Collector-Emitter Voltage (See Note 1)	−15 V*
Emitter-Base Voltage	−3 V*
Continuous Collector Current	−500 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5221 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP P20

*electrical characteristics at 25°C free-air temperature

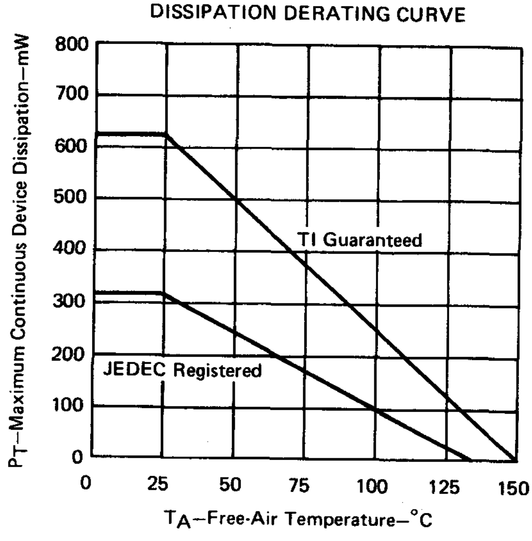
PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$,	$I_E = 0$		−15		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ mA$,	$I_B = 0$,	See Note 3	−15		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$,	$I_C = 0$		−3		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -10\ V$,	$I_E = 0$			−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3\ V$,	$I_C = 0$			−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10\ V$,	$I_C = -10\ mA$	See Note 3	25		
		$V_{CE} = -10\ V$,	$I_C = -50\ mA$		30	600	
V_{BE}	Base-Emitter Voltage	$I_B = -15\ mA$,	$I_C = -150\ mA$,	See Note 3		−1.1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15\ mA$,	$I_C = -150\ mA$,	See Note 3		−0.5	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10\ V$,	$I_C = -50\ mA$,	f = 1 kHz	30	1800	
f_T	Transition Frequency	$V_{CE} = -10\ V$,	$I_C = -20\ mA$,	See Note 4	100		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -5\ V$, See Note 5	$I_E = 0$,	f = 1 MHz,		15	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N5221 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



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TEXAS INSTRUMENTS
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BULLETIN NO. DL-S 7311929, MARCH 1973

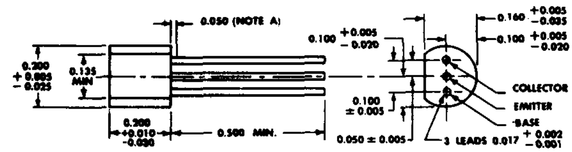
SILECT† TRANSISTORS‡

- For RF Amplifier, Mixer, and Video IF Applications in Radio and Television Receivers
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5222

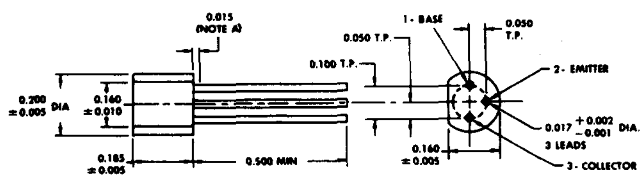


BEC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A6T5222



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	20 V*
Collector-Emitter Voltage (See Note 1)	15 V*
Emitter-Base Voltage	2 V*
Continuous Collector Current	50 mA*
Continuous Device Dissipation at (or below) 25°C Free-air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5222 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP N24

*electrical characteristics at 25°C free-air temperature

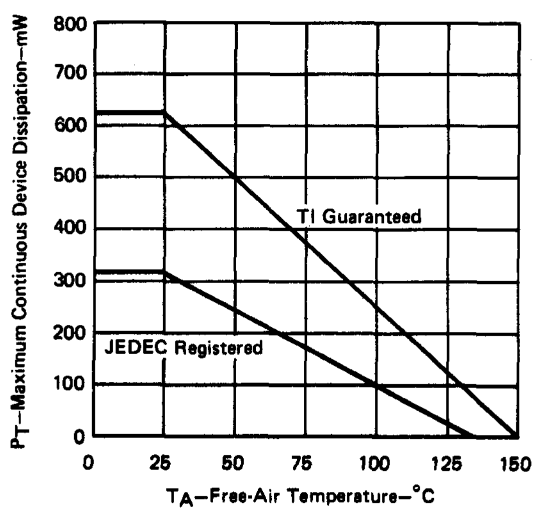
PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		20		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA,	$I_B = 0$,	See Note 3	15		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$		2		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ V,	$I_E = 0$			100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 2$ V,	$I_C = 0$			100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 4$ mA,	See Note 3	20	1500	
V_{BE}	Base-Emitter Voltage	$I_B = 0.4$ mA,	$I_C = 4$ mA			1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.4$ mA,	$I_C = 4$ mA			1	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 4$ mA,	f = 1 kHz	20	3000	
f_T	Transition Frequency	$V_{CE} = 10$ V,	$I_C = 4$ mA,	See Note 4	450		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, See Note 5	$I_E = 0$,	f = 1 MHz,		1.3	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N5222 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



4

BULLETIN NO. DL-S 7311930, MARCH 1973—REVISED DECEMBER 1973

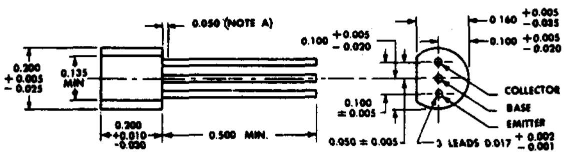
SILECT† TRANSISTORS‡

- **For Low-Level, Small-Signal, General Purpose Amplifier and Oscillator Applications**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5223

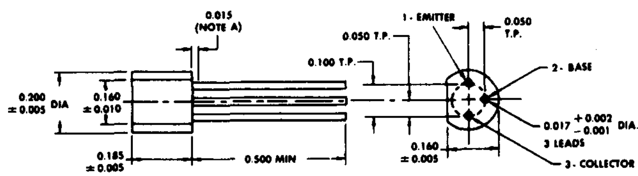


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5223



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	25 V*
Collector-Emitter Voltage (See Note 1)	20 V*
Emitter-Base Voltage	3 V*
Continuous Collector Current	100 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 350 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 150°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 350-mW (JEDEC registered) rating linearly to 150°C free-air temperature at the rate of 2.8 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5223 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP **N21**

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		25		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA,	$I_B = 0$,	See Note 3	20		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$		3		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ V,	$I_E = 0$			100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V,	$I_C = 0$			500	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 2$ mA,	See Note 3	50	800	
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA,	$I_C = 10$ mA,	See Note 3		1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA,	$I_C = 10$ mA,	See Note 3		0.7	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V,	$I_C = 2$ mA,	f = 1 kHz	50	1600	
f_T	Transition Frequency	$V_{CE} = 10$ V,	$I_C = 10$ mA,	See Note 4	150		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, See Note 5	$I_E = 0$,	f = 1 MHz,		4	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 40 MHz to the frequency at which $|h_{fe}| = 1$.

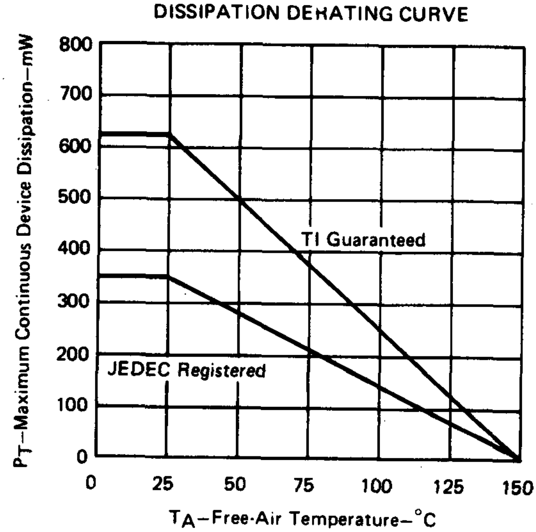
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N5223 only.

4

THERMAL INFORMATION

DISSIPATION DERATING CURVE



PRINTED IN U.S.A. 1273

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311925, MARCH 1973

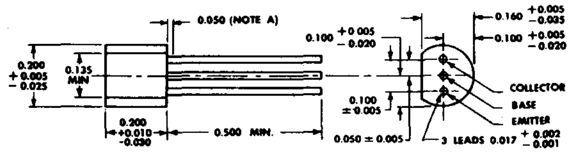
SILECT† TRANSISTORS‡
FOR MEDIUM-CURRENT AUDIO AMPLIFIER APPLICATIONS

- **For Complementary Use with P-N-P Types 2N5226, A5T5226**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5225

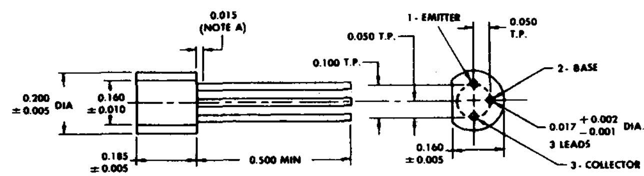


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5225



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	25 V*
Collector-Emitter Voltage (See Note 1)	25 V*
Emitter-Base Voltage	4 V*
Continuous Collector Current	500 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5225 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP N24

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		25		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$,	$I_B = 0$,	See Note 3	25		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$		4		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15\ V$,	$I_E = 0$			300	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4\ V$,	$I_C = 0$			500	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$,	$I_C = 10\ mA$	See Note 3	25		
		$V_{CE} = 10\ V$,	$I_C = 50\ mA$		30	600	
V_{BE}	Base-Emitter Voltage	$I_B = 10\ mA$,	$I_C = 100\ mA$,	See Note 3		1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 10\ mA$,	$I_C = 100\ mA$,	See Note 3		0.8	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$,	$I_C = 50\ \mu A$,	$f = 1\ kHz$	30	1800	
f_T	Transition Frequency	$V_{CE} = 10\ V$,	$I_C = 20\ mA$,	See Note 4	50		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 5\ V$, See Note 5	$I_E = 0$,	$f = 1\ MHz$,		20	pF

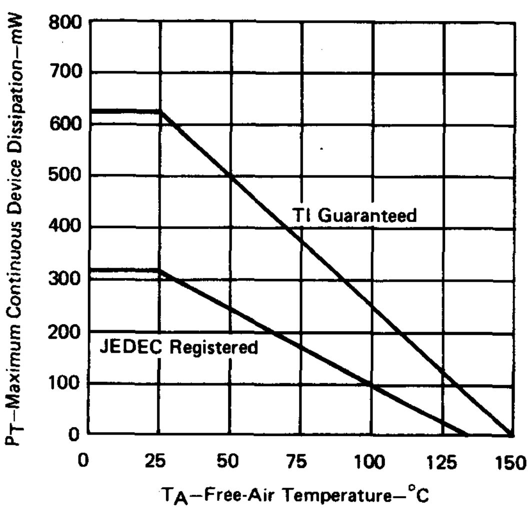
4

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N5225 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311923, MARCH 1973

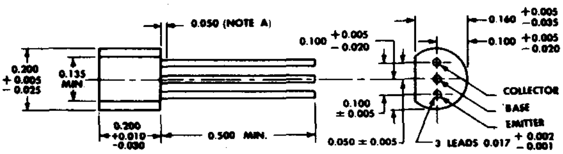
SILECT† TRANSISTORS‡
FOR MEDIUM-CURRENT, AUDIO AMPLIFIER APPLICATIONS

- **For Complementary Use with N-P-N Types 2N5225, A5T5225**
- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5226

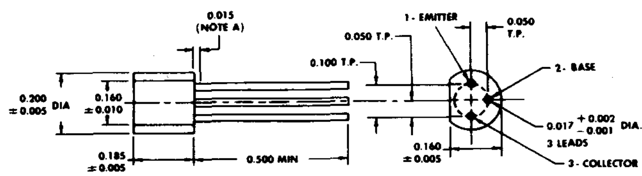


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5226



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−25 V*
Collector-Emitter Voltage (See Note 1)	−25 V*
Emitter-Base Voltage	−4 V*
Continuous Collector Current	−500 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5226 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP P20

*electrical characteristics at 25°C free-air temperature

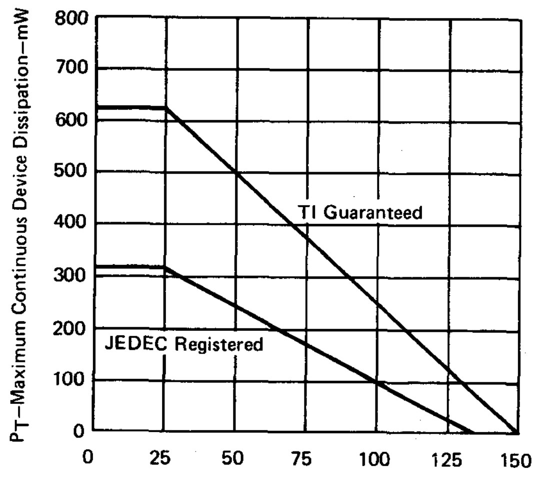
PARAMETER		TEST CONDITIONS		MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$		−25		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 3	−25		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$		−4		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -15$ V, $I_E = 0$			−300	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$			−500	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA	See Note 3	25		
		$V_{CE} = -10$ V, $I_C = -50$ mA		30	600	
V_{BE}	Base-Emitter Voltage	$I_B = -10$ mA, $I_C = -100$ mA,	See Note 3		−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -10$ mA, $I_C = -100$ mA,	See Note 3		−0.8	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -50$ mA,	f = 1 kHz	30	1800	
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -20$ mA,	See Note 4	50		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -5$ V, $I_E = 0$, See Note 5	f = 1 kHz,		20	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N5226 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N5227, A5T5227
P-N-P SILICON TRANSISTORS

BULLETIN NO. DL-S 7311927, MARCH 1973

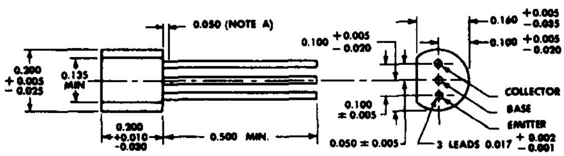
SILECT† TRANSISTORS‡

- For Low-Level, Small-Signal, General Purpose Amplifier and Oscillator Applications
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

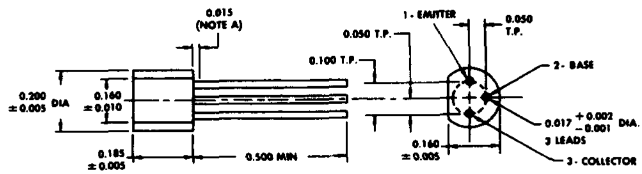
2N5227



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5227



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−30 V*
Collector-Emitter Voltage (See Note 1)	−30 V*
Emitter-Base Voltage	−3 V*
Continuous Collector Current	−50 mA*
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ 310 mW*
Storage Temperature Range	−65°C to 150°C§ −55°C to 135°C*
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C§ 230°C*

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5227 only. This data sheet contains all applicable registered data in effect at the time of publication.

†Trademark of Texas Instruments.

‡U.S. Patent No. 3,439,238.

§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP P18

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature

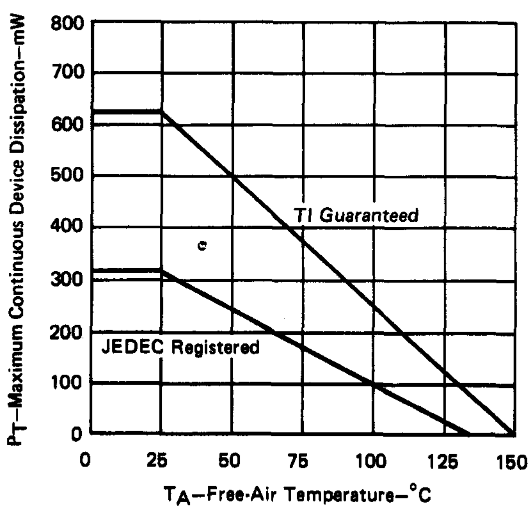
PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$,	$I_E = 0$		−30		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA,	$I_B = 0$,	See Note 3	−30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$,	$I_C = 0$		−3		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -10$ V,	$I_E = 0$			−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -2$ V,	$I_C = 0$			−500	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -100\ \mu A$	See Note 3	30		
		$V_{CE} = -10$ V,	$I_C = -2$ mA		50	700	
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA,	$I_C = -10$ mA,	See Note 3		−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA,	$I_C = -10$ mA,	See Note 3		−0.4	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -2$ mA,	f = 1 kHz	50	1500	
f_T	Transition Frequency	$V_{CE} = -10$ V,	$I_C = -10$ mA,	See Note 4	100		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -10$ V, See Note 5	$I_E = 0$,	f = 1 MHz,		5	pF

NOTES: 3. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*The asterisk identifies JEDEC registered data for the 2N5227 only.

THERMAL INFORMATION

DISSIPATION DERATING CURVE



BULLETIN NO. DL-S 6810917, SEPTEMBER 1968

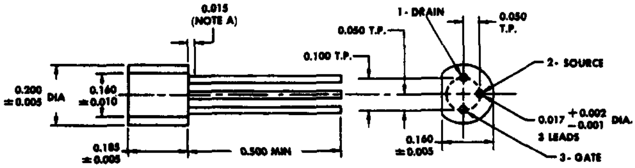
N-CHANNEL SILECT† FIELD-EFFECT TRANSISTORS‡ FOR VHF AMPLIFIER AND MIXER APPLICATIONS

- **High Power Gain . . . 10 dB Min at 400 MHz**
- **High Transconductance . . . 4000 μmho Min at 400 MHz (2N5245, 2N5247)**
- **Low C_{rss} . . . 1 pF Max**
- **High $|y_{fs}|/C_{iss}$ Ratio (High-Frequency Figure-of-Merit)**
- **Drain and Gate Leads Separated for High Maximum Stable Gain**
- **Cross-Modulation Minimized by Square-Law Transfer Characteristic**
- **For Use in VHF Amplifiers in FM, TV, and Mobile Communications Equipment**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

*CASE OUTLINE



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	30 V
Reverse Gate-Source Voltage	−30 V
Continuous Forward Gate Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 2)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.
2. Derate linearly to 150°C lead temperature at the rate of 4 mW/°C. Lead temperature is measured on the gate lead 1/16 inch from the case.

*Indicates JEDEC registered data
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP JN53

4

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N5245 MIN	2N5245 MAX	2N5246 MIN	2N5246 MAX	2N5247 MIN	2N5247 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−30		−30		−30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−1		−1		−1	nA
		$V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 100°C$		−0.5		−0.5		−0.5	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 10$ nA	−1	−6	−0.5	−4	−1.5	−8	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	5	15	1.5	7	8	24	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 1$ kHz	4.5	7.5	3	6	4.5	8	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 1$ kHz		0.05		0.05		0.07	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 1$ MHz		4.5		4.5		4.5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			1		1		1	pF
$Re(y_{is})$	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 100$ MHz		0.1		0.1		0.1	mmho
$Im(y_{is})$	Small-Signal Common-Source Input Susceptance			3		3		3	mmho
$Re(y_{os})$	Small-Signal Common-Source Output Conductance			0.075		0.075		0.1	mmho
$Im(y_{os})$	Small-Signal Common-Source Output Susceptance			1		1		1	mmho
$Re(y_{is})$	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, $f = 400$ MHz		1		1		1	mmho
$Im(y_{is})$	Small-Signal Common-Source Input Susceptance			12		12		12	mmho
$Re(y_{fs})$	Small-Signal Common-Source Forward Transfer Conductance		4		2.5		4		mmho
$Re(y_{os})$	Small-Signal Common-Source Output Conductance			0.1		0.1		0.15	mmho
$Im(y_{os})$	Small-Signal Common-Source Output Susceptance			4		4		4	mmho

NOTE 3: This parameter must be measured using pulse techniques. $t_p = 100$ ms, duty cycle $\leq 10\%$.

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N5245 MIN	2N5245 MAX	UNIT
G_{ps}	Small-Signal Common-Source Neutralized Insertion Power Gain	$V_{DS} = 15$ V, $I_D = 5$ mA, $f = 100$ MHz, $R_G' = 1\ k\Omega$, See Figure 1	18		dB
		$V_{DS} = 15$ V, $I_D = 5$ mA, $f = 400$ MHz, $R_G' = 1\ k\Omega$, See Figure 1	10		
NF	Spot Noise Figure	$V_{DS} = 15$ V, $I_D = 5$ mA, $f = 100$ MHz, $R_G' = 1\ k\Omega$, See Figure 1		2	dB
		$V_{DS} = 15$ V, $I_D = 5$ mA, $f = 400$ MHz, $R_G' = 1\ k\Omega$, See Figure 1		4	

*Indicates JEDEC registered data

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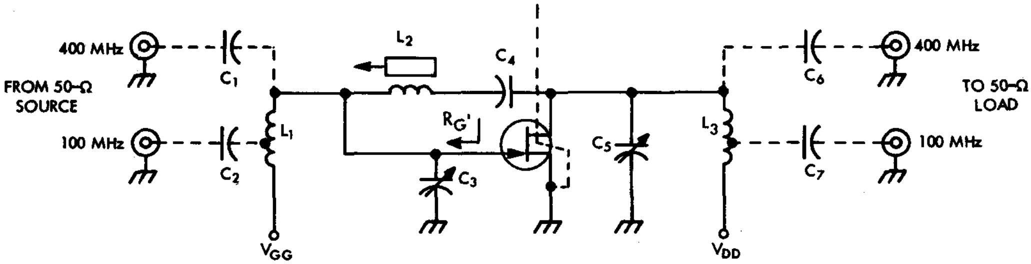
*PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION					
CAPACITORS			COILS		
	100 MHz	400 MHz		100 MHz	400 MHz
C_1	not used	1.8 pF	L_1	8.5 T, #16 copper, tapped 2.5 T from bottom, 3/8" ID, 1 1/4" long	1.25 T, #20 copper, 3/16" ID, 3/8" long
C_2	7 pF	not used			
C_3	1 – 12 pF	0.8 – 8 pF	L_2	15 T, #20 enameled copper, close-wound, 1/4" ID	4 T, #20 enameled copper, close-wound, 3/16" ID
C_4	1000 pF	27 pF			
C_5	1 – 12 pF	0.8 – 8 pF	L_3	13.5 T, #16 copper, tapped 5 T from bottom, 3/8" ID, 1 1/4" long	0.5 T, #20 copper, 1/2" ID, no length
C_6	not used	1 pF			
C_7	3 pF	not used			

FIGURE 1 — SCHEMATIC AND COMPONENT INFORMATION FOR 100-MHz AND 400-MHz NEUTRALIZED INSERTION POWER GAIN AND SPOT NOISE FIGURE TEST CIRCUITS

*Indicates JEDEC registered data

TYPICAL CHARACTERISTICS

ALL TYPES
GATE REVERSE CURRENT
vs
FREE-AIR TEMPERATURE

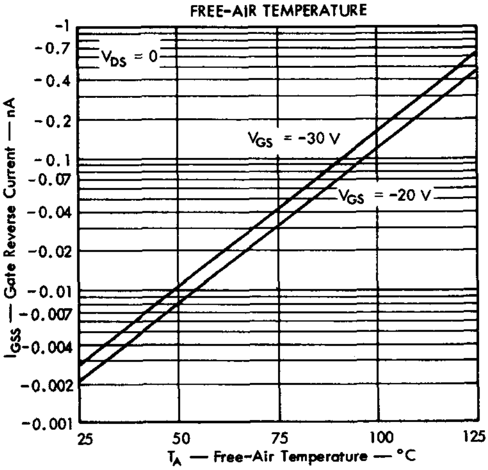


FIGURE 2

2N5245
CORRELATION OF SMALL-SIGNAL COMMON-SOURCE FORWARD TRANSFER ADMITTANCE and GATE-SOURCE CUTOFF VOLTAGE
with
INDIVIDUAL DEVICE ZERO-GATE-VOLTAGE DRAIN CURRENT

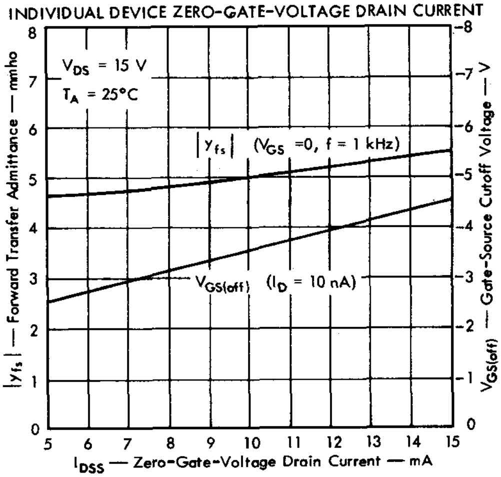


FIGURE 3

TEXAS INSTRUMENTS INCORPORATED
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TYPE 2N5248
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

BULLETIN NO. DL-S 6811052, SEPTEMBER 1968

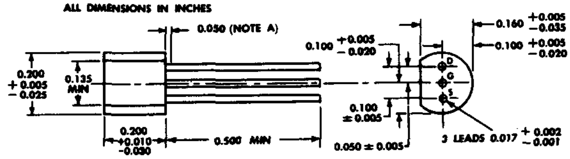
SILECT† FIELD-EFFECT TRANSISTOR‡ FOR VHF AMPLIFIER AND MIXER APPLICATIONS

- Low C_{rss}: ⩽ 2 pF
- High y_{fs}/C_{iss} Ratio (High-Frequency Figure-of-Merit)
- Formerly TIS34

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



NOTE A: Lead diameter is not controlled in this area.

SGD

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	30 V
Reverse Gate-Source Voltage	−30 V
Continuous Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−30		V
I_{GSS}	Gate Cutoff Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−5	nA
		$V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 100°C$		−1.5	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 10$ nA	−1	−8	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 400\ \mu A$	−1	−7.5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2	4	20	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz	3.5	6.5	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz		50	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			2	pF
$Re(y_{is})$	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 200 MHz		0.8	mmho
$Re(y_{fs})$	Small-Signal Common-Source Forward Transfer Conductance		3		mmho
$Re(y_{os})$	Small-Signal Common-Source Output Conductance			0.2	mmho

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.
2. These parameters must be measured using pulse techniques. t_w = 100 ms, duty cycle ⩽ 10%.

*Indicates JEDEC registered data
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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BULLETIN NO. DL-S 6810830, SEPTEMBER 1968

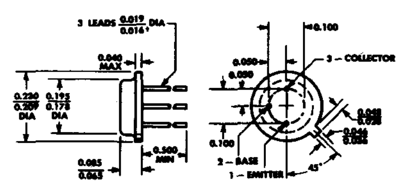
RADIATION-TOLERANT TRANSISTOR FOR SWITCHING AND GENERAL PURPOSE VHF-UHF AMPLIFIER APPLICATIONS

- **Guaranteed I_{CBO}, h_{FE}, and $V_{CE(sat)}$ after 1×10^{15} Fast Neutrons/cm^2**
- **Complement to N-P-N type 2N5399**

description

The 2N5332 transistor offers a significant advance in radiation-tolerant-device technology. Unique construction techniques produce transistors which maintain useful characteristics after fast-neutron radiation fluences through 10^{15} n/cm^2.

*mechanical data



THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE.

ALL JEDEC TO-46 DIMENSIONS AND NOTES ARE APPLICABLE.

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

†TI guaranteed minimum. The JEDEC registered minimum lead diameter for the TO-46 is 0.012.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	–20 V
Collector-Emitter Voltage (See Note 1)	–12 V
Emitter-Base Voltage	– 2 V
Continuous Collector Current	–100 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 W
Storage Temperature Range	–65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. This value applies between 0 and 100 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/deg.
3. Derate linearly to 175°C case temperature at the rate of 8 mW/deg.

*Indicates JEDEC registered data

TYPE 2N5332
P-N-P SILICON TRANSISTOR

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

Symbol	Parameter	Test Conditions		MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$		−20		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$,	See Note 4	−12		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$,	See Note 5	−2		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -15$ V, $I_E = 0$			−10	nA
		$V_{CB} = -15$ V, $I_E = 0$, $T_A = 125°C$			−10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -1.5$ V, $I_C = 0$			−1	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -1$ mA		20	80	
		$V_{CE} = -1$ V, $I_C = -10$ mA	See Note 4	20	80	
		$V_{CE} = -1$ V, $I_C = -20$ mA		20	80	
		$V_{CE} = -1$ V, $I_C = -20$ mA, $T_A = -55°C$		10		
		$V_{CE} = -5$ V, $I_C = -50$ mA		20	80	
V_{BE}	Base-Emitter Voltage	$I_B = -4$ mA, $I_C = -20$ mA,	See Note 4	−0.7	−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -4$ mA, $I_C = -20$ mA,	See Note 4		−0.2	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -10$ mA, $f = 100$ MHz		6		
		$V_{CE} = -5$ V, $I_C = -50$ mA, $f = 100$ MHz		8		
C_{cb}	Collector-Base Capacitance	$V_{CB} = -5$ V, $I_E = 0$, $f = 1$ MHz,	See Note 6		3.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, $f = 1$ MHz,	See Note 6		8	pF

*post-irradiation electrical characteristics at 25°C free-air temperature

Symbol	Parameter	Test Conditions	Radiation Fluence†	MIN	MAX	UNIT
I_{CBO}	Collector Cutoff Current	$V_{CB} = -15$ V, $I_E = 0$	1×10^{15} n/cm²		−10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -2$ V, $I_C = -20$ mA, See Note 4		10		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -4$ mA, $I_C = -20$ mA, See Note 4			−0.6	V

NOTES: 4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

5. The applicable test methods of MIL-STD-750A are recommended for testing all parameters; however, due to the unusual construction of this device, it is particularly important to observe the test procedures detailed in Method 3026.1 for testing $V_{(BR)EBO}$. The voltage shall be gradually increased from zero until either the 2-V limit or the 10-μA test current is reached. The device is acceptable if 2 V is reached before the test current exceeds 10 μA.

6. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

†Radiation is fast neutrons (n) at E $\geq$ 10 keV (reactor spectrum).

*switching characteristics at 25°C free-air temperature

Symbol	Parameter	Test Conditions‡	MIN	MAX	UNIT
t_d	Delay Time	$V_{CC} = -3$ V, $I_C = -20$ mA, $I_{B(1)} = -4$ mA,		12	ns
t_r	Rise Time	$V_{BE(off)} = 0.7$ V, See Figure 1		8	ns
t_s	Storage Time	$V_{CC} = -3$ V, $I_C = -20$ mA, $I_{B(1)} = -4$ mA,		70	ns
t_f	Fall Time	$I_{B(2)} = 4$ mA, See Figure 1		16	ns

‡Voltage and current values shown are nominal; exact values vary slightly with transistor and diode parameters.

*Indicates JEDEC registered data

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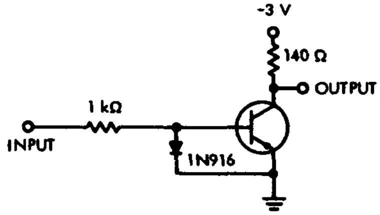
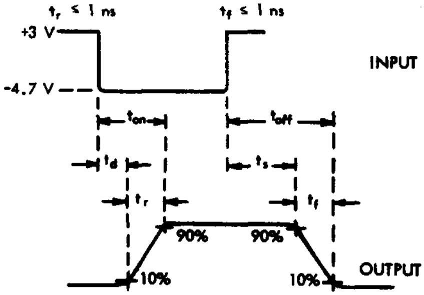
*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_p \ge 300$ ns, duty cycle $\le 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \le 1$ ns, $R_{in} \ge 100\ k\Omega$, $C_{in} \le 10$ pF.

*Indicates JEDEC registered data

TYPICAL CHARACTERISTICS, POST IRRADIATION

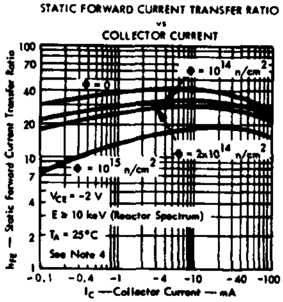


FIGURE 2

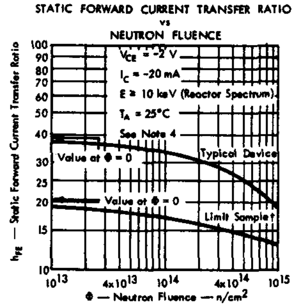


FIGURE 3

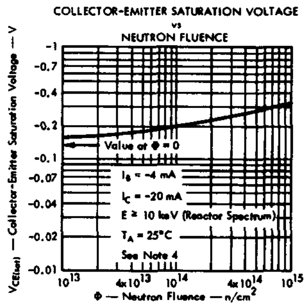


FIGURE 4

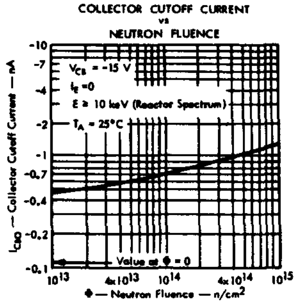


FIGURE 5

NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\le 2\%$.

†This curve indicates typical behavior of a device having $h_{FE} = 20$ at $V_{CE} = -1$ V, $I_C = -20$ mA, $\Phi = 0$.

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N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

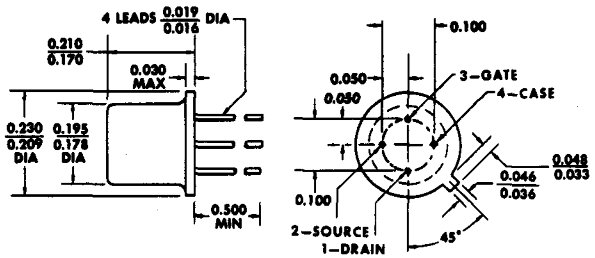
BULLETIN NO. DL-S 7111436, APRIL 1971

FOR SMALL-SIGNAL APPLICATIONS

- Narrow I_{DSS} and $V_{GS(off)}$ Ranges
- For Low-Noise Audio-Frequency Amplifier Applications
- For RF Amplifier Applications Thru 100 MHz
- For Chopper and Switching Applications

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Source Voltage	40 V
Reverse Gate-Source Voltage	−40 V
Continuous Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE 1: Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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INCORPORATED
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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	2N5358 MIN	2N5358 MAX	2N5359 MIN	2N5359 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -10\,\mu A$, $V_{DS} = 0$	−40		−40		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−0.1		−0.1	nA
		$V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.1		−0.1	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 100$ nA	−0.5	−3	−0.8	−4	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 50\,\mu A$	−0.3	−1.5			V
		$V_{DS} = 15$ V, $I_D = 80\,\mu A$			−0.4	−2	
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2	0.5	1	0.8	1.6	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 3	1	3	1.2	3.6	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			10		10	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 3		6		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			2		2	pF
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz See Note 3	0.8		0.9		mmho

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	2N5360 MIN	2N5360 MAX	2N5361 MIN	2N5361 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -10\,\mu A$, $V_{DS} = 0$	−40		−40		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−0.1		−0.1	nA
		$V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.1		−0.1	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 100$ nA	−0.8	−4	−1	−6	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 150\,\mu A$	−0.5	−2.5			V
		$V_{DS} = 15$ V, $I_D = 250\,\mu A$			−1	−5	
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2	1.5	3	2.5	5	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 3	1.4	4.2	1.5	4.5	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			20		20	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 3		6		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			2		2	pF
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz, See Note 3	1.4		1.7		mmho

NOTES: 2. This parameter must be measured using pulse techniques. $t_w = 300\,\mu s$, duty cycle ≤ 2%.
3. These parameters must be measured with bias conditions applied for less than 5 seconds to avoid overheating.

*JEDEC registered data

†The fourth lead (case) is connected to the source for all measurements.

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		2N5362		2N5363		2N5364		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -10\ \mu A$,	$V_{DS} = 0$	−40		−40		−40		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20\ V$,	$V_{DS} = 0$		−0.1		−0.1		−0.1	nA
		$V_{GS} = -20\ V$, $T_A = 150°C$	$V_{DS} = 0$,		−0.1		−0.1		−0.1	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15\ V$,	$I_D = 100\ nA$	−2	−7	−2.5	−8	−2.5	−8	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15\ V$,	$I_D = 0.4\ mA$	−1.3	−5					V
		$V_{DS} = 15\ V$,	$I_D = 0.7\ mA$			−2	−6			
		$V_{DS} = 15\ V$,	$I_D = 0.9\ mA$					−2	−6	
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15\ V$, See Note 2	$V_{GS} = 0$,	4	8	7	14	9	18	mA
$\|y_{fs}\|$	*Small-Signal Common-Source* Forward Transfer Admittance	$V_{DS} = 15\ V$, $f = 1\ kHz$,	$V_{GS} = 0$, See Note 3	2	5.5	2.5	6	2.7	6.5	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance				40		40		60	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15\ V$, $f = 1\ MHz$,	$V_{GS} = 0$, See Note 3		6		6		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance				2		2		2	pF
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance	$V_{DS} = 15\ V$, $f = 100\ MHz$,	$V_{GS} = 0$, See Note 3	1.9		2.1		2.2		mmho

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	ALL TYPES		UNIT
			MIN	MAX	
NF	Common-Source Spot Noise Figure	$V_{DS} = 15\ V$, $V_{GS} = 0$, $f = 100\ Hz$, $R_G = 1\ M\Omega$, See Note 3		2.5	dB

NOTES: 2. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
3. These parameters must be measured with bias conditions applied for less than 5 seconds to avoid overheating.

*JEDEC registered data

†The fourth lead (case) is connected to the source for all measurements.

TYPICAL CHARACTERISTICS

2N5362 THRU 2N5364

GATE CUTOFF CURRENT vs FREE-AIR TEMPERATURE

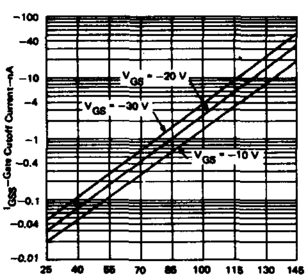

FIGURE 1

NOMINAL CHARACTERISTIC VALUES FOR NORMALIZED CURVES AT $V_{DS} = 15\ V$, $T_A = 25°C$

PARAMETER	I_{DSS} (mA)	V_{GS} (V)	$\|y_{fs}\|$ (mmho)
Conditions	$V_{GS} = 0$	$I_D = 100\ \mu A$	$V_{GS} = 0$, $f = 1\ kHz$
2N5362	6	−2.0	4.3
2N5363	10	−3.0	4.7
2N5364	15	−4.0	5.2

NORMALIZED SMALL-SIGNAL COMMON-SOURCE FORWARD TRANSFER ADMITTANCE vs NORMALIZED GATE-SOURCE VOLTAGE

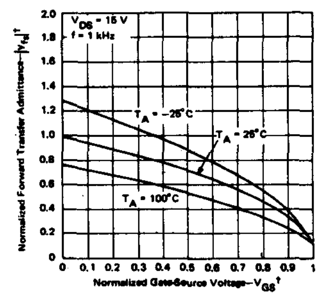

FIGURE 2

†Normalized $V_{GS} = \dfrac{V_{GS}}{V_{GS} \text{ at } I_D = 100\ \mu A,\ T_A = 25°C}$; Normalized $|y_{fs}| = \dfrac{|y_{fs}|}{|y_{fs}| \text{ at } V_{GS} = 0,\ T_A = 25°C}$

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TYPE 2N5397
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

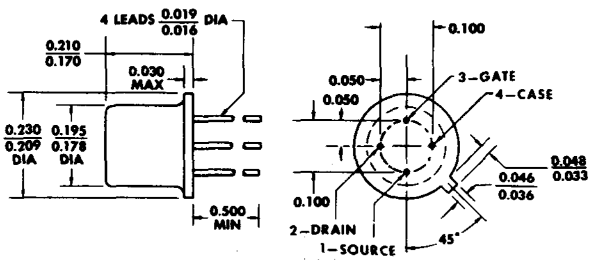
BULLETIN NO. DL-S 7111424, AUGUST 1971

FOR VHF AMPLIFIER AND MIXER APPLICATIONS

- **High Power Gain . . . 15 dB Min at 450 MHz**
- **Low Noise Figure . . . 3.5 dB Max at 450 MHz**
- **High Transconductance . . . 5500 μmho Min at 450 MHz**
- **Low C_{rss} . . . 1.2 pF Max**

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	25 V
Drain-Source Voltage	25 V
Reverse Gate-Source Voltage	−25 V
Continuous Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE 1: Derate linearly to 200°C free-air temperature at the rate of 1.7 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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TYPE 2N5397
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−25		V
V_{GSF}	Gate-Source Forward Voltage	$I_G = 1$ mA, $V_{DS} = 0$		1	V
I_{GSS}	Gate Reverse Current	$V_{GS} = -15$ V, $V_{DS} = 0$		−0.1	nA
		$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.1	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 10$ V, $I_D = 1$ nA	−1	−6	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 10$ V, $V_{GS} = 0$, See Note 3	10	30	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 10$ V, $I_D = 10$ mA, f = 1 kHz	6	10	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			0.2	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DG} = 10$ V, $I_D = 10$ mA, f = 1 MHz		5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			1.2	pF
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DG} = 10$ V, $I_D = 10$ mA, f = 450 MHz		2	mmho
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance		5.5	9	mmho
g_{os}	Small-Signal Common-Source Output Conductance			0.4	mmho

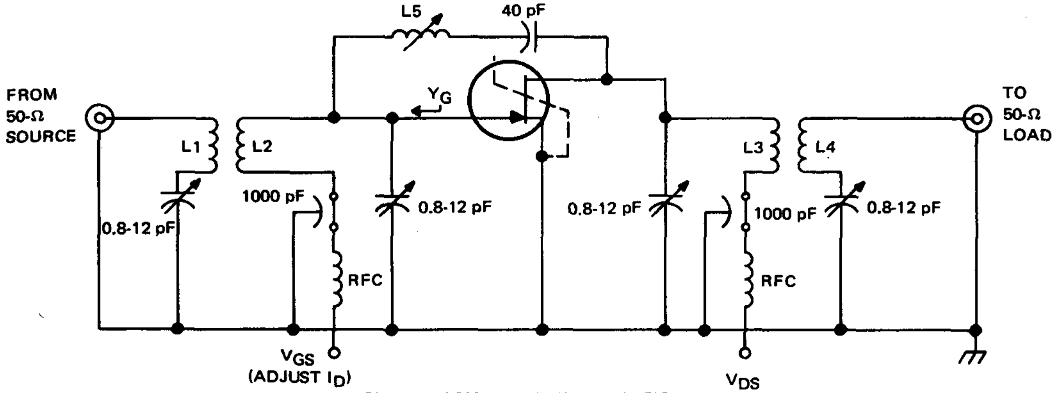
NOTE 3: This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 1%.

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
G_{ps}	Small-Signal Common-Source Neutralized Insertion Power Gain	$V_{DG} = 10$ V, $I_D = 10$ mA, f = 450 MHz, $R_G = 1\ k\Omega$, $Y_G' = 1.1$ mmho−j4 mmho,	15		dB
NF	Spot Noise Figure	See Figure 1		3.5	dB

*JEDEC registered data. †The fourth lead (case) is connected to the source for all measurements.

PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

(L1, L2, L3, and L4 are straight pieces of the specified conductor)

L1: 1.4 inch #22 enamel spaced 0.1 inch from L2.
L2: 1.1 inch #16 solid copper
L3: 1.3 inch #16 solid copper
L4: 1.4 inch #22 enamel spaced 0.3 inch from L3
L5: 3 T #22 enamel, close-wound on 0.25-inch-diameter form with adjustable aluminum slug.
RFC: 0.15 µH, Delevan type 1537-00, or the equivalent.

FIGURE 1—NEUTRALIZED INSERTION POWER GAIN AND SPOT NOISE FIGURE TEST CIRCUIT

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TYPE 2N5398
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

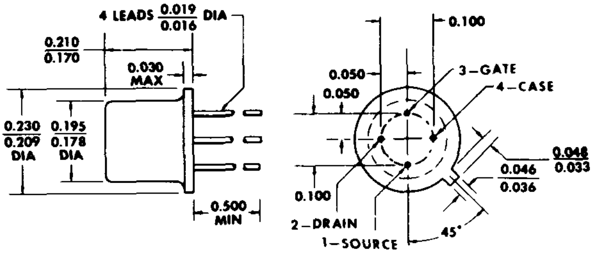
BULLETIN NO. DL-S 7111425, AUGUST 1971

FOR VHF AMPLIFIER AND MIXER APPLICATIONS

- High Transconductance . . . 5000 μmho Min at 450 MHz
- Low C_{rss} . . . 1.3 pF Max

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	25 V
Drain-Source Voltage	25 V
Reverse Gate-Source Voltage	−25 V
Continuous Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE 1: Derate linearly to 200°C free-air temperature at the rate of 1.7 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TYPE 2N5398
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−25		V
V_{GSF}	Gate-Source Forward Voltage	$I_G = 1$ mA, $V_{DS} = 0$		1	V
I_{GSS}	Gate Reverse Current	$V_{GS} = -15$ V, $V_{DS} = 0$		−0.1	nA
		$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.1	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 10$ V, $I_D = 1$ nA	−1	−6	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 10$ V, $V_{GS} = 0$, See Note 2	5	40	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 10$ V, $V_{GS} = 0$, f = 1 kHz	5.5	10	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			0.4	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 10$ V, $V_{GS} = 0$, f = 1 MHz		5.5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			1.3	pF
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DS} = 10$ V, $V_{GS} = 0$, f = 450 MHz		3	mmho
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance		5	10	mmho
g_{os}	Small-Signal Common-Source Output Conductance			0.5	mmho

NOTE 2: This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 1%.
* JEDEC registered data
†The fourth lead (case) is connected to the source for all measurements.

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PRINTED IN U.S.A. 373

BULLETIN NO. DL-S 6810668, SEPTEMBER 1968

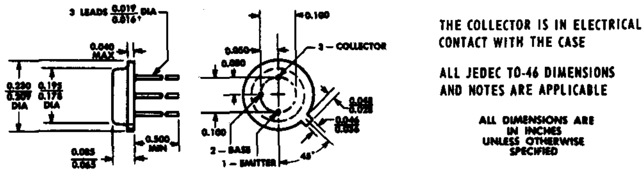
RADIATION - TOLERANT TRANSISTOR FOR LOW-POWER GENERAL PURPOSE VHF – UHF AMPLIFIER AND SATURATED-SWITCHING APPLICATIONS

- **Guaranteed I_{CBO}, h_{FE} and $V_{CE(sat)}$ after 1×10^{15} Fast Neutrons/cm²**
- **Complement to P-N-P Type 2N5332**

description

The 2N5399 transistor offers a significant advance in radiation-tolerant-device technology. Unique construction techniques produce transistors which maintain useful characteristics after fast-neutron radiation fluences through 10^{15} n/cm².

*mechanical data



†TI guaranteed minimum. The JEDEC registered minimum lead diameter for the TO-46 is 0.012.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	25 V
Collector-Emitter Voltage (See Note 1)	15 V
Emitter-Base Voltage	2 V
Continuous Collector Current	100 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 W
Storage Temperature Range	–65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. This value applies between 0 and 100 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/deg.
3. Derate linearly to 175°C case temperature at the rate of 8 mW/deg.

*Indicates JEDEC registered data

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TYPE 2N5399
N-P-N SILICON TRANSISTOR

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS				MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$			25		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA,	$I_B = 0$,		See Note 4	15		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$,		See Note 5	2		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ V,	$I_E = 0$				10	nA
		$V_{CB} = 15$ V,	$I_E = 0$	$T_A = 125°C$			10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 1.5$ V,	$I_C = 0$				1	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V,	$I_C = 1$ mA		See Note 4	30	90	
		$V_{CE} = 1$ V,	$I_C = 10$ mA			30	90	
		$V_{CE} = 1$ V,	$I_C = 20$ mA			30	90	
		$V_{CE} = 1$ V,	$I_C = 20$ mA,	$T_A = -55°C$		15		
		$V_{CE} = 5$ V,	$I_C = 50$ mA			30	90	
V_{BE}	Base-Emitter Voltage	$I_B = 4$ mA,	$I_C = 20$ mA,		See Note 4	0.7	1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 4$ mA,	$I_C = 20$ mA,		See Note 4		0.2	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V,	$I_C = 10$ mA,	$f = 100$ MHz		6		
		$V_{CE} = 5$ V,	$I_C = 50$ mA,	$f = 100$ MHz		8		
C_{cb}	Collector-Base Capacitance	$V_{CB} = 5$ V,	$I_E = 0$,	$f = 1$ MHz,	See Note 6		3	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5$ V,	$I_C = 0$,	$f = 1$ MHz,	See Note 6		6	pF

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*post-irradiation electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			RADIATION FLUENCE†	MIN	MAX	UNIT
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ V,	$I_E = 0$		$1 \times 10^{15}\ n/cm^2$		10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V,	$I_C = 20$ mA,	See Note 4		12		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 4$ mA,	$I_C = 20$ mA,	See Note 4			0.5	V

NOTES: 4. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

5. The applicable test methods of MIL-STD-750A are recommended for testing all parameters; however, due to the unusual construction of this device, it is particularly important to observe the test procedures detailed in Method 3026.1 for testing $V_{(BR)EBO}$. The voltage shall be gradually increased from zero until either the 2-V limit or the 10-μA test current is reached. The device is acceptable if 2 V is reached before the test current exceeds 10 μA.

6. C_{ob} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

†Radiation is fast neutrons (n) at $E \geq 10$ keV (reactor spectrum).

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS‡			MIN	MAX	UNIT
t_d	Delay Time	$V_{CC} = 3$ V,	$I_C = 20$ mA,	$I_{B(1)} = 4$ mA,		12	ns
t_r	Rise Time	$V_{BE(off)} = -0.7$ V,		See Figure 1		8	ns
t_s	Storage Time	$V_{CC} = 3$ V,	$I_C = 20$ mA,	$I_{B(1)} = 4$ mA,		70	ns
t_f	Fall Time	$I_{B(2)} = -4$ mA,		See Figure 1		16	ns

‡Voltage and current values shown are nominal; exact values vary slightly with transistor and diode parameters.

* JEDEC registered data

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PARAMETER MEASUREMENT INFORMATION

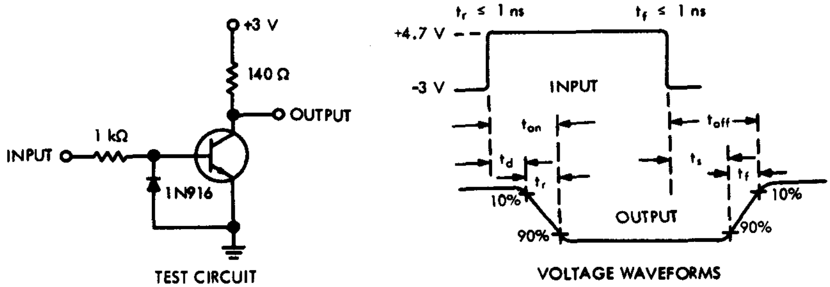

FIGURE 1

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_p \geq 300$ ns, duty cycle $\leq 2\%$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 10$ pF.

*JEDEC registered data

TYPICAL CHARACTERISTICS, POST IRRADIATION

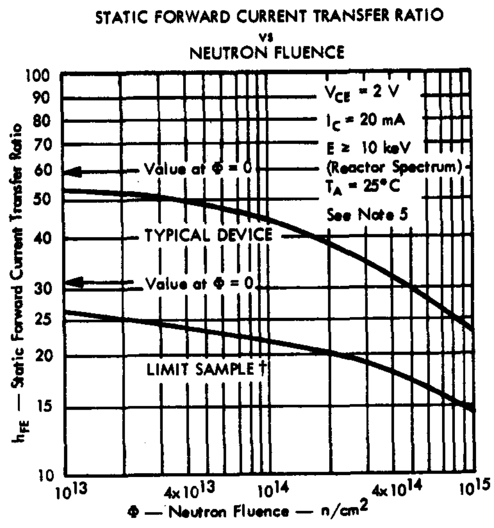

FIGURE 2

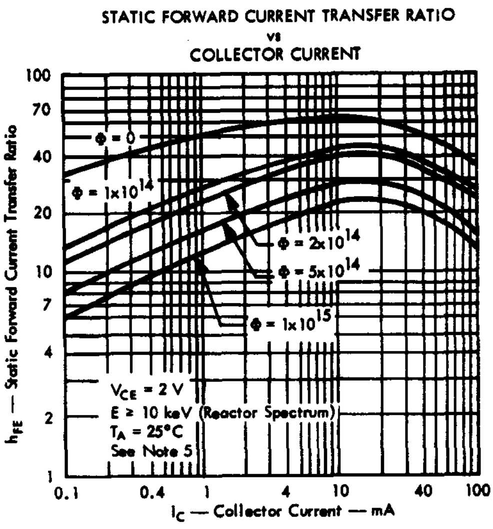

FIGURE 3

NOTE 5: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

†This curve indicates typical behavior of a device having the limit value of $h_{FE} = 30$ at $V_{CE} = 1$ V, $\Phi = 0$.

TYPICAL CHARACTERISTICS, POST IRRADIATION

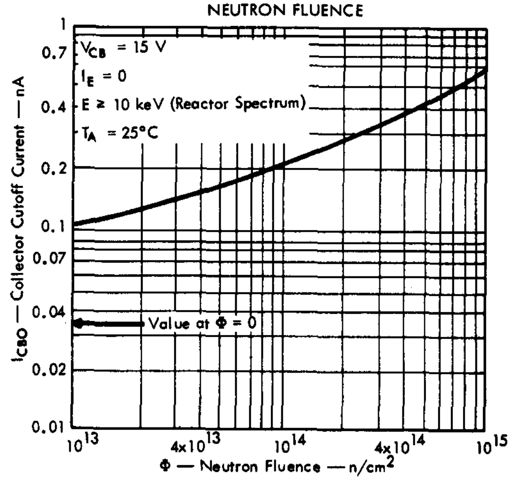

FIGURE 4

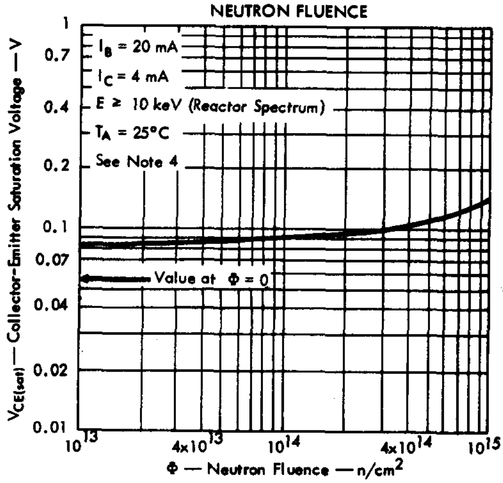

FIGURE 5

NOTE 4: These parameters must be measured using pulse techniques. t_p = 300 μs, duty cycle ≤ 2%.

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TYPICAL CHARACTERISTICS

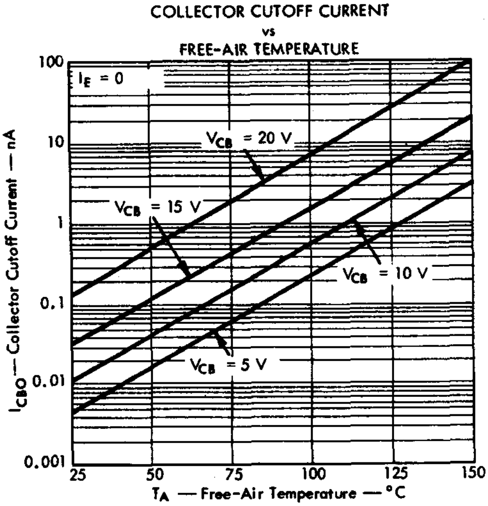

FIGURE 6

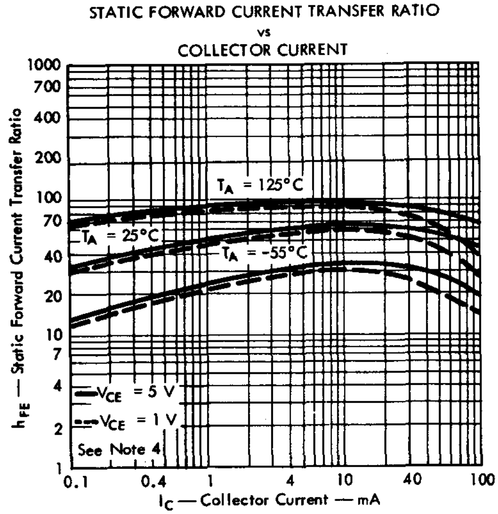

FIGURE 7

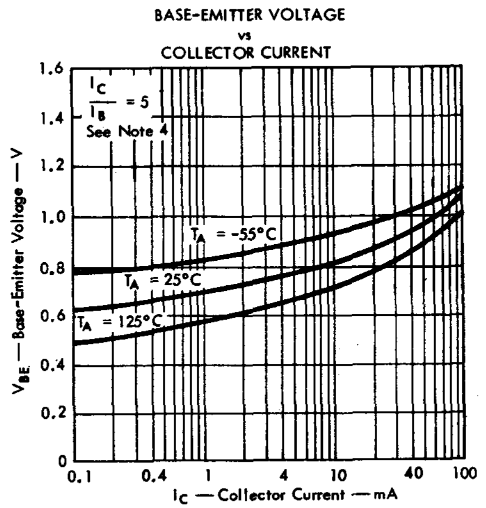

FIGURE 8

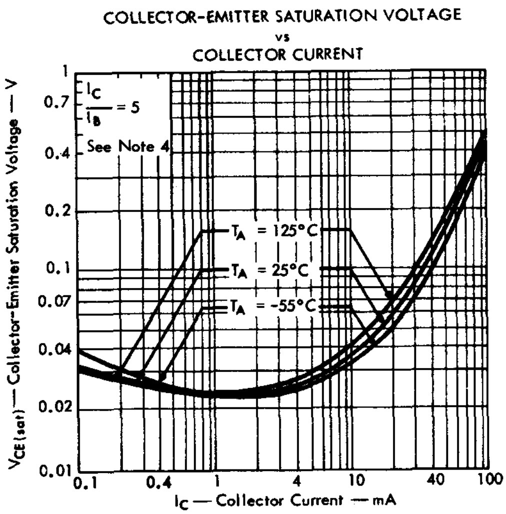

FIGURE 9

NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

4

TYPICAL CHARACTERISTICS

SMALL-SIGNAL COMMON-EMITTER INPUT IMPEDANCE
vs
COLLECTOR CURRENT

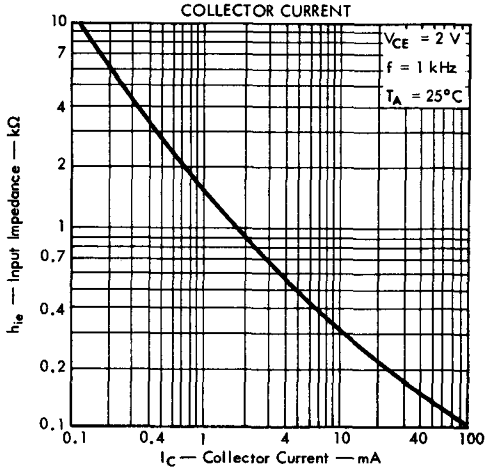

FIGURE 10

SMALL-SIGNAL COMMON-EMITTER
FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

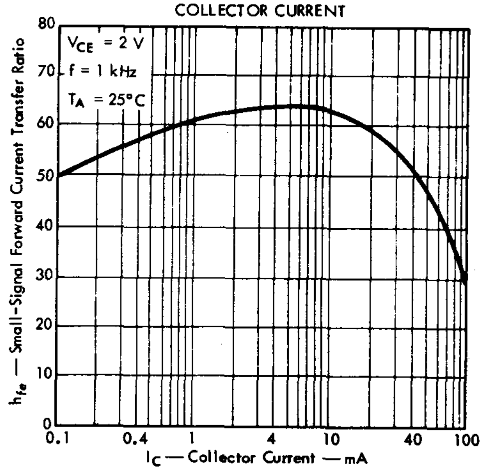

FIGURE 11

SMALL-SIGNAL COMMON-EMITTER
REVERSE VOLTAGE TRANSFER RATIO
vs
COLLECTOR CURRENT

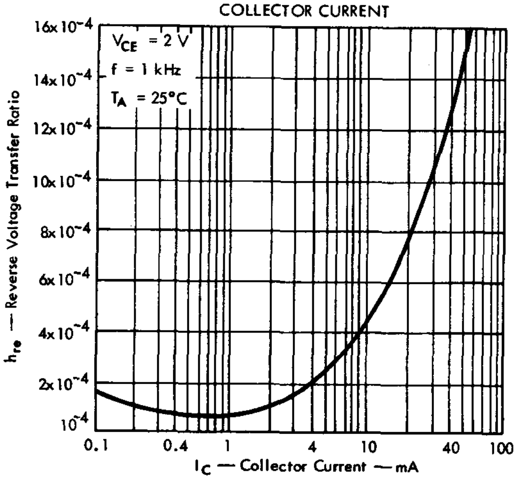

FIGURE 12

SMALL-SIGNAL COMMON-EMITTER
OUTPUT ADMITTANCE
vs
COLLECTOR CURRENT

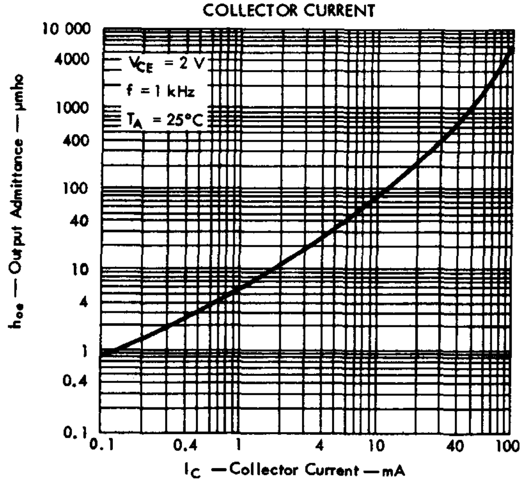

FIGURE 13

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TYPICAL CHARACTERISTICS

CONTOURS OF CONSTANT TRANSISTION FREQUENCY, f_T

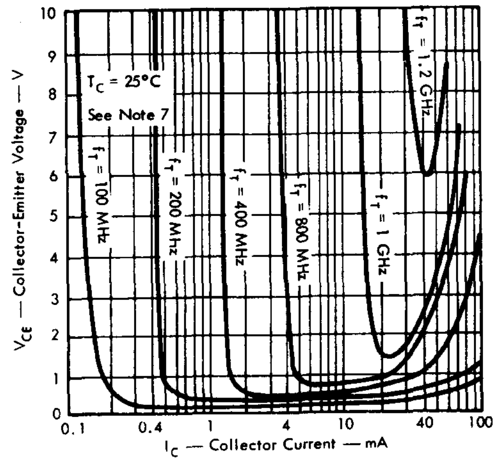

FIGURE 14

COMMON-BASE OPEN-CIRCUIT OUTPUT CAPACITANCE AND COLLECTOR-BASE CAPACITANCE vs COLLECTOR-BASE VOLTAGE

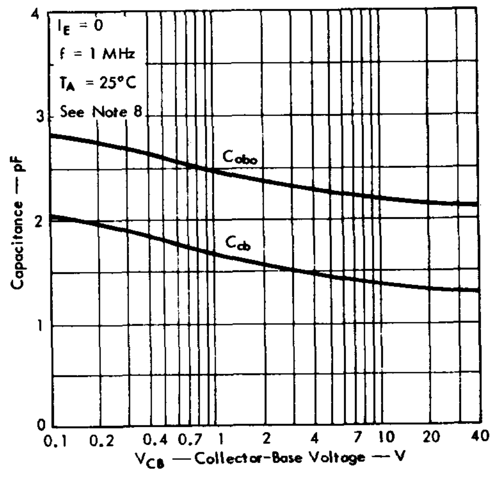

FIGURE 15

COMMON-BASE OPEN-CIRCUIT INPUT CAPACITANCE AND EMITTER-BASE CAPACITANCE vs EMITTER-BASE VOLTAGE

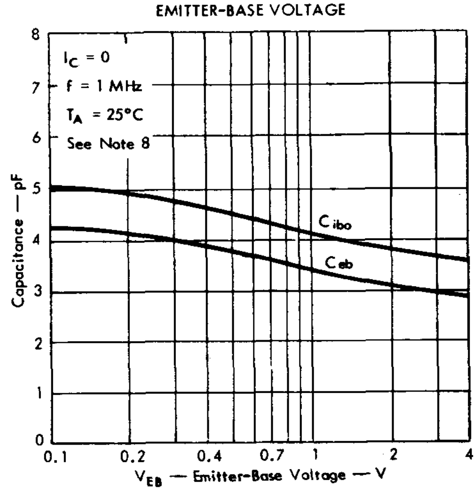

FIGURE 16

NOTES: 7. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

8. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} are measured with the third electrode floating.

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BULLETIN NO. DL-S 7211749, JUNE 1972

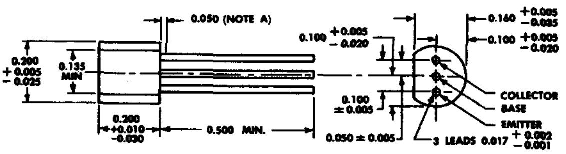
SILECT† TRANSISTORS‡
FOR GENERAL PURPOSE, HIGH-VOLTAGE AMPLIFIER APPLICATIONS

- 120 V or 150 V Min $V_{(BR)CEO}$
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5400, 2N5401

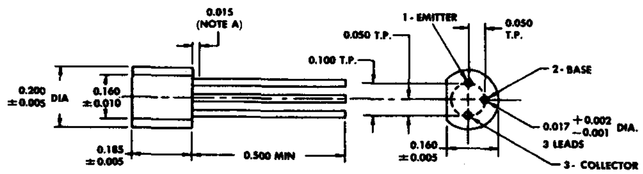


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5400, A5T5401



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N5400 A5T5400	2N5401 A5T5401
Collector-Base Voltage	−130 V*	−160 V*
Collector-Emitter Voltage (See Note 1)	−120 V*	−150 V*
Emitter-Base Voltage	−5 V*	−5 V*
Continuous Collector Current	←600 mA*→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←625 mW§ / 310 mW*→	
Storage Temperature Range	−65°C to 150°C§ / −55°C to 135°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←260°C§ / 230°C*→	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate the 625-mW ratings linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.81 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5400 and 2N5401 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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TEXAS INSTRUMENTS
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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			2N5400 A5T5400 MIN	MAX	2N5401 A5T5401 MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$,	$I_E = 0$		−130		−160		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA,	$I_B = 0$,	See Note 3	−120		−150		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -100$ V,	$I_E = 0$			−100			nA
		$V_{CB} = -100$ V,	$I_E = 0$,	$T_A = 100°C$		−100			μA
		$V_{CB} = -120$ V,	$I_E = 0$					−50	nA
		$V_{CB} = -120$ V,	$I_E = 0$,	$T_A = 100°C$				−50	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V,	$I_C = 0$			−50		−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V,	$I_C = -1$ mA	See Note 3	30		50		
		$V_{CE} = -5$ V,	$I_C = -10$ mA		40	180	60	240	
		$V_{CE} = -5$ V,	$I_C = -50$ mA		40		50		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA,	$I_C = -10$ mA	See Note 3		−1		−1	V
		$I_B = -5$ mA,	$I_C = -50$ mA			−1		−1	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA,	$I_C = -10$ mA	See Note 3		−0.2		−0.2	V
		$I_B = -5$ mA,	$I_C = -50$ mA			−0.5		−0.5	
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -1$ mA,	f = 1 kHz	30	200	40	200	
f_T	Transition Frequency	$V_{CE} = -10$ V,	$I_C = -10$ mA,	See Note 4	100	400	100	300	MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V,	$I_E = 0$,	f = 1 MHz		6		6	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N5400 A5T5400 MIN	MAX	2N5401 A5T5401 MIN	MAX	UNIT
$\bar{F}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -250\ \mu A$, $R_G = 1$ kΩ, Noise bandwidth = 15.7 kHz, See Note 5		8		8	dB

NOTES: 3. These parameters must be measured using pulse techniques, $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. To obtain f_T, the $|h_{fe}|$ response is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.
5. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*The asterisk indientifies JEDEC registered data for the 2N5400 and 2N5401 only.

4

BULLETIN NO. DL-S 7311970, MARCH 1973

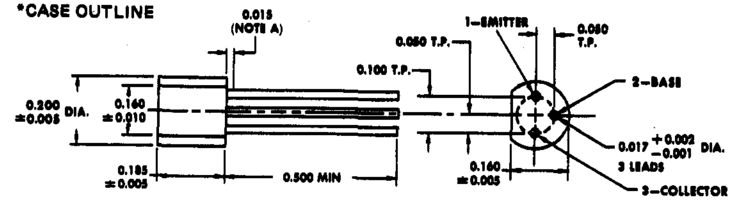
SILECT† TRANSISTORS‡

- For Medium-Power Amplifiers, Class B Audio Outputs, Hi-Fi Drivers
- Also Available in TO-92 Versions . . . 2N3702, 2N3703
- For Complementary Use with 2N5449, 2N5450, and 2N5451

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting *MIL-STD-202C, Method 106B. The transistors are insensitive to light.*

*CASE OUTLINE



A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N5447	2N5448
Collector-Base Voltage	−40 V*	−50 V*
Collector-Emitter Voltage (See Note 1)	−25 V*	−30 V*
Emitter-Base Voltage	−5 V*	−5 V*
Continuous Collector Current	←—200 mA*—→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←{625 mW§ / 360 mW*}→	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	←{1.25 W§ / 500 mW*}→	
Storage Temperature Range	−65°C to 150°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←—260°C*—→	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 360-mW (JEDEC registered) rating linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.
3. Derate the 1.25-W rating linearly to 150°C lead temperature at the rate of 10 mW/°C. Derate the 500-mW (JEDEC registered) rating linearly to 150°C lead temperature at the rate of 4 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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TEXAS INSTRUMENTS
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*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N5447 MIN	2N5447 MAX	2N5448 MIN	2N5448 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−40		−50		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 4	−25		−30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−5		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -20$ V, $I_E = 0$		−100		−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$		−100		−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -50$ mA, See Note 4	60	300	30	150	
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -50$ mA, See Note 4	−0.6	−1	−0.6	−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -5$ mA, $I_C = -50$ mA, See Note 4		−0.25		−0.25	V
f_T	Transition Frequency	$V_{CE} = -5$ V, $I_C = -50$ mA, See Note 5	100		100		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -10$ V, $I_E = 0$, $f = 1$ MHz, See Note 6		12		12	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
6. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*JEDEC registered data

4

THERMAL INFORMATION

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

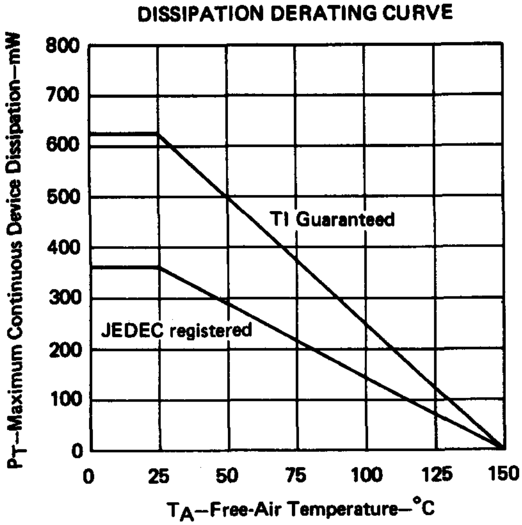


FIGURE 1

LEAD TEMPERATURE
DISSIPATION DERATING CURVE

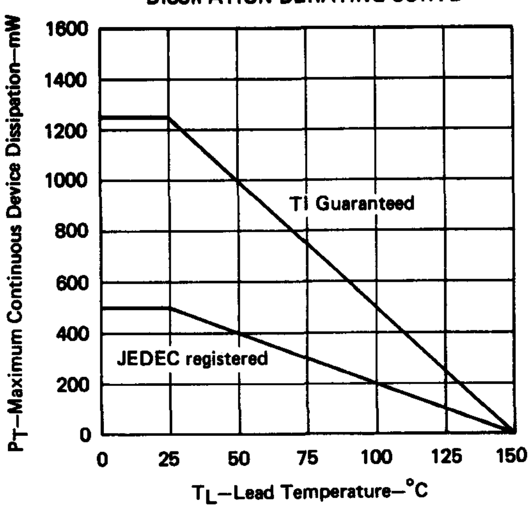


FIGURE 2

TYPES 2N5449, 2N5450, 2N5451
N-P-N SILICON TRANSISTORS

BULLETIN NO. DL-S 7311969, MARCH 1973

SILECT† TRANSISTORS‡

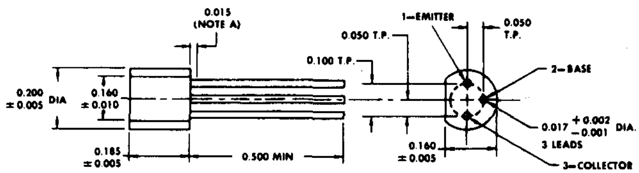
- For Medium-Power Amplifiers, Class B Audio Outputs, Hi-Fi Drivers
- Also Available in TO-92 Versions . . . 2N3704 thru 2N3706
- For Complementary Use with 2N5447 and 2N5448

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

4

*CASE OUTLINE



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N5449 2N5450	2N5451
Collector-Base Voltage	50 V*	40 V*
Collector-Emitter Voltage (See Note 1)	30 V*	20 V*
Emitter-Base Voltage	5 V*	5 V*
Continuous Collector Current	← 800 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← {625 mW§, 360 mW*} →	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	← {1.25 W§, 500 mW*} →	
Storage Temperature Range	−65°C to 150°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 260°C* →	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 360-mW (JEDEC registered) rating linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.
3. Derate the 1.25-W rating linearly to 150°C lead temperature at the rate of 10 mW/°C. Derate the 500-mW (JEDEC registered) rating linearly to 150°C lead temperature at the rate of 4 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

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***electrical characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	2N5449 MIN	2N5449 MAX	2N5450 MIN	2N5450 MAX	2N5451 MIN	2N5451 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	50		50		40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 4	30		30		20		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	5		5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20$ V, $I_E = 0$		100		100		100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V, $I_C = 0$		100		100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V, $I_C = 50$ mA, See Note 4	100	300	50	150	30	600	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 2$ V, $I_C = 100$ mA, See Note 4	0.5	1	0.5	1	0.5	1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ mA, $I_C = 100$ mA, See Note 4		0.6		0.8		1	V
f_T	Transition Frequency	$V_{CE} = 2$ V, $I_C = 50$ mA, See Note 5	100		100		100		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz, See Note 6		12		12		12	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 20 MHz to the frequency at which $|h_{fe}| = 1$.
6. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

*JEDEC registered data

4

TYPICAL CHARACTERISTICS

2N5450
STATIC FORWARD CURRENT TRANSFER RATIO vs COLLECTOR CURRENT

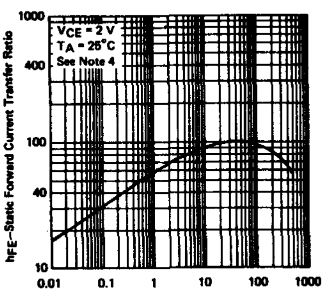

FIGURE 1

BASE-EMITTER VOLTAGE vs COLLECTOR CURRENT

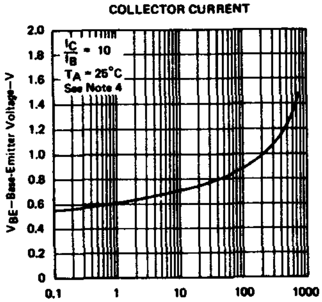

FIGURE 2

COLLECTOR-EMITTER SATURATION VOLTAGE vs COLLECTOR CURRENT

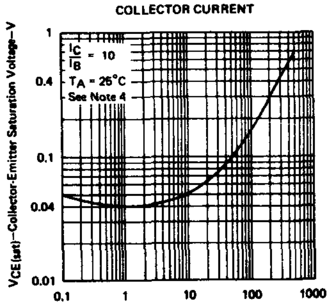

FIGURE 3

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TYPES 2N5460, 2N5461, 2N5462, A5T5460, A5T5461, A5T5462
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7111466, JULY 1971

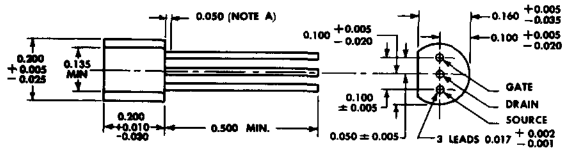
SILECT† FIELD-EFFECT TRANSISTORS ‡
FOR INDUSTRIAL AND CONSUMER SMALL-SIGNAL APPLICATIONS

- **Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5460, 2N5461, 2N5462

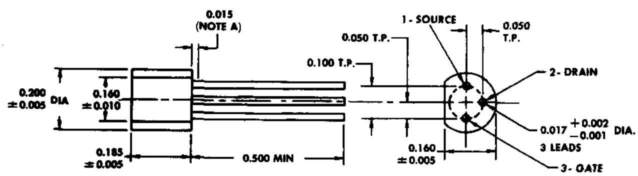


SDG

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5460, A5T5461, A5T5462



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum diameter package.
C. All dimensions are in inches.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	−40 V
Reverse Gate-Source Voltage	40 V
Continuous Forward Gate Current	−10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	310 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	240°C

NOTE 1: Derate linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5460, 2N5461, and 2N5462 only. This data sheet contains all applicable registered data in effect at the time of publication.

†Trademark of Texas Instruments

‡U. S. Patent No. 3,439,238

USES CHIP JP71

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N5460 A5T5460 MIN	MAX	2N5461 A5T5461 MIN	MAX	2N5462 A5T5462 MIN	MAX	UNIT
*$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 10\ \mu A$, $V_{DS} = 0$	40		40		40		V
*I_{GSS}	Gate Reverse Current	$V_{GS} = 20\ V$, $V_{DS} = 0$		5		5		5	nA
		$V_{GS} = 20\ V$, $V_{DS} = 0$, $T_A = 100°C$		1		1		1	μA
*$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = -15\ V$, $I_D = -1\ \mu A$	0.75	6	1	7.5	1.8	9	V
*V_{GS}	Gate-Source Voltage	$V_{DS} = -15\ V$, $I_D = -100\ \mu A$	0.5	4					V
		$V_{DS} = -15\ V$, $I_D = -200\ \mu A$			0.8	4.5			
		$V_{DS} = -15\ V$, $I_D = -400\ \mu A$					1.5	6	
*I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15\ V$, $V_{GS} = 0$, See Note 2	−1	−5	−2	−9	−4	−16	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, $f = 1\ kHz$		2		0.8		0.4	kΩ
*$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15\ V$, $V_{GS} = 0$, $f = 1\ kHz$	1	4	1.5	5	2	6	mmho
*$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = -15\ V$, $V_{GS} = 0$, $f = 1\ kHz$		75		75		75	μmho
*C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15\ V$, $V_{GS} = 0$, $f = 1\ MHz$		7		7		7	pF
*C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = -15\ V$, $V_{GS} = 0$, $f = 1\ MHz$		2		2		2	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N5460 A5T5460 MIN	MAX	2N5461 A5T5461 MIN	MAX	2N5462 A5T5462 MIN	MAX	UNIT
F	Spot Noise Figure	$V_{DS} = -15\ V$, $V_{GS} = 0$, $R_G = 1\ M\Omega$, $f = 100\ Hz$, $BW = 1\ Hz$		2.5		2.5		2.5	dB
V_n	Equivalent Input Noise Voltage	$V_{DS} = -15\ V$, $V_{GS} = 0$, $f = 100\ Hz$, $BW = 1\ Hz$		115		115		115	$nV/\sqrt{Hz}$

NOTE 2: This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

*The asterisk indicates JEDEC registered data for the 2N5460, 2N5461, and 2N5462 only.

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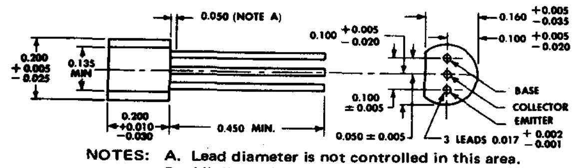
BULLETIN NO. DL-S 7211553, JANUARY 1972

SILECT† TRANSISTORS‡
TWO N-P-N TRIODES INTERNALLY CONNECTED IN DARLINGTON CONFIGURATION

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

***CASE OUTLINE**



NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

ECB

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	40 V
Collector-Emitter Voltage (See Note 1)	30 V
Emitter-Base Voltage	9 V
Continuous Collector Current	200 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

*electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N5525 MIN	2N5525 MAX	2N5526 MIN	2N5526 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	40		40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 4	30		30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	9		9		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20$ V, $I_E = 0$		100		100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 4	5000		1000		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 100$ mA, See Note 4	0.9	1.8	0.9	1.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ mA, $I_C = 50$ mA, See Note 4		1		1	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 10$ mA, $f = 1$ kHz	5000		1000		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 20$ mA, $f = 100$ MHz	2		2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz		10		10	pF

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 4 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.
4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U.S. Patent No. 3,439,238.

USES TWO N21 CHIPS

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

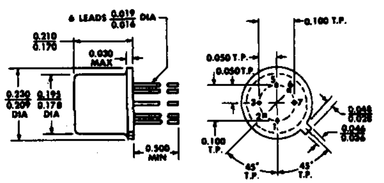
TYPES 2N5545, 2N5546, 2N5547
DUAL N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7311696, MARCH 1972–REVISED MARCH 1973

MATCHED FIELD-EFFECT TRANSISTORS

- High $|y_{fs}|/C_{iss}$ Ratio (High-Frequency Figure-of-Merit)
- Low Input Capacitance C_{iss} . . . 6 pF Max
- Low Gate-Current Differential . . . 5 nA Max at T_A = 125°C
- Recommended for Low-Level D-C Amplifiers, Sample-Hold Circuits, and Series-Shunt Choppers
- Improved Matching and Tracking Characteristics

*mechanical data



1. SOURCE 1
2. DRAIN 1
3. GATE 1
5. SOURCE 2
6. DRAIN 2
7. GATE 2

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE

ALL JEDEC TO-71 DIMENSIONS AND NOTES ARE APPLICABLE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Drain-Gate Voltage	50 V	
Reverse Gate-Source Voltage	−50 V	
Continuous Forward Gate Current	30 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	250 mW	400 mW
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from case for 10 Seconds	←300°C→	

NOTE 1: Derate linearly to 175°C free-air temperature at the rates of 1.67 mW/°C for each triode and 2.67 mW/°C for the total device.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN51

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 2N5545, 2N5546, 2N5547
DUAL N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 2)

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
I_{GSS}	Gate Reverse Current	$V_{GS} = -50$ V,	$V_{DS} = 0$			−1	μA
		$V_{GS} = -30$ V,	$V_{DS} = 0$			−0.1	nA
		$V_{GS} = -30$ V,	$V_{DS} = 0$,	$T_A = 150°C$		−150	nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V,	$I_D = 0.5$ nA		−0.5	−4.5	V
I_G	Gate Current	$V_{DG} = 15$ V,	$I_D = 200$ μA			−50	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$		0.5	8	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 kHz	1.5	6	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 kHz		25	μmho
C_{iss}	Small-Signal Common-Source Input Capacitance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 MHz		6	pF
C_{rss}	Small-Signal Common-Source Reverse Transfer Capacitance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 MHz		2	pF
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 100 MHz	1.5		mmho

triode matching characteristics

PARAMETER		TEST CONDITIONS	2N5545 MIN	2N5545 MAX	2N5546 MIN	2N5546 MAX	2N5547 MIN	2N5547 MAX	UNIT
$\|I_{G1}-I_{G2}\|$	Gate-Current Differential	$V_{DG} = 15$ V, $I_D = 200$ μA, $T_A = 125°C$		5		5		5	nA
$\|V_{GS1}-V_{GS2}\|$	Gate-Source-Voltage Differential	$V_{DG} = 15$ V, $I_D = 50$ μA		5		10		15	mV
		$V_{DG} = 15$ V, $I_D = 200$ μA		5		10		15	mV
$\|\Delta(V_{GS1}-V_{GS2})/\Delta T_A\|$	Gate-Source-Voltage-Differential Change with Temperature	$V_{DG} = 15$ V, $I_D = 200$ μA, $T_{A(1)} = 25°C$, $T_{A(2)} = -55°C$		0.8		1.6		3.2	mV
		$V_{DG} = 15$ V, $I_D = 200$ μA, $T_{A(1)} = 25°C$, $T_{A(2)} = 125°C$		1		2		4	mV
$\frac{I_{DSS1}}{I_{DSS2}}$	Zero-Gate-Voltage Drain Current Ratio	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	0.95	1	0.9	1	0.9	1	
$\frac{\|y_{fs}\|_1}{\|y_{fs}\|_2}$	Small-Signal Common-Source Forward Transfer Admittance Ratio	$V_{DG} = 15$ V, $I_D = 200$ μA, f = 1 kHz, See Note 3	0.97	1	0.95	1	0.9	1	
$\|y_{os}\|_1-\|y_{os}\|_2$	Small-Signal Common-Source Output Admittance Differential	$V_{DG} = 15$ V, $I_D = 200$ μA, f = 1 kHz, See Note 3		1		2		3	μmho

*operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 2)

PARAMETER		TEST CONDITIONS	2N5545 MAX	2N5546 MAX	UNIT
F	Spot Noise Figure	$V_{DG} = 15$ V, $I_D = 200$ μA, f = 10 Hz, $R_G = 1$ MΩ, Noise Bandwidth = 5 Hz	3.5	5	dB
V_n	Equivalent Input Noise Voltage	$V_{DG} = 15$ V, $I_D = 200$ μA, f = 10 Hz, Noise Bandwidth = 5 Hz	180	200	nV/$\sqrt{Hz}$

NOTES: 2. The terminals of the triode not under test are grounded for the measurement of these characteristics.
3. The lower of the two characteristic readings is taken as the numerator or subtrahend.

*JEDEC registered data

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE 2N5549
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

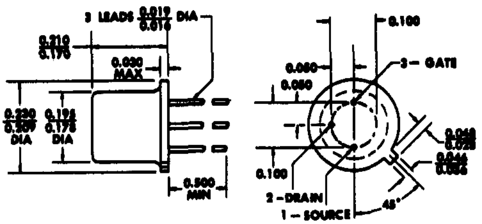
BULLETIN NO. DL-S 7011124, JUNE 1970

FOR LOW-LEVEL CHOPPERS, LOGIC SWITCHES, MULTIPLEXERS, AND RF AND VHF AMPLIFIERS

- High $|y_{fs}|/C_{iss}$ Ratio (High-Frequency Figure-of-Merit)
- Low Feedback Capacitance C_{rss} . . . 2 pF Max
- Low On-State Resistance $r_{ds(on)}$ . . . 100 Ω Max

*mechanical data

THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	40 V
Reverse Gate-Source Voltage	−40 V
Continuous Forward Gate Current	25 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTE 1: Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN52

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE 2N5549
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTOR

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−40		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−0.25	nA
		$V_{GS} = -20$ V, $V_{DS} = 0$, $T_A = 150°C$		−0.5	μA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 15$ V, $V_{GS} = -10$ V		0.25	nA
		$V_{DS} = 15$ V, $V_{GS} = -10$ V, $T_A = 150°C$		0.5	μA
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 1$ nA	−2	−6	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2	10	60	mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$I_D = 5$ mA, $V_{GS} = 0$		0.75	V
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, f = 1 kHz		100	Ω
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 2	6	15	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 0$, $V_{GS} = -10$ V, f = 1 MHz		8	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			2	pF

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NOTE 2: These parameters must be measured using pulse techniques. $t_w \approx 100$ ms, duty cycle ≤ 10%.

*JEDEC registered data

THERMAL INFORMATION

DISSIPATION DERATING CURVE

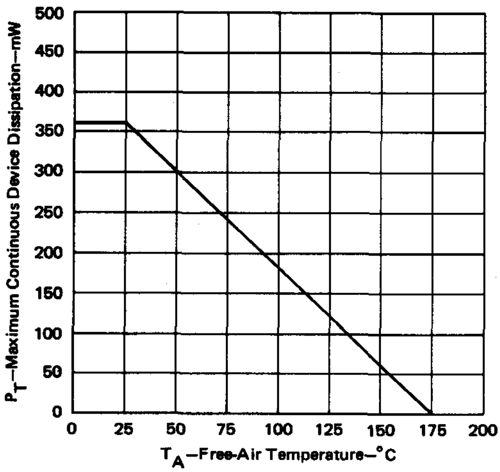


FIGURE 1

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311935, MARCH 1973

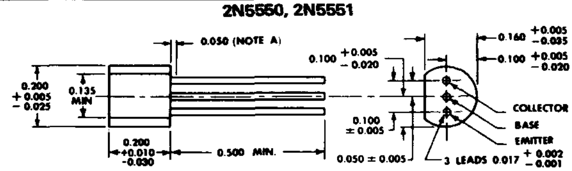
SILECT† TRANSISTORS‡
FOR GENERAL PURPOSE, HIGH-VOLTAGE AMPLIFIER APPLICATIONS

- High $V_{(BR)CEO}$ . . . 140 V (2N5550, A5T5550) or 160 V (2N5551, A5T5551)
- Suitable for Controlling Gas-Discharge Indicator Tubes and Other High-Voltage Applications
- Rugged One-Piece Construction with In-Line Leads or Standard TO-18 100-mil Pin-Circle Configuration

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

2N5550, 2N5551

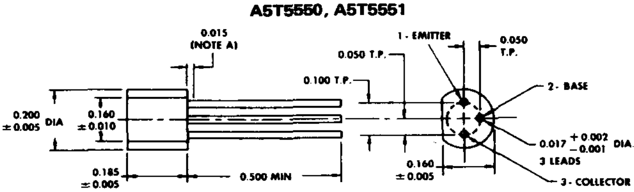


EBC

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

*ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

A5T5550, A5T5551



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N5550 A5T5550	2N5551 A5T5551
Collector-Base Voltage	160 V*	180 V*
Collector-Emitter Voltage (See Note 1)	140 V*	160 V*
Emitter-Base Voltage	6 V*	6 V*
Continuous Collector Current	600 mA*	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW§ / 310 mW*	
Storage Temperature Range	−65°C to 150°C§ / −55°C to 135°C*	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C§ / 230°C*	

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. Derate the 625-mW rating linearly to 150°C free-air temperature at the rate of 5 mW/°C. Derate the 310-mW (JEDEC registered) rating linearly to 135°C free-air temperature at the rate of 2.82 mW/°C.

*The asterisk identifies JEDEC registered data for the 2N5550 and 2N5551 only. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238
§Texas Instruments guarantees these values in addition to the JEDEC registered values which are also shown.

USES CHIP N27

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N5550 A5T5550 MIN	2N5550 A5T5550 MAX	2N5551 A5T5551 MIN	2N5551 A5T5551 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	160		180		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA, $I_B = 0$, See Note 3	140		160		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 100$ V, $I_E = 0$		100			nA
		$V_{CB} = 120$ V, $I_E = 0$				50	nA
		$V_{CB} = 100$ V, $I_E = 0$, $T_A = 100°C$		100			μA
		$V_{CB} = 120$ V, $I_E = 0$, $T_A = 100°C$				50	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ V, $I_C = 0$		50		50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ mA	60		80		
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 3	60	250	80	250	
		$V_{CE} = 5$ V, $I_C = 50$ mA, See Note 3	20		30		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA, $I_C = 10$ mA, See Note 3		1		1	V
		$I_B = 5$ mA, $I_C = 50$ mA, See Note 3		1.2		1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA, See Note 3		0.15		0.15	V
		$I_B = 5$ mA, $I_C = 50$ mA, See Note 3		0.25		0.2	V
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA, $f = 1$ kHz	50	200	50	200	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 10$ mA, $f = 100$ MHz	1	3	1	3	
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz		6		6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 1$ MHz		30		20	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	2N5550 A5T5550 MIN	2N5550 A5T5550 MAX	2N5551 A5T5551 MIN	2N5551 A5T5551 MAX	UNIT
$\overline{F}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 250\ \mu A$, $R_G = 1\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 4		10		8	dB

NOTES: 3. *These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.*
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

*JEDEC registered data

4

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

4

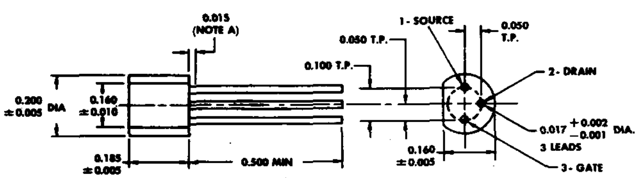
SILECT† FIELD-EFFECT TRANSISTORS‡

- Narrow I_{DSS} and $V_{GS(off)}$ Ranges
- For Low-Noise Audio-Frequency Amplifier Applications
- For RF Amplifier Applications Thru 100 MHz
- Low $r_{ds(on)}$ for Chopper and Switching Applications

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C Method 106B. The transistors are insensitive to light.

***CASE OUTLINE**



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum diameter package.
C. All dimensions are in inches.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	30 V
Reverse Gate-Source Voltage	−30 V
Continuous Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 2)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.
2. Derate linearly to 150°C lead temperature at the rate of 4 mW/°C. Lead temperature is measured on the gate lead 1/16 inch from the case.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.
†Trademark of Texas Instruments.
‡U. S. Patent No. 3,439,238

USES CHIP JN51

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N5949 MIN	2N5949 MAX	2N5950 MIN	2N5950 MAX	2N5951 MIN	2N5951 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−30		−30		−30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -15$ V, $V_{DS} = 0$		−1		−1		−1	nA
		$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$		−200		−200		−200	
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 100$ nA	−3	−7	−2.5	−6	−2	−5	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 1.2$ mA	−2.25	−6					V
		$V_{DS} = 15$ V, $I_D = 1$ mA			−1.8	−5			
		$V_{DS} = 15$ V, $I_D = 0.7$ mA					−1.3	−4.5	
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	12	18	10	15	7	13	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, f = 1 kHz		200		210		250	Ω
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 4	3.5	7.5	3.5	7.5	3.5	6.5	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			75		75		75	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 4		6		6		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			2		2		2	pF
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz, See Note 4		250		250		250	μmho
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance		3	7.5	3	7.5	3	6.5	mmho
g_{os}	Small-Signal Common-Source Output Conductance			150		125		100	μmho

PARAMETER		TEST CONDITIONS	2N5952 MIN	2N5952 MAX	2N5953 MIN	2N5953 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−30		−30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -15$ V, $V_{DS} = 0$		−1		−1	nA
		$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$		−200		−200	
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 100$ nA	−1.3	−3.5	−0.8	−3	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 0.4$ mA	−0.75	−3			V
		$V_{DS} = 15$ V, $I_D = 0.25$ mA			−0.5	−2.5	
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	4	8	2.5	5	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, f = 1 kHz		300		375	Ω
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 4	2	6.5	2	6.5	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			50		50	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 4		6		6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			2		2	pF
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz, See Note 4		250		250	μmho
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance		1	6.5	1	6.5	mmho
g_{os}	Small-Signal Common-Source Output Conductance			75		50	μmho

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	ALL TYPES MIN	ALL TYPES MAX	UNIT
F	Common-Source Spot Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz, $R_G = 1$ kΩ, See Note 4		5	dB
		$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, $R_G = 1$ MΩ, See Note 4		2	
V_n	Equivalent Input Noise Voltage	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 4		100	$nV/\sqrt{Hz}$

NOTES: 3. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. These parameters must be measured with bias conditions applied for less than 5 seconds to avoid overheating.

*JEDEC registered data

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES A7T6027, A7T6028
P-N-P-N SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

BULLETIN NO. DL-S 7311796, JANUARY 1973

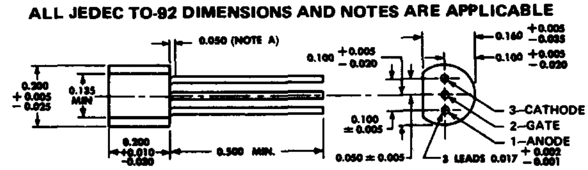
SILECT† TRANSISTORS‡ FOR USE IN PULSE, TIMING, SWEEP, TRIGGER, AND OSCILLATOR CIRCUITS

- Plug-in Replacements for 2N6027, 2N6028 (TO-98 Package)
- Low Peak-Point Current and Low Forward Voltage
- Programmable η, r_{BB}, I_P, and I_V

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

THE GATE IS CONNECTED TO AN N REGION
ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE



AGK

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

4

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Anode-Cathode Voltage	±40 V
Gate-Anode Voltage	40 V
Gate-Cathode Voltage: (Positive Limit)	40 V
(Negative Limit)	−5 V
Continuous Anode Current	150 mA
Repetitive Peak Anode Current: (t_w = 100 μs, Duty Cycle ⩽ 1%)	1 A
(t_w = 20 μs, Duty Cycle ⩽ 1%)	2 A
Nonrepetitive Peak Anode Current: (t_w = 10 μs, Duty Cycle = 0)	5 A
Continuous Gate Current	±50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A7T6027		A7T6028		UNIT
			MIN	MAX	MIN	MAX	
I_{GAO}	Gate Reverse Current	V_{GA} = 40 V, I_K = 0		10		10	nA
		V_{GA} = 40 V, I_K = 0, T_A = 75°C		100		100	
I_{GKS}	Gate Reverse Current	V_{GK} = 40 V, V_{AK} = 0		100		100	nA
V_P-V_S	Offset Voltage	V_S = 10 V, R_G = 10 kΩ	0.2	0.6	0.2	0.6	V
		V_S = 10 V, R_G = 1 MΩ	0.2	1.6	0.2	0.6	
I_P	Peak-Point Current	V_S = 10 V, R_G = 10 kΩ		5		1	μA
		V_S = 10 V, R_G = 1 MΩ		2		0.15	
I_V	Valley-Point Current	V_S = 10 V, R_G = 200 Ω	1500		1000		μA
		V_S = 10 V, R_G = 10 kΩ	70		25		
		V_S = 10 V, R_G = 1 MΩ		50		25	
V_F	Anode-Cathode On-State Voltage	V_S = 10 V, R_G = 10 kΩ, I_F = 50 mA		1.5		1.5	V

NOTE 1: Derate linearly to 125°C free-air temperature at the rate of 3 mW/°C.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A7T6027 MIN	A7T6027 TYP	A7T6027 MAX	A7T6028 MIN	A7T6028 TYP	A7T6028 MAX	UNIT
V_{OM}	Peak Output Voltage	V_{AA} = 20 V, C1 = 0.2 μF,	6			6			V
t_r	Output Pulse Rise Time	See Figure 4		65	80		65	80	ns

PARAMETER MEASUREMENT INFORMATION

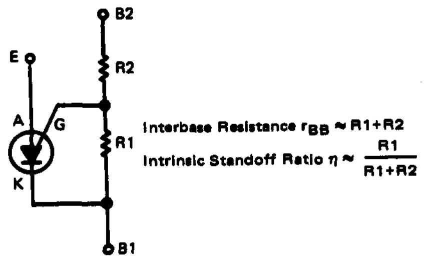


FIGURE 1—PROGRAMMABLE UNIJUNCTION CIRCUIT

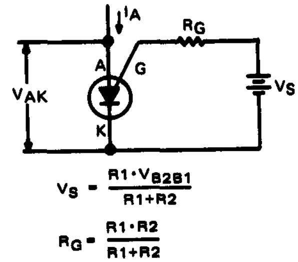


FIGURE 2—EQUIVALENT CIRCUIT USED FOR TESTING

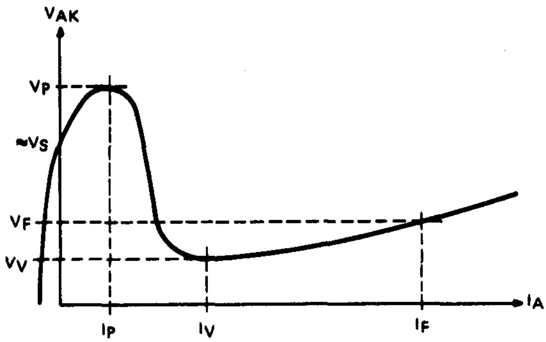
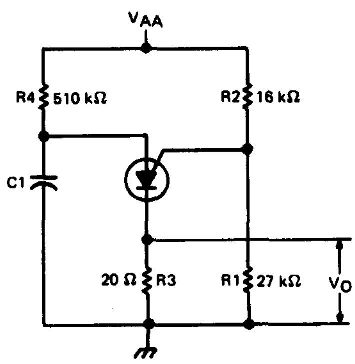
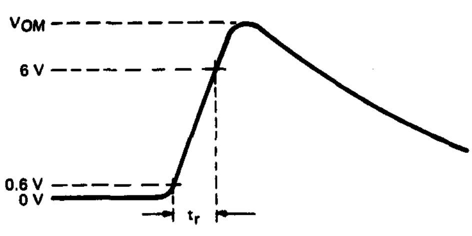


FIGURE 3—GENERAL ANODE CHARACTERISTICS



TEST CIRCUIT



OUTPUT VOLTAGE WAVEFORM

FIGURE 4—TESTING OPERATING CHARACTERISTICS

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

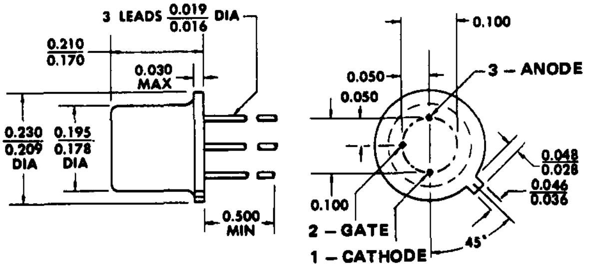
P-N-P-N SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

BULLETIN NO. DL-S 7211776, DECEMBER 1972

- For Use in Pulse, Timing, Sweep, Trigger, and Oscillator Circuits
- Features Low Peak-Point Current and Low Forward Voltage
- Programmable η, r_{BB}, I_P, and I_V

mechanical data

*THE ANODE IS IN ELECTRICAL CONTACT WITH THE CASE
THE GATE IS CONNECTED TO AN N REGION



*ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Anode-Cathode Voltage	±40 V
Gate-Anode Voltage	40 V
Gate-Cathode Voltage: (Positive Limit)	40 V
(Negative Limit)	−5 V
Continuous Anode Current at (or below) 25°C Free-Air Temperature (See Note 1)	200 mA
Repetitive Peak Anode Current: (t_w = 100 μs, Duty Cycle < 1%)	1 A
(t_w = 20 μs, Duty Cycle < 1%)	2 A
Nonrepetitive Peak Anode Current: (t_w = 10 μs, Duty Cycle = 0)	5 A
Continuous Gate Current	±20 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N6116		2N6117		2N6118		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{GAO}	Gate Reverse Current	V_{GA} = 40 V, I_K = 0		5		5		5	nA
		V_{GA} = 40 V, I_K = 0, T_A = 75°C		75		75		75	
I_{GKS}	Gate Reverse Current	V_{GK} = 40 V, V_{AK} = 0		50		50		50	nA
V_P–V_S	Offset Voltage	V_S = 10 V, R_G = 10 kΩ	0.2	0.6	0.2	0.6	0.2	0.6	V
		V_S = 10 V, R_G = 1 MΩ	0.2	1.6	0.2	0.6	0.2	0.6	
I_P	Peak-Point Current	V_S = 10 V, R_G = 10 kΩ		5		2		1	μA
		V_S = 10 V, R_G = 1 MΩ		2		0.3		0.15	
I_V	Valley-Point Current	V_S = 10 V, R_G = 10 kΩ	70		50		50		μA
		V_S = 10 V, R_G = 1 MΩ		50		50		25	
V_F	Anode-Cathode On-State Voltage	V_S = 10 V, R_G = 10 kΩ, I_F = 50 mA		1.5		1.5		1.5	V

NOTES: 1. Derate linearly to 125°C free-air temperature at the rate of 2 mA/°C.
2. Derate linearly to 125°C free-air temperature at the rate of 2.5 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP U41

TYPES 2N6116, 2N6117, 2N6118
P-N-P-N SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

***operating characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	2N6116		2N6117		2N6118		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
V_{OM}	Peak Output Voltage	V_{AA} = 20 V, C1 = 0.2 μF,	6		6		6		V
t_r	Output Pulse Rise Time	See Figure 4		80		80		80	ns

*PARAMETER MEASUREMENT INFORMATION

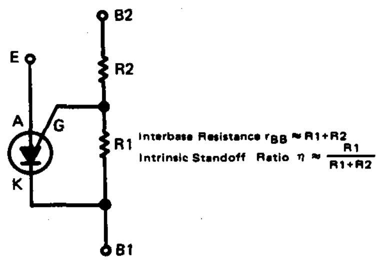


FIGURE 1—PROGRAMMABLE UNIJUNCTION CIRCUIT

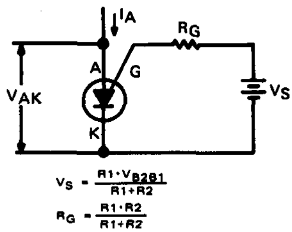


FIGURE 2—EQUIVALENT CIRCUIT USED FOR TESTING

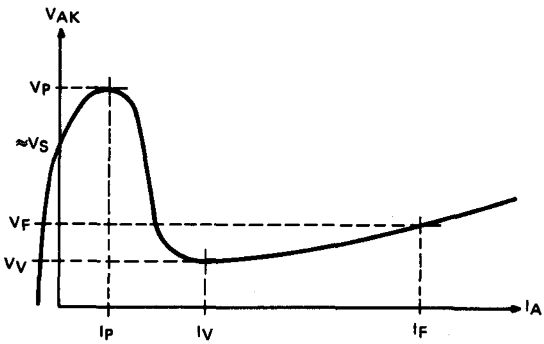
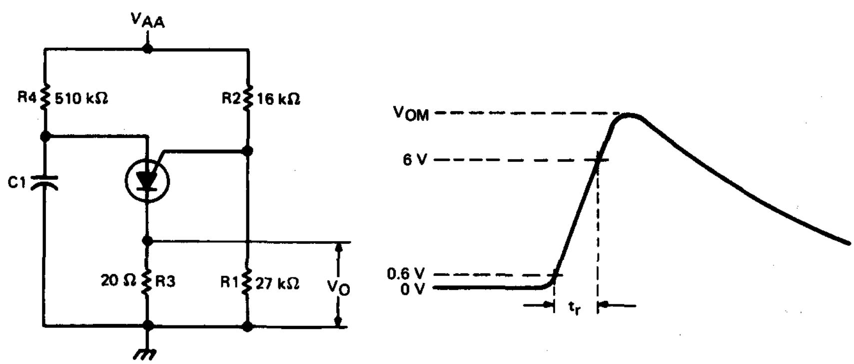


FIGURE 3—GENERAL ANODE CHARACTERISTICS



TEST CIRCUIT

OUTPUT VOLTAGE WAVEFORM

FIGURE 4—TESTING OPERATING CHARACTERISTICS

*JEDEC registered data

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES A5T6116, A5T6117, A5T6118
P-N-P-N SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

BULLETIN NO DL-S 7311984, MARCH 1973

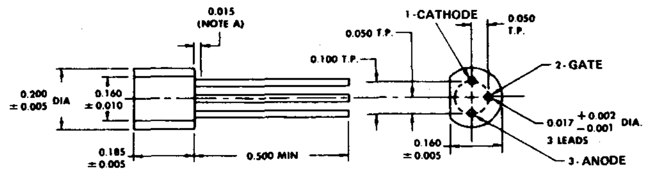
SILECT† TRANSISTORS‡ FOR USE IN PULSE, TIMING, SWEEP, TRIGGER, AND OSCILLATOR CIRCUITS

- **Rugged One-Piece Construction with Standard TO-18 100-mil Pin-Circle Configuration**
- **Low Peak-Point Current and Low Forward Voltage**
- **Programmable η, r_{BB}, I_P, and I_V**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

THE GATE IS CONNECTED TO AN N REGION



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Anode-Cathode Voltage	±40 V
Gate-Anode Voltage	40 V
Gate-Cathode Voltage: (Positive Limit)	40 V
(Negative Limit)	−5 V
Continuous Anode Current	200 mA
Repetitive Peak Anode Current: (t_w = 100 µs, Duty Cycle ≤ 1%)	1 A
(t_w = 20 µs, Duty Cycle ≤ 1%)	2 A
Nonrepetitive Peak Anode Current: (t_w = 10 µs, Duty Cycle = 0)	5 A
Continuous Gate Current	±20 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 60 Seconds	260°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	A5T6116		A5T6117		A5T6118		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
I_{GAO}	Gate Reverse Current	V_{GA} = 40 V, I_K = 0		5		5		5	nA
		V_{GA} = 40 V, I_K = 0, T_A = 75°C		75		75		75	
I_{GKS}	Gate Reverse Current	V_{GK} = 40 V, V_{AK} = 0		50		50		50	nA
$V_P - V_S$	Offset Voltage	V_S = 10 V, R_G = 10 kΩ	0.2	0.6	0.2	0.6	0.2	0.6	V
		V_S = 10 V, R_G = 1 MΩ	0.2	1.6	0.2	0.6	0.2	0.6	
I_P	Peak-Point Current	V_S = 10 V, R_G = 10 kΩ		5		2		1	µA
		V_S = 10 V, R_G = 1 MΩ		2		0.3		0.15	
I_V	Valley-Point Current	V_S = 10 V, R_G = 10 kΩ	70		50		50		µA
		V_S = 10 V, R_G = 1 MΩ		50		50		25	
V_F	Anode-Cathode On-State Voltage	V_S = 10 V, R_G = 10 kΩ, I_F = 50 mA		1.5		1.5		1.5	V

NOTE 1: Derate linearly to 125°C free-air temperature at the rate of 3 mW/°C.
†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP U41

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	A5T6116		A5T6117		A5T6118		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
V_{OM}	Peak Output Voltage	V_{AA} = 20 V, C1 = 0.2 μF,	6		6		6		V
t_r	Output Pulse Rise Time	See Figure 4		80		80		80	ns

PARAMETER MEASUREMENT INFORMATION

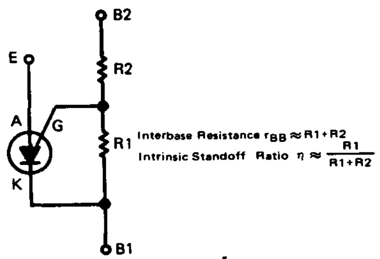


FIGURE 1—PROGRAMMABLE UNIJUNCTION CIRCUIT

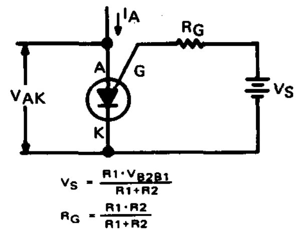


FIGURE 2—EQUIVALENT CIRCUIT USED FOR TESTING

4

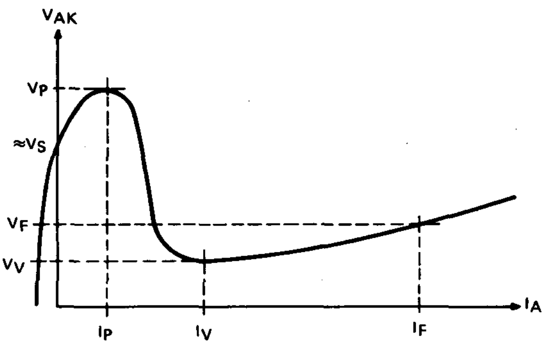
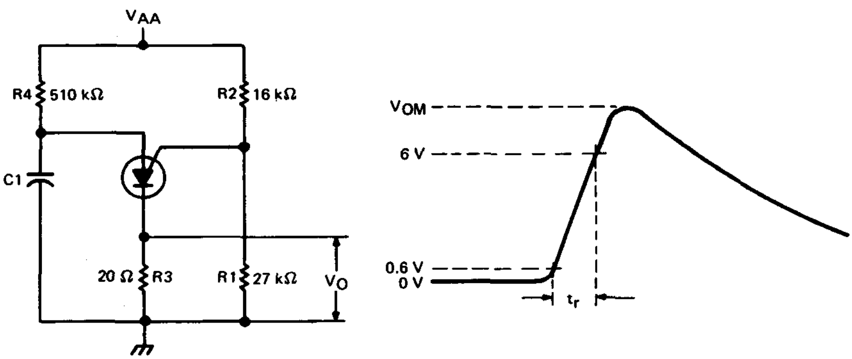


FIGURE 3—GENERAL ANODE CHARACTERISTICS



TEST CIRCUIT

OUTPUT VOLTAGE WAVEFORM

FIGURE 4—TESTING OPERATING CHARACTERISTICS

N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 12003, MAY 1973—REVISED SEPTEMBER 1978

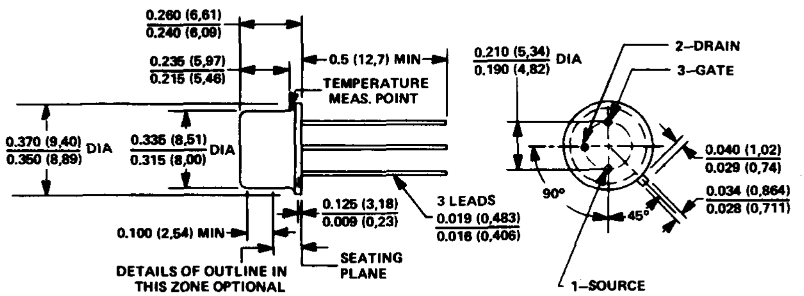
HIGH-VOLTAGE FIELD-EFFECT TRANSISTORS

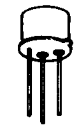
- High $V_{(BR)GSS}$ . . . 300 V Min (2N6449)
- High Dissipation Capability . . . 5 W

4

*mechanical data

THE GATE IS IN ELECTRICAL CONTACT WITH THE CASE





ALL LINEAR DIMENSIONS ARE IN INCHES AND PARENTHETICALLY IN MILLIMETERS. INCH DIMENSIONS GOVERN.

ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N6449	2N6450
Drain-Gate Voltage	300 V	200 V
Reverse Gate-Source Voltage	−300 V	−200 V
Continuous Forward Gate Current	10 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	800 mW	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	5 W	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch (1,6 mm) from Case for 10 Seconds	300°C	

NOTES: 1. Derate linearly to 175°C free-air temperature at the rate of 5.33 mW/°C.
2. Derate linearly to 175°C case temperature at the rate of 33.3 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN54

TEXAS INSTRUMENTS
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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	2N6449 MIN	2N6449 MAX	2N6450 MIN	2N6450 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -10\ \mu A$, $V_{DS} = 0$	−300		−200		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -150$ V, $V_{DS} = 0$		−100			nA
		$V_{GS} = -100$ V, $V_{DS} = 0$				−100	nA
		$V_{GS} = -150$ V, $V_{DS} = 0$, $T_A = 150°C$		−100			μA
		$V_{GS} = -100$ V, $V_{DS} = 0$, $T_A = 150°C$				−100	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 30$ V, $I_D = 4$ nA	−2	−15	−2	−15	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 30$ V, $V_{GS} = 0$, See Note 3	2	10	2	10	mA
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 30$ V, $V_{GS} = 0$, $f = 1$ kHz, See Note 4	0.5	3	0.5	3	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance			100		100	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 30$ V, $V_{GS} = 0$, $f = 1$ MHz, See Note 4		20		20	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			2.5		2.5	pF

NOTES: 3. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. To obtain repeatable results, these parameters must be measured with bias conditions applied for less than 5 seconds.
*JEDEC registered data

THERMAL INFORMATION

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

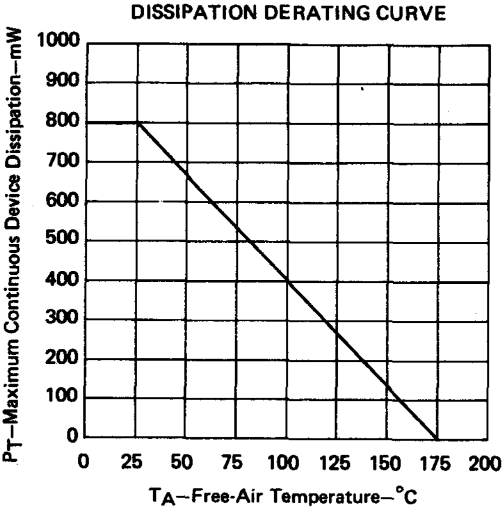


FIGURE 1

CASE TEMPERATURE DISSIPATION DERATING CURVE

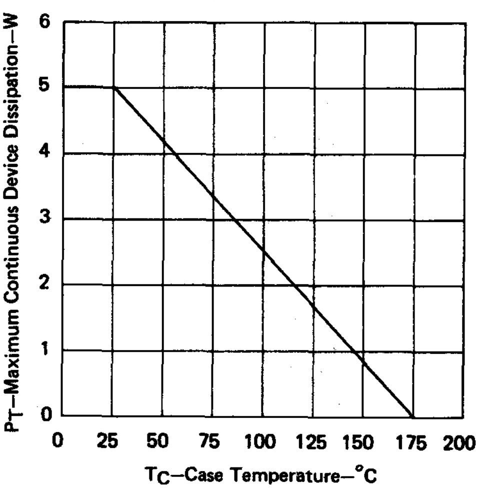


FIGURE 2

PRINTED IN U.S.A. 978

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 225012 • DALLAS, TEXAS 75265

TYPES A5T6449, A5T6450, A8T6449, A8T6450
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

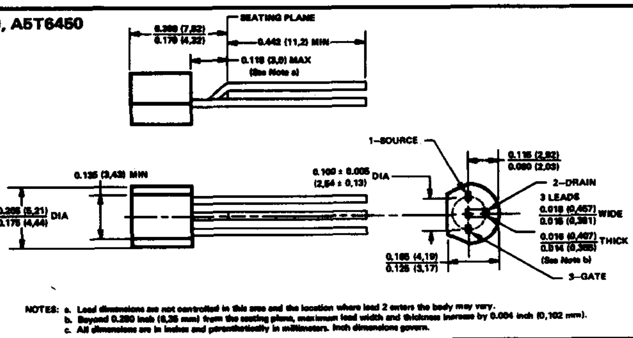
BULLETIN NO. DL-S 12010, MAY 1973—REVISED OCTOBER 1978

SILECT† HIGH-VOLTAGE FIELD-EFFECT TRANSISTORS

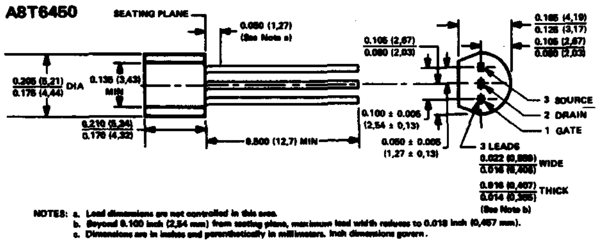
- High $V_{(BR)GSS}$ . . . 300 V Min (A5T6449, A8T6449)
- High Dissipation Capability . . . 1.6 W at 25°C Case Temperature

mechanical data

A5T6449, A5T6450



A8T6449, A8T6450



GDS

ALL JEDEC TO-226AA DIMENSIONS AND NOTES ARE APPLICABLE

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T6449 A8T6449	A5T6450 A8T6450
Drain-Gate Voltage	300 V	200 V
Reverse Gate-Source Voltage	−300 V	−200 V
Continuous Forward Gate Current	10 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	625 mW	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 2)	1.25 W	
Continuous Device Dissipation at (or below) 25°C Case-and-Lead Temperature (See Note 3)	1.6 W	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch (1,6 mm) from Case for 10 Seconds	260°C	

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
2. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.
3. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP **JN54**

4

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	A5T6449 A8T6449 MIN	A5T6449 A8T6449 MAX	A5T6450 A8T6450 MIN	A5T6450 A8T6450 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -10\ \mu A$, $V_{DS} = 0$	−300		−200		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -150$ V, $V_{DS} = 0$		−100			nA
		$V_{GS} = -100$ V, $V_{DS} = 0$				−100	nA
		$V_{GS} = -150$ V, $V_{DS} = 0$, $T_A = 100°C$		−10			µA
		$V_{GS} = -100$ V, $V_{DS} = 0$, $T_A = 100°C$				−10	µA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 30$ V, $I_D = 4$ nA	−2	−15	−2	−15	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 30$ V, $V_{GS} = 0$, See Note 4	2	10	2	10	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 30$ V, $V_{GS} = 0$, $f = 1$ kHz, See Note 5	0.5	3	0.5	3	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance			100		100	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 30$ V, $V_{GS} = 0$, $f = 1$ MHz, See Note 5		20		20	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			2.5		2.5	pF

NOTES: 4. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
5. To obtain repeatable results, these parameters must be measured with bias conditions applied for less than 5 seconds.

4

THERMAL INFORMATION

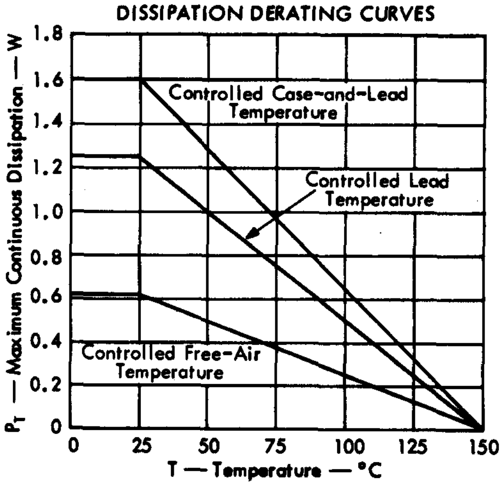


FIGURE 1

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TEXAS INSTRUMENTS
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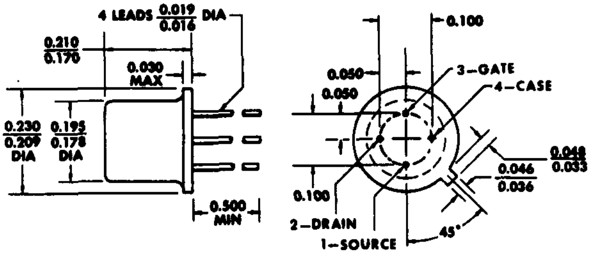
BULLETIN NO. DL-S 7312008, JUNE 1973

DESIGNED FOR LOW-NOISE PREAMPLIFIER APPLICATIONS ESPECIALLY HYDROPHONES, IR SENSORS, AND PARTICLE DETECTORS

- Low V_n . . . 5 nV/$\sqrt{\text{Hz}}$ Max at 10 Hz (2N6451, 2N6453)
- High $|y_{fs}|$ . . . 20 mmho Min (2N6453, 2N6454)
- Low I_{GSS} . . . 100 pA Max (2N6451, 2N6453)

*mechanical data

THE ACTIVE ELEMENTS ARE ELECTRICALLY INSULATED FROM THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

4

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N6451 2N6453	2N6452 2N6454
Drain-Gate Voltage	20 V	25 V
Reverse Gate-Source Voltage	−20 V	−25 V
Continuous Forward Gate Current	←10 mA→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	←360 mW→	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←300°C→	

NOTE 1: Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP JN55

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		2N6451 MIN	2N6451 MAX	2N6452 MIN	2N6452 MAX	2N6453 MIN	2N6453 MAX	2N6454 MIN	2N6454 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$		−20		−25		−20		−25		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -10\ V$, $V_{DS} = 0$			−0.1				−0.1			nA
		$V_{GS} = -15\ V$, $V_{DS} = 0$					−0.5				−0.5	nA
		$V_{GS} = -10\ V$, $V_{DS} = 0$	$T_A = 125°C$		−0.2				−0.2			μA
		$V_{GS} = -15\ V$, $V_{DS} = 0$	$T_A = 125°C$				−1				−1	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 10\ V$, $I_D = 0.5\ nA$		−0.5	−3.5	−0.5	−3.5	−0.75	−5	−0.75	−5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 10\ V$, $V_{GS} = 0$, See Note 2		5	20	5	20	15	50	15	50	mA
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 10\ V$, $I_D = 5\ mA$, f = 1 kHz		15	30	15	30					mmho
		$V_{DS} = 10\ V$, $I_D = 15\ mA$, f = 1 kHz, See Note 3						20	40	20	40	mmho
$\lvert y_{os}\rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = 10\ V$, $I_D = 5\ mA$, f = 1 kHz			50		50					μmho
		$V_{DS} = 10\ V$, $I_D = 15\ mA$, f = 1 kHz, See Note 3							100		100	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 10\ V$, $I_D = 5\ mA$, f = 1 MHz			25		25					pF
		$V_{DS} = 10\ V$, $I_D = 15\ mA$, f = 1 MHz, See Note 3							25		25	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 10\ V$, $I_D = 5\ mA$, f = 1 MHz			5		5					pF
		$V_{DS} = 10\ V$, $I_D = 15\ mA$, f = 1 MHz, See Note 3							5		5	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	2N6451 MIN	2N6451 MAX	2N6452 MIN	2N6452 MAX	2N6453 MIN	2N6453 MAX	2N6454 MIN	2N6454 MAX	UNIT
F	Common-Source Spot Noise Figure	$V_{DS} = 10\ V$, $I_D = 5\ mA$, $R_G = 10\ k\Omega$, f = 10 Hz		1.5		2.5		1.5		2.5	dB
V_n	Equivalent Input Noise Voltage	$V_{DS} = 10\ V$, $I_D = 5\ mA$, f = 10 Hz		5		10		5		10	$nV/\sqrt{Hz}$
		$V_{DS} = 10\ V$, $I_D = 5\ mA$, f = 1 kHz		3		8		3		8	$nV/\sqrt{Hz}$

*JEDEC registered data

†*The fourth lead (case) is connected to the source for all measurements.*

NOTES: 2. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

3. To obtain repeatable results, this parameter must be measured with bias conditions applied for less than five seconds.

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4

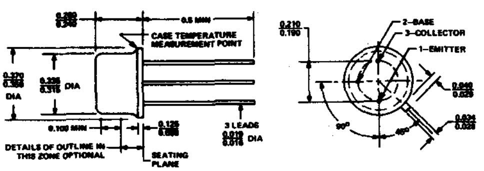
BULLETIN NO. DL-S 7312012, MAY 1973

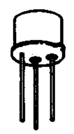
HIGH-VOLTAGE 10-WATT TRANSISTORS FOR GENERAL PURPOSE AMPLIFIER APPLICATIONS IN LINE-OPERATED CIRCUITS

- Solid-State Relays
- High-Voltage Inverters
- Voltage Regulators
- Video Output

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE





ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-39 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	2N6461 2N6462	2N6463 2N6464
Collector-Base Voltage	300 V	250 V
Collector-Emitter Voltage (See Note 1)	300 V	250 V
Emitter-Base Voltage	7 V	6 V
Continuous Collector Current	← 100 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 1 W →	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	← 10 W →	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTES: 1. This value applies between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 175°C free-air temperature at the rate of 6.67 mW/°C.
3. Derate linearly to 175°C case temperature at the rate of 66.7 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP N31

TEXAS INSTRUMENTS
INCORPORATED
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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	2N6461		2N6462		2N6463		2N6464		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 μA, I_E = 0	300		300		250		250		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA, I_B = 0, See Note 4	300		300		250		250		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 100 μA, I_C = 0	7		7		6		6		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 200 V, I_E = 0		50		50					nA
		V_{CB} = 150 V, I_E = 0						50		50	nA
		V_{CB} = 200 V, I_E = 0, T_A = 125°C		20		20					μA
		V_{CB} = 150 V, I_E = 0, T_A = 125°C						20		20	μA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		10		10		10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 4 mA	20		20		20		20		
		V_{CE} = 10 V, I_C = 20 mA, See Note 4	30	120	100	300	30	120	100	300	
		V_{CE} = 10 V, I_C = 40 mA, See Note 4					30		40		
V_{BE}	Base-Emitter Voltage	V_{CE} = 10 V, I_C = 20 mA, See Note 4		1		1		1		1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 2 mA, I_C = 20 mA, See Note 4		1.1		1.1		1		1	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 20 V, I_C = 20 mA, f = 20 MHz	3.5	10	3.5	10	3.5	10	3.5	10	
C_{cb}	Collector-Base Capacitance	V_{CB} = 20 V, I_E = 0, f = 1 MHz, See Note 5		3		3		3		3	pF

NOTES: 4. These parameters must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

THERMAL INFORMATION

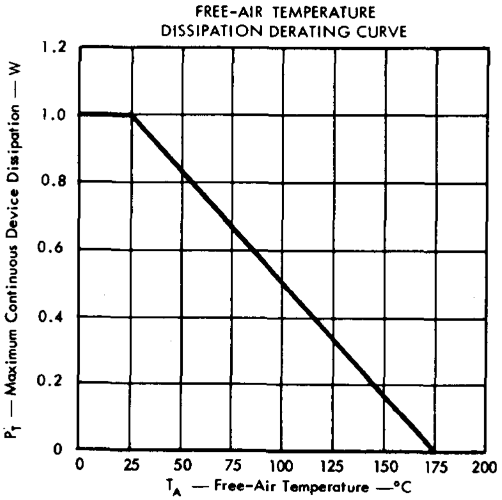

FIGURE 1

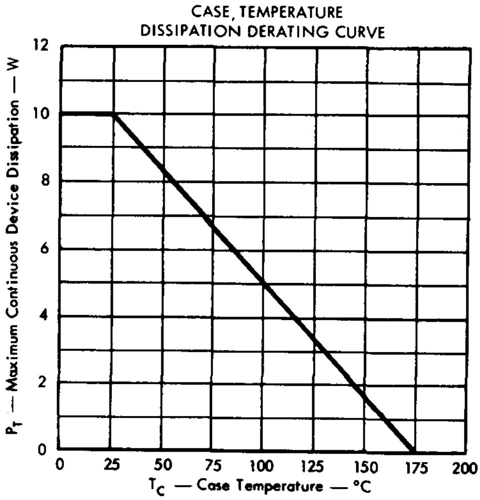

FIGURE 2

*JEDEC registered data

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4

TYPE 3N34
N-P-N GROWN-JUNCTION SILICON TETRODE TRANSISTOR

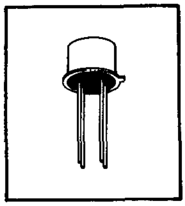
BULLETIN NO. DL-S 58960, AUGUST 1958

Typical 22db Power Gain at 30 MC

High Gain at High Temperature

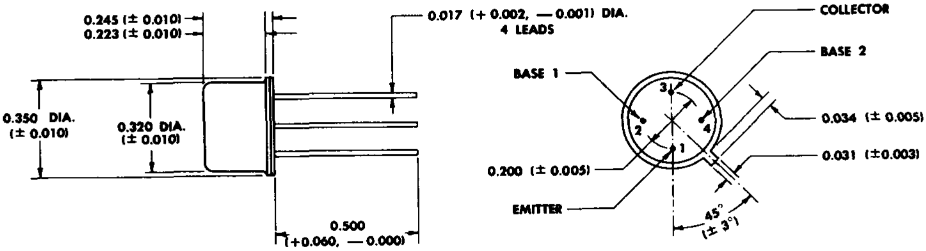
Designed for High Frequency • IF Amplifiers

RF Amplifiers • Video Amplifiers • Oscillators



mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is 1 gram. These units meet JEDEC outline TO-12 dimensions.



ALL CONNECTIONS INSULATED FROM CASE

ALL DIMENSIONS IN INCHES

maximum ratings at $T_J = 25°C$

Emitter Current	20 mA
Collector Current	20 mA
Base No. 1 Current	5 mA
Base No. 2 Current	5 mA
Collector Dissipation (Derate 1 mW/°C for Advanced Temperatures)	125 mW

junction temperature

Maximum Range	–65°C to +150°C

design characteristics at $T_J = 25°C$ (except as indicated)

	dc measurements	conditions			min	design center	max	unit
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20V$	$I_E = 0$	$I_{B2} = 0$		0.005	0.4	μA
	at 150°C	$V_{CB} = 20V$	$I_E = 0$	$I_{B2} = 0$			40	μA
BV_{CBO}	Breakdown Voltage	$I_C = 50\mu A$	$I_{B2} = 0$	$I_E = 0$	30	60		V
BV_{EBO}	Breakdown Voltage	$I_C = 50\mu A$	$I_{B2} = 0$	$I_E = 0$	1			V
BV_{CEO}	Breakdown Voltage	$I_C = 1mA$	$I_{B2} = 0$	$I_{B1} = 0$	30	45		V
R_{CS}	Saturation Resistance	$I_C = 5mA$	$I_{B2} = 0$	$I_{B1} = 1.0mA$		150	300	Ohm
$R_{B1}-R_{B2}$	Base-to-Base Resistance	$I_B = 100\mu A$				10K		Ohm
	low frequency measurements							
h_{fe}	Current Transfer Ratio	$V_C = 20V$, f = 1000 cps	$I_E = -1.3mA$	$I_{B2} = -100\mu A$	10	25		
C_{ob}	Output Capacity	$V_C = 20V$, f = 1Mc	$I_E = -1.3mA$	$I_{B2} = -100\mu A$		1.5		μμf
C_H	Header Capacity					0.4		μμf
	high frequency measurements							
h_{fe}	Current Transfer Ratio	$V_C = 20V$, $I_E = -1.3mA$, $I_{B2} = -100\mu A$, f = 30Mc			1.0	4		
r_{ies}	Series Input Resistance				20	100	300	Ohm
r_{oep}	Parallel Output Resistance				4K	9K	15K	Ohm
C_{oep}	Parallel Output Capacitance					1.5	3	μμf
$f_{\alpha b}$	Alpha Cutoff Frequency					100		Mc
NF	Noise Figure					15	20	db
PG_e	Power Gain					22		db

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TYPE 3N35
N-P-N GROWN-JUNCTION SILICON TETRODE TRANSISTOR

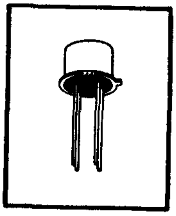
BULLETIN NO. DL-S 58961, AUGUST 1958

Typical 20db Power Gain at 70 MC

High Gain at High Temperature

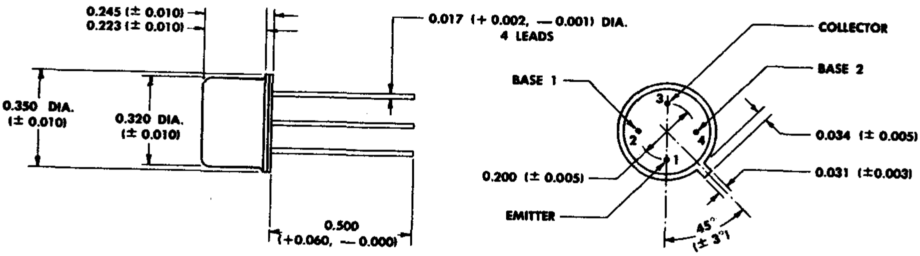
Designed for High Frequency • IF Amplifiers

RF Amplifiers • Video Amplifiers • Oscillators



mechanical data

Welded case with glass-to-metal hermetic seal between case and leads. Unit weight is 1 gram. These units meet JEDEC outline TO-12 dimensions.



ALL CONNECTIONS INSULATED FROM CASE

ALL DIMENSIONS IN INCHES

maximum ratings at $T_J = 25°C$

Emitter Current	20 mA
Collector Current	20 mA
Base No. 1 Current	5 mA
Base No. 2 Current	5 mA
Collector Dissipation (Derate 1 mW/°C for Advanced Temperatures)	125 mW

junction temperature

Maximum Range	−65°C to +150°C

design characteristics at $T_J = 25°C$ (except as indicated)

	dc measurements	conditions			min	design center	max	unit
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20V$	$I_E = 0$	$I_{B2} = 0$		0.005	0.4	µA
	at 150°C	$V_{CB} = 20V$	$I_E = 0$	$I_{B2} = 0$			40	µA
BV_{CBO}	Breakdown Voltage	$I_C = 50\mu A$	$I_{B2} = 0$	$I_E = 0$	30	60		V
BV_{EBO}	Breakdown Voltage	$I_C = 50\mu A$	$I_{B2} = 0$	$I_E = 0$	1			V
BV_{CEO}	Breakdown Voltage	$I_C = 1mA$	$I_{B2} = 0$	$I_{B1} = 0$	30	45		V
R_{CS}	Saturation Resistance	$I_C = 5mA$	$I_{B2} = 0$	$I_{B1} = 1.0mA$		150	300	Ohm
$R_{B1}-R_{B2}$	Base-to-Base Resistance	$I_B = 100\mu A$				10K		Ohm
	low frequency measurements							
h_{fe}	Current Transfer Ratio	$V_C = 20V$, f = 1000 cps	$I_E = -1.3mA$	$I_{B2} = -100\mu A$	10	25		
c_{ob}	Output Capacity	$V_C = 20V$, f = 1Mc	$I_E = -1.3mA$	$I_{B2} = -100\mu A$		1.5		µµf
c_H	Header Capacity					0.4		µµf
	high frequency measurements							
h_{fe}	Current Transfer Ratio	$V_C = 20V$, $I_E = -1.3mA$, $I_{B2} = -100\mu A$, f = 70Mc			1.0	1.6		
r_{ies}	Series Input Resistance				20	50	90	Ohm
r_{oep}	Parallel Output Resistance				4K	7K	15K	Ohm
C_{oep}	Parallel Output Capacitance					2	3	µµf
$f_{\alpha b}$	Alpha Cutoff Frequency					150		Mc
NF	Noise Figure					9	14	db
PG_e	Power Gain					20		db

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TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

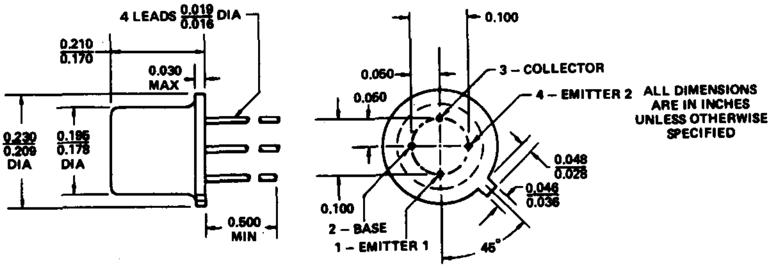
BULLETIN NO. DL-S 7211692, MARCH 1972

DOUBLE-EMITTER TRANSISTORS DESIGNED FOR CHOPPER APPLICATIONS

- Low Offset Voltage
- Excellent Thermal Stability
- Very Low Leakage . . . 2 nA max at 15 V (3N74, 3N75, 3N76)
- High Breakdown Voltage . . . 18 V min (3N74, 3N75, 3N76)

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE.



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	3N74 3N75 3N76	3N77 3N78 3N79
Collector-Base Voltage	50 V	40 V
Emitter-One—Collector Voltage (See Note 1)	18 V	12 V
Emitter-Two—Collector Voltage (See Note 1)	18 V	12 V
Emitter-One—Emitter-Two Voltage (See Note 2)	±18 V	±12 V
Emitter-One—Base Voltage	18 V	12 V
Emitter-Two—Base Voltage	18 V	12 V
Continuous Collector Current	±20 mA	
Continuous Base Current	±20 mA	
Continuous Emitter-One Current	±10 mA	
Continuous Emitter-Two Current	±10 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	300 mW	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	600 mW	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C	

NOTES: 1. These values apply when the base and other emitter are open-circuited.
2. These values apply when the collector is short-circuited to the base but open-circuited with respect to the emitters.
3. Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.
4. Derate linearly to 175°C case temperature at the rate of 4 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP N12

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	3N74		3N75		3N76		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_{E1} = I_{E2} = 0$	50		50		50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$, See Note 5	18		18		18		V
$V_{(BR)E1E2}$	Emitter-Emitter Breakdown Voltage	$I_{E1} = \pm 10\ \mu A$, $V_{CB} = 0$, See Note 6	±18		±18		±18		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30\ V$, $I_{E1} = I_{E2} = 0$		10		10		10	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 15\ V$, $I_C = 0$, See Note 5		2		2		2	nA
$I_{E1E2(off)}$	Emitter Cutoff Current	$V_{E1E2} = \pm 15\ V$, $V_{CB} = 0$, See Note 6		±2		±2		±2	nA
		$V_{E1E2} = \pm 15\ V$, $V_{CB} = 0$, $T_A = 100°C$, See Note 6		±100		±100		±100	
$\lvert V_{E1E2(ofs)} \rvert$	Emitter-Emitter Offset Voltage	$I_B = 1\ mA$, $I_{E1} = I_{E2} = 0$, See Figure 1, $T_A = -25°C$, 25°C, and 100°C		50		100		200	μV
$\lvert \Delta V_{E1E2(ofs)} \rvert_{\Delta I_B}$	Offset Voltage Change with Base Current†	$I_{B(1)} = 1.5\ mA$, $I_{B(2)} = 0.5\ mA$, $I_{E1} = I_{E2} = 0$		25		25		50	μV
$\lvert \Delta V_{E1E2(ofs)} \rvert_{\Delta T_A}$	Offset Voltage Change with Temperature†	$I_B = 1\ mA$, $I_{E1} = I_{E2} = 0$, $T_{A(1)} = 100°C$, $T_{A(2)} = -25°C$		75		125		175	μV
$r_{e1e2(on)}$	Small-Signal Emitter-Emitter On-State Resistance	$I_B = 1\ mA$, $I_{E1} = I_{E2} = 0$, $I_e = 100\ \mu A$, $f = 1\ kHz$, See Figure 2	10	40	10	40	10	50	Ω
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 20\ MHz$, See Note 5	1.5		1.5		1.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5\ V$, $I_{E1} = I_{E2} = 0$, $f = 140\ kHz$		8		8		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 5\ V$, $I_C = 0$, $f = 140\ kHz$, See Note 5		5		5		5	pF

NOTES: 5. These limits apply separately for each emitter with the other emitter open-circuited.

6. These parameters must be measured with the collector short-circuited to the base but open-circuited with respect to the emitters. The limits apply to both polarities of emitter-to-emitter voltage.

†Offset Voltage Change is defined as the magnitude of the algebraic difference between the offset voltages at two specified base currents or temperatures.

*JEDEC registered data

4

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	3N77 MIN	3N77 MAX	3N78 MIN	3N78 MAX	3N79 MIN	3N79 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_{E1} = I_{E2} = 0$	40		40		40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$, See Note 5	12		12		12		V
$V_{(BR)E1E2}$	Emitter-Emitter Breakdown Voltage	$I_{E1} = \pm 10\ \mu A$, $V_{CB} = 0$, See Note 6	±12		±12		±12		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ V, $I_{E1} = I_{E2} = 0$		10		10		20	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$, See Note 5		5		5		10	nA
$I_{E1E2(off)}$	Emitter Cutoff Current	$V_{E1E2} = \pm 5$ V, $V_{CB} = 0$, See Note 6		±5		±5		±10	nA
		$V_{E1E2} = \pm 5$ V, $V_{CB} = 0$, $T_A = 100°C$, See Note 6		±100		±100		±200	nA
$\lvert V_{E1E2(ofs)} \rvert$	Emitter-Emitter Offset Voltage	$I_B = 1$ mA, $I_{E1} = I_{E2} = 0$, See Figure 1, $T_A = -25°C$, 25°C, and 100°C		50		100		200	µV
$\lvert \Delta V_{E1E2(ofs)} \rvert \Delta I_B$	Offset Voltage Change with Base Current†	$I_{B(1)} = 1.5$ mA, $I_{B(2)} = 0.5$ mA, $I_{E1} = I_{E2} = 0$		25		50		75	µV
$\lvert \Delta V_{E1E2(ofs)} \rvert \Delta T_A$	Offset Voltage Change with Temperature†	$I_B = 1$ mA, $I_{E1} = I_{E2} = 0$, $T_{A(1)} = 100°C$, $T_{A(2)} = -25°C$		75		125		175	µV
$r_{e1e2(on)}$	Small-Signal Emitter-Emitter On-State Resistance	$I_B = 1$ mA, $I_{E1} = I_{E2} = 0$, $I_e = 100\ \mu A$, $f = 1$ kHz, See Figure 2	10	50	10	50	10	60	Ω
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ mA, $f = 20$ MHz, See Note 5	1.5		1.5		1.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_{E1} = I_{E2} = 0$, $f = 140$ kHz		8		8		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 5$ V, $I_C = 0$, $f = 140$ kHz, See Note 5		5		5		6	pF

NOTES: 5. These limits apply separately for each emitter with the other emitter open-circuited.
6. These parameters must be measured with the collector short-circuited to the base but open-circuited with respect to the emitters. The limits apply to both polarities of emitter-to-emitter voltage.

†Offset Voltage Change is defined as the magnitude of the algebraic difference between the offset voltages at two specified base currents or temperatures.

PARAMETER MEASUREMENT INFORMATION

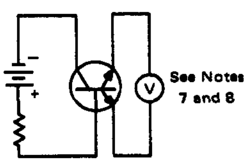
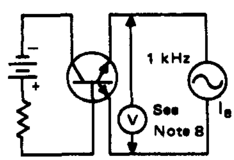


FIGURE 1



$$r_{e1e2(on)} = \frac{V_{e1e2}}{I_e}$$

FIGURE 2

NOTES: 7. Care must be taken to avoid error due to thermocouple action.
8. The voltmeter impedance must be high enough that halving it does not change the measured value.

*JEDEC registered data

TEXAS INSTRUMENTS
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POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7211693, MARCH 1972

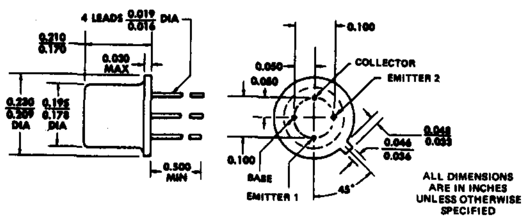
HIGH-VOLTAGE DOUBLE-EMITTER TRANSISTORS DESIGNED FOR LOW-LEVEL, HIGH-SPEED CHOPPER APPLICATIONS REQUIRING VERY LOW OFFSET VOLTAGE

- **May be Used in Some Circuits Designed for N-P-N Types by Reversing Collector and Base Terminations**
- **High Breakdown Voltages . . . 50 V Min (3N108, 3N109)**
- **Low Offset-Voltage/Temperature Sensitivity**
- **Extremely Low Leakage . . . 0.1 nA Max at 25 V (3N108, 3N109)**

4

*mechanical data

THE COLLECTOR IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	3N108 3N109	3N110 3N111
Collector-Base Voltage	−50 V	−50 V
Emitter-One—Collector Voltage (See Note 1)	−50 V	−30 V
Emitter-Two—Collector Voltage (See Note 1)	−50 V	−30 V
Emitter-One—Emitter-Two Voltage (See Note 2)	±50 V	±30 V
Emitter-One—Base Voltage	−50 V	−30 V
Emitter-Two—Base Voltage	−50 V	−30 V
Continuous Collector Current	±20 mA	
Continuous Base Current	±20 mA	
Continuous Emitter-One Current	±10 mA	
Continuous Emitter-Two Current	±10 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	300 mW	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 4)	600 mW	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C	

NOTES: 1. These values apply when the base and other emitter are open-circuited.
2. These values apply when the collector is short-circuited to the base but open-circuited with respect to the emitters.
3. Derate linearly to 200°C free-air temperature at the rate of 1.71 mW/°C.
4. Derate linearly to 200°C case temperature at the rate of 3.43 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP P13

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	3N108		3N109		3N110		3N111		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -1\ \mu A$, $I_{E1} = I_{E2} = 0$	−50		−50		−50		−50		V
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	$I_E = -1\ \mu A$, $I_B = 0$, See Note 5	−50		−50		−30		−30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -1\ \mu A$, $I_C = 0$, See Note 5	−50		−50		−30		−30		V
$V_{(BR)E1E2}$	Emitter-Emitter Breakdown Voltage	$I_{E1} = \pm 1\ \mu A$, $V_{CB} = 0$, See Note 6	±50		±50		±30		±30		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V, $I_{E1} = I_{E2} = 0$		−0.25		−0.25		−0.5		−0.5	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -25$ V, $I_C = 0$, See Note 5		−0.1		−0.1		−0.5		−0.5	nA
$I_{E1E2(off)}$	Emitter Cutoff Current	$V_{E1E2} = \pm 25$ V, $V_{CB} = 0$, See Note 6		±0.1		±0.1		±0.5		±0.5	nA
		$V_{E1E2} = \pm 25$ V, $V_{CB} = 0$, $T_A = 100°C$, See Note 6		±10		±10		±50		±50	nA
$\lvert V_{E1E2(ofs)} \rvert$	Emitter-Emitter Offset Voltage	$I_B = -1$ mA, $I_{E1} = I_{E2} = 0$, $T_A = -25°C$, 25°C, and 100°C, See Figure 1		30		150		30		150	μV
$\lvert \Delta V_{E1E2(ofs)} \rvert_{\Delta I_B}$	Offset Voltage Change with Base Current†	$I_{B(1)} = -1.5$ mA, $I_{B(2)} = -0.5$ mA, $I_{E1} = I_{E2} = 0$		20		50		20		50	μV
$\lvert \Delta V_{E1E2(ofs)} \rvert_{\Delta T_A}$	Offset Voltage Change with Temperature†	$I_B = -1$ mA, $I_{E1} = I_{E2} = 0$, $T_{A(1)} = 100°C$, $T_{A(2)} = -25°C$		50		150		50		150	μV
$r_{e1e2(on)}$	Small-Signal Emitter-Emitter On-State Resistance	$I_B = -1$ mA, $I_{E1} = I_{E2} = 0$, $I_e = 100\ \mu A$, f = 1 kHz, See Figure 2	10	50	10	50	10	50	10	50	Ω
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -6$ V, $I_C = -1$ mA, f = 4 MHz, See Note 5	3		3		3		3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -6$ V, $I_{E1} = I_{E2} = 0$, f = 1 MHz		10		10		10		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -6$ V, $I_C = 0$, f = 1 MHz, See Note 5		3		3		3		3	pF

NOTES: 5. These limits apply separately for each emitter with the other emitter open-circuited.
6. These parameters must be measured with the collector short-circuited to the base but open-circuited with respect to the emitters. The limits apply to both polarities of emitter-to-emitter voltage.
7. Care must be taken to avoid error due to thermocouple action.
8. The voltmeter impedance must be high enough that halving it does not change the measured value.

†Offset Voltage Change is defined as the magnitude of the algebraic difference between the offset voltages at two specified base currents or temperatures.

*JEDEC registered data

*PARAMETER MEASUREMENT INFORMATION

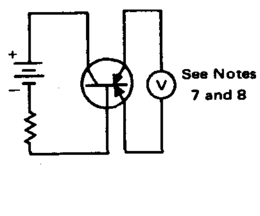
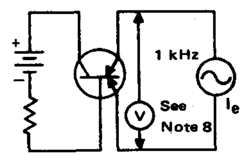


FIGURE 1



$$r_{e1e2(on)} = \frac{V_{e1e2}}{I_e}$$

FIGURE 2

TEXAS INSTRUMENTS
INCORPORATED
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TYPE 3N128
N-CHANNEL INSULATED-GATE DEPLETION-TYPE FIELD-EFFECT TRANSISTOR

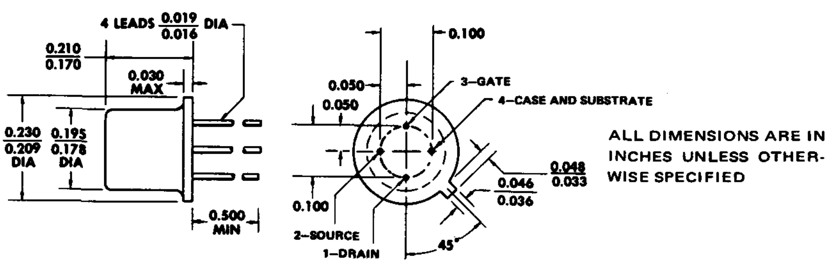
BULLETIN NO. DL-S 7312006, MARCH 1973

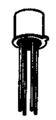
DEPLETION-TYPE MOS SILICON TRANSISTOR
For Use in VHF Amplifier Applications to 300 MHz

- **High $|y_{fs}|$ . . . 5000 μmho Min**
- **Low Feedback Capacitance, C_{rss} . . . 0.35 pF Max**

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE





ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

handling precautions

Curve-tracer testing and static-charge buildup are common causes of damage to insulated-gate devices. Permanent damage may result if either gate-voltage rating is exceeded even for extremely short time periods. Each transistor is protected during shipment by a gate-shorting device, which should be removed only during testing and after permanent mounting of the transistor. Personnel and equipment, including soldering irons, should be grounded.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	20 V
Drain-Source Voltage (See Note 1)	20 V
Forward Gate-Source Voltage	1 V
Reverse Gate-Source Voltage	−8 V
Peak Drain Current (See Note 2)	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	330 mW
Storage Temperature Range	−65°C to 175°C
Lead Temperature 1/32 Inch from Case for 10 Seconds	265°C

NOTES: 1. This rating applies when the substrate is at the same potential as the source.
2. This value applies for $t_w \leq 20\ \mu s$, duty cycle $\leq 1\%$.
3. Derate linearly to 175°C free-air temperature at the rate of 2.2 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP MN82

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

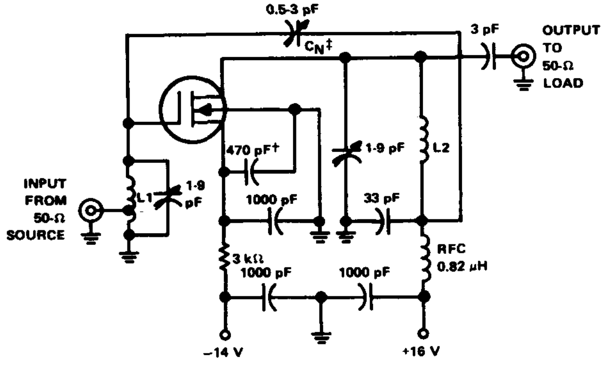
PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = 1$ V, $V_{DS} = 0$		50	pA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = -8$ V, $V_{DS} = 0$		−50	pA
		$V_{GS} = -8$ V, $V_{DS} = 0$, $T_A = 125°C$		−5	nA
$V_{GS(off)}$	Gate-Source Cutoff Current	$V_{DS} = 15$ V, $I_D = 50\ \mu A$	−0.5	−8	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 4	5	25	mA
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $I_D = 5$ mA, f = 1 kHz	5	12	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $I_D = 5$ mA, f = 0.1 to 1 MHz		7	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 15$ V, $I_D = 5$ mA, f = 0.1 to 1 MHz	0.15	0.35	pF
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $I_D = 5$ mA, f = 200 MHz		800	μmho
g_{os}	Small-Signal Common-Source Output Conductance	$V_{DS} = 15$ V, $I_D = 5$ mA, f = 200 MHz		500	μmho

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	MIN	MAX	UNIT
F	Common-Source Spot Noise Figure	$V_{DS} = 15$ V, $I_D = 5$ mA, f = 200 MHz, See Figure 1		5	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain	$V_{DD} = 16$ V, f = 200 MHz, See Figure 1	13.5	21	dB
B	Bandwidth (6 dB)		10	15	MHz

†All measurements are made with the substrate connected to the source.
NOTE 4: This parameter must be measured using pulse techniques. $t_w < 20$ ms, duty cycle < 15%.

PARAMETER MEASUREMENT INFORMATION*



CIRCUIT COMPONENT INFORMATION

L1: 4½ turns #20 AWG, 3/16" dia., approx. 1/2" long, tapped 1 turn from ground end
L2: 3½ turns #20 AWG, 3/8" dia., approx. 1/2" long
†Leadless disc ceramic capacitor
‡Neutralization fixed for a transistor having a typical value of C_{rss}
Equivalent parallel input network:
$Y_G' = 0.175$ mmho−j (6.3 ± 2.5) mmho; input network loss = 0.8 dB; 3-dB bandwidth = 20 MHz
Equivalent parallel output network:
$Y_L' = 0.5$ mmho −j (1.9 ± 0.63) mmho; output network loss = 2 dB; 3-dB bandwidth = 7.5 MHz

FIGURE 1

*JEDEC registered data

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE 3N153
N-CHANNEL DEPLETION-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTOR

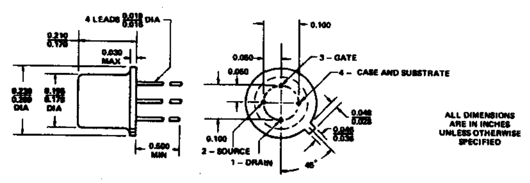
BULLETIN NO. DL-S 7311985, MARCH 1973

DEPLETION-TYPE MOS SILICON TRANSISTOR DESIGNED FOR CHOPPER AND SWITCHING APPLICATIONS

- Low $r_{ds(on)}$ . . . 300 Ω Max
- Low C_{rss} . . . 0.6 pF Max
- Low I_{GSS} . . . 50 pA Max

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

handling precautions

Curve-tracer testing and static-charge buildup are common causes of damage to insulated-gate devices. Permanent damage may result if either gate-voltage rating is exceeded even for extremely short time periods. Each transistor is protected during shipment by a gate-shorting device, which should be removed only during testing and after permanent mounting of the transistor. Personnel and equipment, including soldering irons, should be grounded.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	20 V
Drain-Source Voltage	20 V
Forward Gate-Source Voltage	6 V
Reverse Gate-Source Voltage	−8 V
Peak Drain Current (See Note 1)	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	400 mW
Storage Temperature Range	−65°C to 175°C
Lead Temperature 1/32 Inch from Case for 10 Seconds	265°C

NOTES: 1. This value applies for $t_w \leq 20$ ms, duty cycle $\leq 10\%$.
2. Derate linearly to 175°C free-air temperature at the rate of 2.67 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP MN82

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N-CHANNEL DEPLETION-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTOR

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†			MIN	MAX	UNIT
I_{GSSF}	Gate-Terminal Forward Current	$V_{GS} = 6$ V,	$V_{DS} = 0$			50	pA
I_{GSSR}	Gate-Terminal Reverse Current	$V_{GS} = -8$ V,	$V_{DS} = 0$			−50	pA
		$V_{GS} = -8$ V,	$V_{DS} = 0$,	$T_A = 125°C$		−5	nA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 1$ V,	$V_{GS} = -8$ V			1	nA
		$V_{DS} = 1$ V,	$V_{GS} = -8$ V,	$T_A = 125°C$		1	μA
$I_{D(on)}$	On-State Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 3	5		mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$,	$I_D = 0$,	f = 1 kHz		300	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 0$,	$V_{GS} = -8$ V,	f = 1 MHz		8	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$,	$V_{GS} = -8$ V,	f = 1 MHz		0.6	pF
C_{ds}	Drain-Source Capacitance	$V_{DS} = 0$, See Note 4	$V_{GS} = -8$ V,	f = 1 MHz,		3	pF

NOTES: 3. This parameter must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
4. C_{ds} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The gate and case are connected to the guard terminal of the bridge.

4

†All measurements are made with the case and substrate connected to the source.
*JEDEC registered data

BULLETIN NO. DL-S 7311918, JUNE 1973

ENHANCEMENT-TYPE† MOS SILICON TRANSISTORS

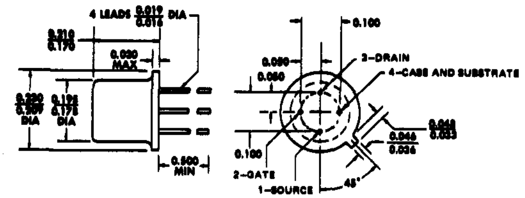
3N155, 3N155A, 3N156, and 3N156A
Are Characterized For Applications Requiring Very High Input Impedance, Such as Series and Shunt Choppers, Mutliplexers, and Commutators

3N157, 3N157A, 3N158, and 3N158A
Are Characterized For Audio Amplifier Applications

- **Channel Cut Off with Zero Gate Voltage**
- **Square-Law Transfer Characteristic Reduces Distortion**
- **Independent Substrate Connection Provides Flexibility in Biasing**

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

handling precautions

Curve-tracer testing and static-charge buildup are common causes of damage to insulated-gate devices. Permanent damage may result if either gate-voltage rating is exceeded even for extremely short time periods. Each transistor is protected during shipment by a gate-shorting device which should be removed only during testing and after permanent mounting of the transistor. Personnel and equipment, including soldering irons, should be grounded.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	3N155 3N155A 3N156 3N156A	3N157 3N157A 3N158 3N158A
*Drain-Gate Voltage	−50 V	−50 V
*Drain-Source Voltage (See Note 1)	−35 V	−50 V
*Forward Gate-Source Voltage	−50 V	−50 V
*Reverse Gate-Source Voltage	50 V	50 V
*Continuous Drain Current	← −30 mA →	
*Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 300 mW →	
*Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTES: 1. These voltage ratings apply when the substrate is at the same potential as the least-negative element.
2. Derate linearly to 175°C free-air temperature at the rate of 2 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at time of publication.

†Enhancement-mode operation entails the use of a forward gate-source voltage to increase drain current from I_{DSS}, the drain current at $V_{GS} = 0$, as opposed to depletion-mode operation wherein a reverse gate-source voltage is used to decrease drain current. An enhancement-type transistor is in the "off" state at $V_{GS} = 0$ and hence will not operate normally in the depletion mode.

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*3N155 and 3N156 electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	3N155 MIN	3N155 MAX	3N156 MIN	3N156 MAX	UNIT
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -25$ V, $V_{DS} = 0$		−10		−10	pA
		$V_{GS} = -50$ V, $V_{DS} = 0$		−1		−1	nA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 25$ V, $V_{DS} = 0$		10		10	pA
		$V_{GS} = 50$ V, $V_{DS} = 0$		1		1	nA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -10$ V, $V_{GS} = 0$		−1		−1	nA
		$V_{DS} = -10$ V, $V_{GS} = 0$, $T_A = 125°C$		−1		−1	μA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -10$ V, $I_D = -10$ μA	−1.5	−3.2	−3	−5	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -10$ V, See Note 3	−5		−5		mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$V_{GS} = -10$ V, $I_D = -2$ mA		−1		−1	V
$r_{DS(on)}$	Static Small-Signal Drain-Source On-State Resistance	$V_{GS} = -10$ V, $I_D = 0$		600		600	Ω
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = -10$ V, $I_D = 0$, f = 1 kHz		600		600	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 140 kHz		5		5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = 0$, f = 140 kHz		1.3		1.3	pF

*3N155A and 3N156A electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	3N155A MIN	3N155A MAX	3N156A MIN	3N156A MAX	UNIT
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -25$ V, $V_{DS} = 0$		−10		−10	pA
		$V_{GS} = -50$ V, $V_{DS} = 0$		−1		−1	nA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 25$ V, $V_{DS} = 0$		10		10	pA
		$V_{GS} = 50$ V, $V_{DS} = 0$		1		1	nA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -10$ V, $V_{GS} = 0$		−0.25		−0.25	nA
		$V_{DS} = -10$ V, $V_{GS} = 0$, $T_A = 125°C$		−250		−250	
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -10$ V, $I_D = -10$ μA	−1.5	−3.2	−3	−5	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -10$ V, See Note 3	−5		−5		mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$V_{GS} = -10$ V, $I_D = -2$ mA		−1		−1	V
$r_{DS(on)}$	Static Small-Signal Drain-Source On-State Resistance	$V_{GS} = -10$ V, $I_D = 0$		300		300	Ω
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = -10$ V, $I_D = 0$, f = 1 kHz		300		300	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 140 kHz		5		5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = 0$, f = 140 kHz		1.3		1.3	pF

NOTE 3: This parameter must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
*JEDEC registered data
‡All measurements are made with the case and substrate connected to the source.

4

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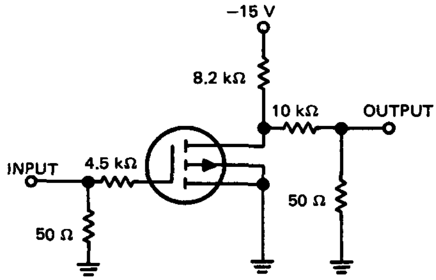
*3N155, 3N155A, 3N156, 3N156A switching characteristics at 25°C free-air temperature

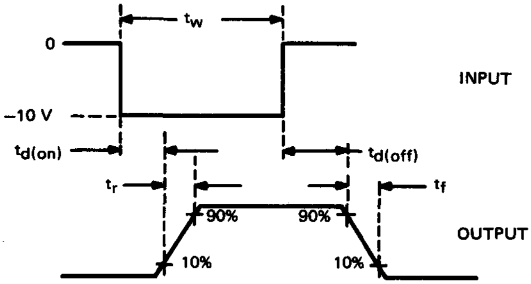
PARAMETER		TEST CONDITIONS‡	MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = -10$ V, $I_{D(on)} = -2$ mA, $V_{GS(on)} = -10$ V, $V_{GS(off)} = 0$, See Figure 1	45	ns
t_r	Rise Time		65	ns
$t_{d(off)}$	Turn-Off Delay Time		60	ns
t_f	Fall Time		100	ns

‡All measurements are made with the case and substrate connected to the source.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 2$ ns, $t_f \leq 2$ ns, $t_w \geq 10\ \mu s$, duty cycle ≈ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 10$ ns, $R_{in} \geq 1 M\Omega$, $C_{in} \leq 1$ pF.

FIGURE 1

*JEDEC registered data

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*3N157 and 3N158 electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	3N157		3N158		UNIT
			MIN	MAX	MIN	MAX	
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -25$ V, $V_{DS} = 0$		−10		−10	pA
		$V_{GS} = -50$ V, $V_{DS} = 0$		−1		−1	nA
		$V_{GS} = -25$ V, $V_{DS} = 0$, $T_A = 55°C$		−10		−10	nA
		$V_{GS} = -50$ V, $V_{DS} = 0$, $T_A = 55°C$		−1		−1	µA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 25$ V, $V_{DS} = 0$		10		10	pA
		$V_{GS} = 50$ V, $V_{DS} = 0$		1		1	nA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V, $V_{GS} = 0$		−1		−1	nA
		$V_{DS} = -35$ V, $V_{GS} = 0$		−10		−10	µA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10$ µA	−1.5	−3.2	−3	−5	V
V_{GS}	Gate-Source Voltage	$V_{DS} = -15$ V, $I_D = -0.5$ mA	−1.5	−5.5	−3	−7	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -10$ V, See Note 3	−5		−5		mA
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $I_D = -2$ mA, f = 1 kHz	1	4	1	4	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance			60		60	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 140 kHz		5		5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			1.3		1.3	pF

*3N157A and 3N158A electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	3N157A		3N158A		UNIT
			MIN	MAX	MIN	MAX	
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -25$ V, $V_{DS} = 0$		−10		−10	pA
		$V_{GS} = -50$ V, $V_{DS} = 0$		−1		−1	nA
		$V_{GS} = -25$ V, $V_{DS} = 0$, $T_A = 55°C$		−10		−10	nA
		$V_{GS} = -50$ V, $V_{DS} = 0$, $T_A = 55°C$		−1		−1	µA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 25$ V, $V_{DS} = 0$		10		10	pA
		$V_{GS} = 50$ V, $V_{DS} = 0$		1		1	nA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V, $V_{GS} = 0$		−0.25		−0.25	nA
		$V_{DS} = -50$ V, $V_{GS} = 0$		−10		−10	µA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10$ µA	−1.5	−3.2	−3	−5	V
V_{GS}	Gate-Source Voltage	$V_{DS} = -15$ V, $I_D = -0.5$ mA	−1.5	−5.5	−3	−7	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -10$ V, See Note 3	−5		−5		mA
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $I_D = -2$ mA, f = 1 kHz	1	4	1	4	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance			60		60	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 140 kHz		5		5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			1.3		1.3	pF

NOTE 3: This parameter must be measured using pulse techniques. $t_w = 300$ µs, duty cycle $\leq 2\%$.
*JEDEC registered data
‡All measurements are made with the case and substrate connected to the source.

4

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BULLETIN NO. DL-S 7011149, MARCH 1970

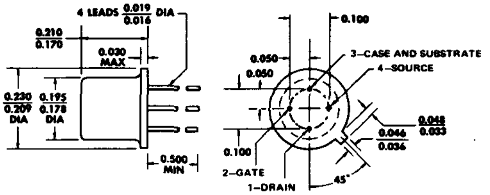
ENHANCEMENT-TYPE† MOS SILICON TRANSISTOR

For Applications Requiring Very High Input Impedance, Such as Series and Shunt Choppers, Multiplexers, and Commutators

- **Channel Cut Off with Zero Gate Voltage**
- **Square-Law Transfer Characteristic Reduces Distortion**
- **Independent Substrate Connection Provides Flexibility in Biasing**
- **Diode-Protected Version Available . . . 3N161**

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

handling precautions

Curve-tracer testing and static-charge buildup are common causes of damage to insulated-gate devices. Permanent damage may result if either gate-voltage rating is exceeded even for extremely short time periods. Each transistor is protected during shipment by a gate-shorting device, which should be removed only during testing and after permanent mounting of the transistor. Personnel and equipment, including soldering irons, should be grounded.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	−25 V
Drain-Source Voltage	−25 V
Forward Gate-Source Voltage	−25 V
Reverse Gate-Source Voltage	25 V
Continuous Drain Current	−125 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	1.8 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.
2. Derate linearly to 175°C case temperature at the rate of 12 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†Enhancement-mode operation entails the use of a forward gate-source voltage to increase drain current from I_{DSS}, the drain current at $V_{GS} = 0$, as opposed to depletion-mode operation wherein a reverse gate-source voltage is used to decrease drain current. An enhancement-type transistor is in the "off" state at $V_{GS} = 0$ and hence will not operate normally in the depletion mode.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		MIN	MAX	UNIT
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -25$ V, $V_{DS} = 0$			−10	pA
		$V_{GS} = -25$ V, $V_{DS} = 0$	$T_A = 100°C$		−50	pA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 25$ V, $V_{DS} = 0$			10	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V, $V_{GS} = 0$			−10	nA
		$V_{DS} = -25$ V, $V_{GS} = 0$			−10	μA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10\ \mu A$		−1.5	−5	V
V_{GS}	Gate-Source Voltage	$V_{DS} = -15$ V, $I_D = -8$ mA		−4.5	−8	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -15$ V, See Note 3		−40	−120	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $I_D = -8$ mA	f = 1 kHz	3.5	6.5	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance				0.25	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance		f = 1 MHz		10	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance				4	pF

NOTE 3: These parameters must be measured using pulse techniques. $t_p \approx 100$ ms, duty cycle ≤ 10%.
*JEDEC registered data
†All measurements are made with the third lead (case and substrate) connected to the fourth lead (source).

4

THERMAL INFORMATION

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

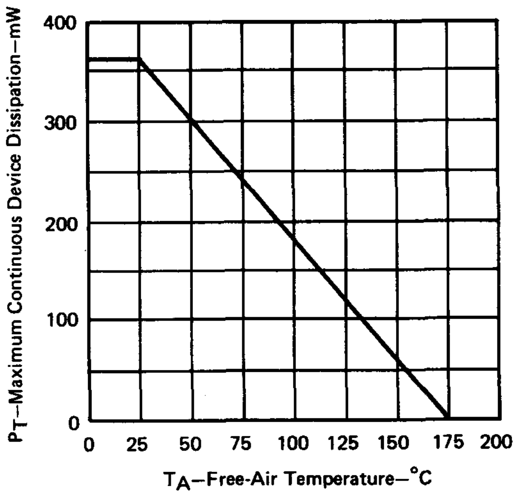


FIGURE 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

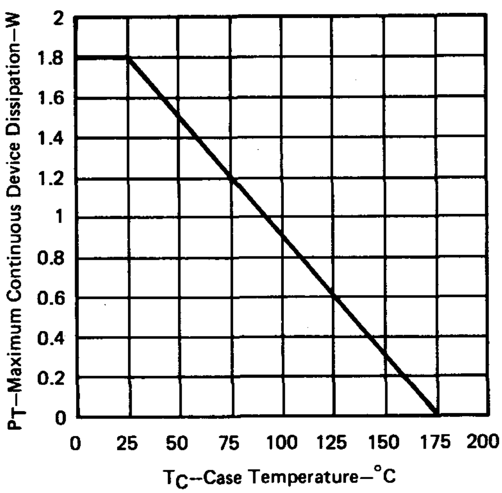


FIGURE 2

BULLETIN NO. DL-S 7311298, FEBRUARY 1970—REVISED MARCH 1973

DIODE-PROTECTED ENHANCEMENT-TYPE† MOS SILICON TRANSISTOR

For Applications Requiring Very High Input Impedance, Such as Series and Shunt Choppers, Multiplexers, and Commutators

- Channel Cut Off with Zero Gate Voltage
- Square-Law Transfer Characteristic Reduces Distortion
- Independent Substrate Connection Provides Flexibility in Biasing
- Internally Connected Diode Protects Gate from Damage due to Overvoltage
- Version Available without Diode Protection . . . 3N160

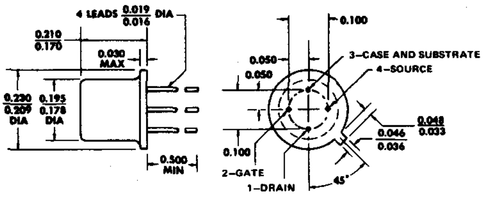
description

This device is designed for applications requiring very high input impedance, such as choppers, commutators, and logic switches. The device is protected from excessive input voltage by a shunting diode connected from the gate to the substrate. This eliminates the need for most precautionary handling procedures associated with unprotected MOS devices.

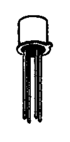
4

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	−25 V
Drain-Source Voltage	−25 V
Continuous Forward Gate-Terminal Current	−0.1 mA
Continuous Reverse Gate-Terminal Current	10 mA
Continuous Drain Current	−125 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 2)	1.8 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.
2. Derate linearly to 175°C case temperature at the rate of 12 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†Enhancement-mode operation entails the use of a forward gate-source voltage to increase drain current from I_{DSS}, the drain current at $V_{GS} = 0$, as opposed to depletion-mode operation wherein a reverse gate-source voltage is used to decrease drain current. An enhancement-type transistor is in the "off" state at $V_{GS} = 0$ and hence will not operate normally in the depletion mode. The protective shunting diode is reverse-biased by the application of forward gate-source voltage.

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS†		MIN	MAX	UNIT
$V_{(BR)GSSF}$	Forward Gate-Source Breakdown Voltage	$I_G = -0.1$ mA, $V_{DS} = 0$,	See Note 3	−25		V
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -25$ V, $V_{DS} = 0$			−0.1	nA
		$V_{GS} = -25$ V, $V_{DS} = 0$,	$T_A = 100°C$		−10	nA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V, $V_{GS} = 0$			−10	nA
		$V_{DS} = -25$ V, $V_{GS} = 0$			−10	μA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10$ μA		−1.5	−5	V
V_{GS}	Gate-Source Voltage	$V_{DS} = -15$ V, $I_D = -8$ mA		−4.5	−8	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -15$ V,	See Note 4	−40	−120	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $I_D = -8$ mA	f = 1 kHz	3.5	6.5	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance				0.25	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance		f = 1 MHz		10	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance				4	pF

NOTES: 3. To ensure that the gate-shunting diode is functioning properly, this voltage is measured while the device is conducting rated forward gate-terminal current.

4. This parameter must be measured using pulse techniques. $t_p \approx 100$ ms, duty cycle $\leqslant$ 10%.

*JEDEC registered data

†All measurements are made with the third lead (case and substrate) connected to the fourth lead (source).

4

THERMAL INFORMATION

FREE-AIR TEMPERATURE DISSIPATION DERATING CURVE

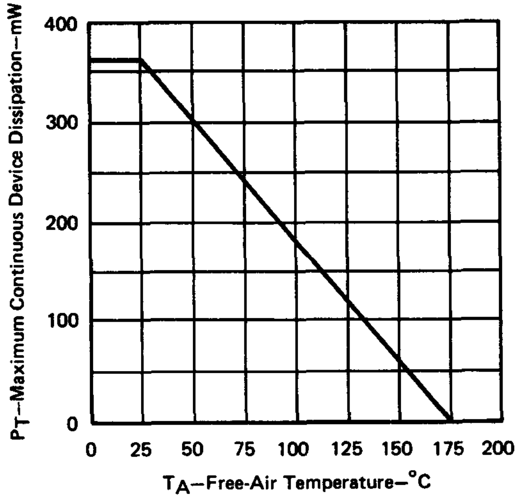


FIGURE 1

CASE TEMPERATURE DISSIPATION DERATING CURVE

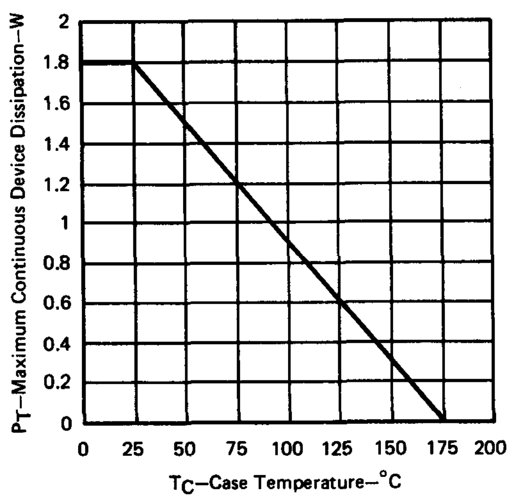


FIGURE 2

TYPES 3N163, 3N164
P-CHANNEL ENHANCEMENT-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7211750, JULY 1972–REVISED NOVEMBER 1972

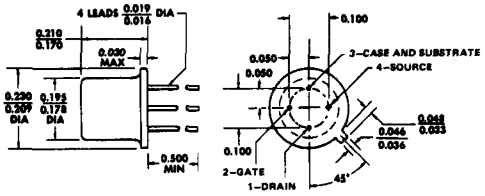
ENHANCEMENT-TYPE† MOS SILICON TRANSISTORS

For Applications Requiring Very High Input Impedance, Such as Series and Shunt Choppers, Multiplexers, and Commutators

- **Channel Cut Off with Zero Gate Voltage**
- **Square-Law Transfer Characteristic Reduces Distortion**
- **Independent Substrate Connection Provides Flexibility in Biasing**

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

4

handling precautions

Curve-tracer testing and static-charge buildup are common causes of damage to insulated-gate devices. Permanent damage may result if either peak gate-voltage rating is exceeded even for extremely short time periods. Each transistor is protected during shipment by a gate-shorting device which should be removed only during testing and after permanent mounting of the transistor. Personnel and equipment, including soldering irons, should be grounded.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	3N163	3N164
*Drain-Gate Voltage	−40 V	−30 V
*Drain-Source Voltage (See Note 1)	−40 V	−30 V
*Source-Drain Voltage (See Note 1)	−40 V	−30 V
*Peak Gate-Source Voltage	±125 V	±125 V
*Gate-Source Working Voltage (See Note 2)	±40 V	±30 V
Gate-Substrate Working Voltage (See Note 2)	−40 V	−30 V
*Continuous Drain Current	← −50 mA →	
*Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	← 375 mW →	
*Storage Temperature Range	−65°C to 200°C	
*Lead Temperature 1/16 Inch from Case for 10 Seconds	← 265°C →	

NOTES: 1. These voltage ratings apply when the substrate is at the same potential as the least-negative element.
2. The working voltage ratings are based on long-term reliability considerations and may be exceeded for short intervals.
3. Derate linearly to 150°C free-air temperature at the rate of 3 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at time of publication.

†Enhancement-mode operation entails the use of a forward gate-source voltage to increase drain current from I_{DSS}, the drain current at $V_{GS} = 0$, as opposed to depletion-mode operation wherein a reverse gate-source voltage is used to decrease drain current. An enhancement-type transistor is in the "off" state at $V_{GS} = 0$ and hence will not operate normally in the depletion mode.

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*3N163 electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	MIN	MAX	UNIT
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -40$ V, $V_{DS} = 0$		−10	pA
		$V_{GS} = -40$ V, $V_{DS} = 0$, $T_A = 125°C$		−25	pA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 40$ V, $V_{DS} = 0$		10	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V, $V_{GS} = 0$		−0.2	nA
		$V_{DS} = -40$ V, $V_{GS} = 0$		−10	μA
I_{SDS}	Zero-Gate-Voltage Source Current	$V_{SD} = -20$ V, $V_{GD} = 0$, See Note 4		−0.4	nA
		$V_{SD} = -40$ V, $V_{GD} = 0$, See Note 4		−10	μA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10$ μA	−2	−5	V
		$V_{DS} = V_{GS}$, $I_D = -10$ μA	−2	−5	V
V_{GS}	Gate-Source Voltage	$V_{DS} = -15$ V, $I_D = -0.5$ mA	−3	−6.5	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -10$ V, See Note 5	−5	−30	mA
$r_{DS(on)}$	Static Drain-Source On-State Resistance	$V_{GS} = -20$ V, $I_D = -100$ μA		250	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $I_D = -10$ mA, f = 1 kHz, See Note 6	2	4	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance			250	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $I_D = -10$ mA, f = 1 MHz, See Note 6		2.5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			0.7	pF
C_{oss}	Common-Source Short-Circuit Output Capacitance			3	pF

*3N164 electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	MIN	MAX	UNIT
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -30$ V, $V_{DS} = 0$		−10	pA
		$V_{GS} = -30$ V, $V_{DS} = 0$, $T_A = 125°C$		−25	pA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 30$ V, $V_{DS} = 0$		10	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V, $V_{GS} = 0$		−0.4	nA
		$V_{DS} = -30$ V, $V_{GS} = 0$		−10	μA
I_{SDS}	Zero-Gate-Voltage Source Current	$V_{SD} = -20$ V, $V_{GD} = 0$, See Note 4		−0.8	nA
		$V_{SD} = -30$ V, $V_{GD} = 0$, See Note 4		−10	μA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10$ μA	−2	−5	V
		$V_{DS} = V_{GS}$, $I_D = -10$ μA	−2	−5	V
V_{GS}	Gate-Source Voltage	$V_{DS} = -15$ V, $I_D = -0.5$ mA	−2.5	−6.5	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -10$ V, See Note 5	−3	−30	mA
$r_{DS(on)}$	Static Drain-Source On-State Resistance	$V_{GS} = -20$ V, $I_D = -100$ μA		300	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $I_D = -10$ mA, f = 1 kHz, See Note 6	1	4	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance			250	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $I_D = -10$ mA, f = 1 MHz, See Note 6		2.5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			0.7	pF
C_{oss}	Common-Source Short-Circuit Output Capacitance			3	pF

NOTES: 4. For the measurement of I_{SDS}, the substrate must be connected to the drain.
5. This parameter must be measured using pulse techniques. $t_w = 300$ μs, duty cycle $\leq 2\%$.
6. These parameters must be measured with bias conditions applied for less than 5 seconds to avoid overheating.

*JEDEC registered data

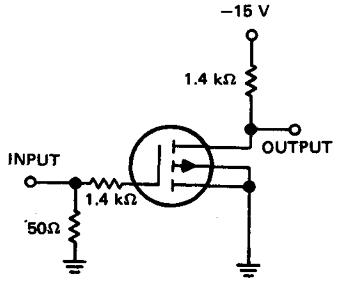
‡All measurements except I_{SDS} are made with the case and substrate connected to the source.

4

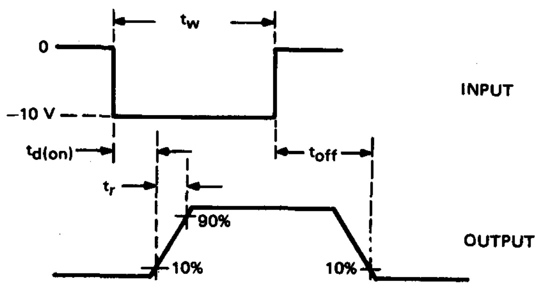
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS‡	MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = -15$ V, $I_{D(on)} = -10$ mA,	12	ns
t_r	Rise Time	$V_{GS(on)} = -10$ V, $V_{GS(off)} = 0$,	24	ns
t_{off}	Turn-Off Time	See Figure 1	50	ns

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, duty cycle ≈ 2%, $t_r < 2$ ns, $t_f < 2$ ns, $t_w > 200$ ns.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r < 0.2$ ns, $R_{in} > 10\ M\Omega$, $C_{in} < 2$ pF.

*JEDEC registered data
‡All measurements except I_{SDS} are made with the case and substrate connected to the source.

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TYPES 3N169, 3N170, 3N171
N-CHANNEL ENHANCEMENT-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7311983, MARCH 1973

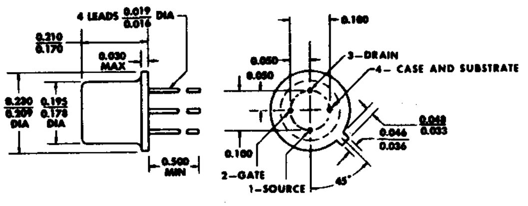
ENHANCEMENT-TYPE† MOS SILICON TRANSISTORS

For Applications Requiring Very High Input Impedance, Such as Series and Shunt Choppers, Multiplexers, and Commutators

- **Channel Cut Off with Zero Gate Voltage**
- **Independent Substrate Connection Provides Flexibility in Biasing**

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

handling precautions

Curve-tracer testing and static-charge buildup are common cuases of damage to insulated-gate devices. Permanent damage may result if either gate-voltage rating is exceeded even for extremely short time periods. Each transistor is protected during shipment by a gate-shorting device which should be removed only during testing and after permanent mounting of the transistor. Personnel and equipment, including soldering irons, should be grounded.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

*Drain-Gate Voltage	±35 V
*Drain-Source Voltage (See Note 1)	25 V
*Forward Gate-Source Voltage	35 V
*Reverse Gate-Source Voltage	−35 V
*Continuous Drain Current	30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	300 mW
*Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	800 mW
*Storage Temperature Range	−65°C to 200°C
*Lead Temperature 1/16 Inch from Case for 60 Seconds	240°C

NOTES: 1. This voltage rating applies when the substrate is at the same potential as the least-negative element.
2. Derate linearly to 200°C free-air temperature at the rate of 1.71 mW/°C.
3. Derate linearly to 200°C case temperature at the rate of 4.56 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at time of publication.

†Enhancement-mode operation entails the use of a forward gate-source voltage to increase drain current from I_{DSS}, the drain current at $V_{GS} = 0$, as opposed to depletion-mode operation wherein a reverse gate-source voltage is used to decrease drain current. An enhancement-type transistor is in the "off" state at $V_{GS} = 0$ and hence will not operate normally in the depletion mode.

USES CHIP **MN83**

TYPES 3N169, 3N170, 3N171
N-CHANNEL ENHANCEMENT-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		MIN	MAX	UNIT
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	$I_D = 10\,\mu A$, $V_{GS} = 0$		25		V
*I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = 35\,V$, $V_{DS} = 0$			10	pA
		$V_{GS} = 35\,V$, $V_{DS} = 0$, $T_A = 125°C$			100	
*I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = -35\,V$, $V_{DS} = 0$			−10	pA
*I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 10\,V$, $V_{GS} = 0$			10	nA
		$V_{DS} = 10\,V$, $V_{GS} = 0$, $T_A = 125°C$			1	μA
*$V_{GS(th)}$	Gate Source Threshold Voltage	$V_{DS} = 10\,V$, $I_D = 10\,\mu A$	3N169	0.5	1.5	V
			3N170	1	2	
			3N171	1.5	3	
*$I_{D(on)}$	On-State Drain Current	$V_{DS} = 10\,V$, $V_{GS} = 10\,V$, See Note 4		10		mA
*$V_{DS(on)}$	Drain-Source On-State Voltage	$V_{GS} = 10\,V$, $I_D = 10\,mA$			2	V
*$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 10\,V$, $I_D = 0$, $f = 1\,kHz$			200	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 10\,V$, $I_D = 2\,mA$, $f = 1\,kHz$		1		mmho
*C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 10\,V$, $V_{GS} = 0$, $f = 1\,MHz$			5	pF
*C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = 0$, $f = 1\,MHz$			1.3	pF
*C_{ds}	Drain-Source Capacitance	$V_{DS} = 10\,V$, $V_{GS} = 0$, $f = 1\,MHz$, See Note 5			5	pF

NOTES: 4. This parameter must be measured using pulse techniques. $t_w = 300\,\mu s$, duty cycle $\leq 2\%$.

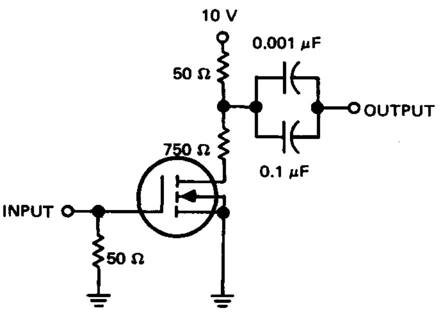
5. C_{ds} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The gate and the case are connected to the guard terminal of the bridge.

*switching characteristics at 25°C free-air temperature

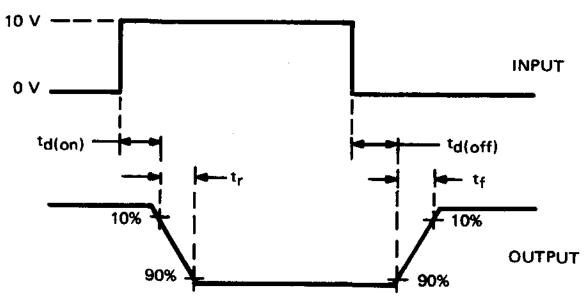
PARAMETER		TEST CONDITIONS†	MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 10\,V$, $I_{D(on)} = 10\,mA$, $V_{GS(on)} = 10\,V$, $V_{GS(off)} = 0$, See Figure 1	3	ns
t_r	Rise Time		10	ns
$t_{d(off)}$	Turn-Off Delay Time		3	ns
t_f	Fall Time		15	ns

† All measurements are made with the case and substrate connected to the source.
*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $Z_{out} = 50\,\Omega$, duty cycle $\leq 1\%$, $t_r \leq 0.33$ ns, $t_f \leq 0.33$ ns, $t_w \approx 0.4\,\mu s$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 0.4$ ns, $R_{in} = 50\,\Omega$, $C_{in} \leq 2$ pF.

FIGURE 1

BULLETIN NO. DL-S 7011285, JANUARY 1970

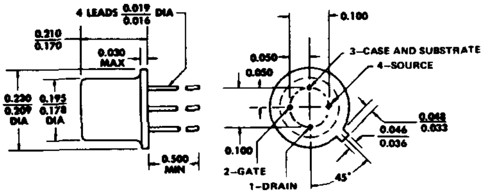
ENHANCEMENT-TYPE† MOS SILICON TRANSISTOR

For Applications Requiring Very High Input Impedance, Such as Series and Shunt Choppers, Multiplexers, and Commutators

- **Channel Cut Off with Zero Gate Voltage**
- **Square-Law Transfer Characteristic Reduces Distortion**
- **Independent Substrate Connection Provides Flexibility in Biasing**
- **Similar to 2N4065**

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

handling precautions

Curve-tracer testing and static-charge buildup are common causes of damage to insulated-gate devices. Permanent damage may result if either gate-voltage rating is exceeded even for extremely short time periods. Each transistor is protected during shipment by a gate-shorting device which should be removed only during testing and after permanent mounting of the transistor. Personnel and equipment, including soldering irons, should be grounded.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

*Drain-Gate Voltage	−30 V
*Drain-Source Voltage (See Note 1)	−30 V
Source-Drain Voltage (See Note 1)	−30 V
*Forward Gate-Source Voltage	−30 V
*Reverse Gate-Source Voltage	30 V
Gate-Substrate Voltage	−30 V
*Continuous Drain Current	−20 mA
*Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mW
*Storage Temperature Range	−65°C to 200°C
*Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. These voltage ratings apply when the substrate is at the same potential as the least-negative element.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.

*JEDEC registered data

†Enhancement-mode operation entails the use of a forward gate-source voltage to increase drain current from I_{DSS}, the drain current at $V_{GS} = 0$, as opposed to depletion-mode operation wherein a reverse gate-source voltage is used to decrease drain current. An enhancement-type transistor is in the "off" state at $V_{GS} = 0$ and hence will not operate normally in the depletion mode.

USES CHIP MP93

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TYPE 3N174
P-CHANNEL ENHANCEMENT-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTOR

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		MIN	MAX	UNIT
I_{GSSF}	Forward Gate-Terminal Current	V_{GS} = −30 V,	V_{DS} = 0		−2.5	pA
		V_{GS} = −30 V, T_A = 150°C	V_{DS} = 0,		−100	nA
I_{GSSR}	Reverse Gate-Terminal Current	V_{GS} = 30 V,	V_{DS} = 0		2.5	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	V_{DS} = −30 V,	V_{GS} = 0		−5	nA
		V_{DS} = −30 V, T_A = 150°C	V_{GS} = 0,		−5	μA
I_{SDS}	Zero-Gate-Voltage Source Current	V_{SD} = −30 V,	V_{GD} = 0, See Note 3		−5	nA
$V_{GS(th)}$	Gate Source Threshold Voltage	V_{DS} = −15 V,	I_D = −10 μA	−2	−6	V
$I_{D(on)}$	On-State Drain Current	V_{DS} = −15 V,	V_{GS} = −15 V, See Note 4	−3	−12	mA
$V_{DS(on)}$	Drain-Source On-State Voltage	V_{GS} = −15 V,	I_D = −1 mA		−1	V
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	V_{GS} = −15 V, f = 1 kHz	I_D = 0,		1	kΩ
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	V_{DS} = −15 V, f = 1 kHz,	V_{GS} = −15 V, See Note 5	400		μmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance				200	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	V_{DS} = −15 V, f = 1 MHz,	V_{GS} = −15 V, See Note 5		4	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	V_{DS} = 0, f = 1 MHz	V_{GS} = 0,		0.7	pF
C_{ds}	Drain-Source Capacitance	V_{DS} = −15 V, f = 1 MHz,	V_{GS} = 0, See Note 6		3	pF

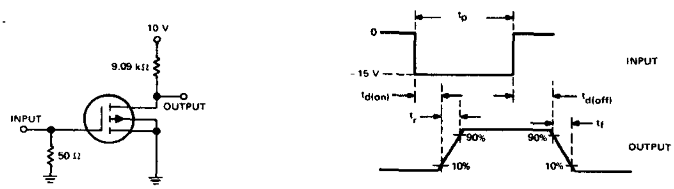
*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†		MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	V_{DD} = −10 V, $V_{GS(on)}$ = −15 V, R_G = 50 Ω,	$I_{D(on)}$ = −1 mA, $V_{GS(off)}$ = 0, See Figure 1	30	ns
t_r	Rise Time			50	ns
$t_{d(off)}$	Turn-Off Delay Time			15	ns
t_f	Fall Time			100	ns

NOTES: 3. For the measurement of I_{SDS}, the substrate must be connected to the drain.
4. This parameter must be measured using pulse techniques. $t_p \approx 100$ ms, duty cycle ≤ 10%.
5. These parameters must be measured with bias conditions applied for less than 5 seconds to avoid overheating.
6. C_{ds} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The gate and case are connected to the guard terminal of the bridge.

†All measurements except I_{SDS} are made with the case and substrate connected to the source.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveform is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, duty cycle ≈ 2%, t_r ≤ 1 ns, t_f ≤ 1 ns, t_p = 200 ns.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ≤ 0.75 ns, R_{in} ≥ 1 MΩ, C_{in} ≤ 2 pF.

*JEDEC registered data

TEXAS INSTRUMENTS INCORPORATED
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PRINTED IN U.S.A.

TYPES 3N201, 3N202, 3N203
N-CHANNEL DUAL-GATE DEPLETION-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7111487, APRIL 1971

DEPLETION-TYPE MOS SILICON TRANSISTORS

- Monolithic Gate-Protection Diodes
- Low C_{rss} . . . 0.03 pF Max
- High $|y_{fs}|$ . . . 12, 000 μmhos Typ

description

The 3N201, 3N202, and 3N203 are N-channel, depletion-type, dual-gate, metal-oxide-semiconductor transistors. They are protected from excessive input voltages by integrated back-to-back diodes between gates and source, thus eliminating precautionary handling procedures required by unprotected MOS transistors. These transistors are ideally suited for many applications which previously only vacuum tubes could fulfill.

The 3N201 is intended for use in VHF pre-amplifiers where linear, low-noise amplification is required. Its extremely low feedback capacitance permits high stable gain without the use of neutralization.

The 3N202 is intended for use as a VHF mixer and is well suited for TV tuners. Its use as a mixer minimizes cross-modulation distortion and provides low-noise operation.

The 3N203 is designed for application in tuned high-frequency amplifiers such as TV IF strips. Its extremely low feedback capacitance permits high stage gain and stability without the necessity for neutralization.

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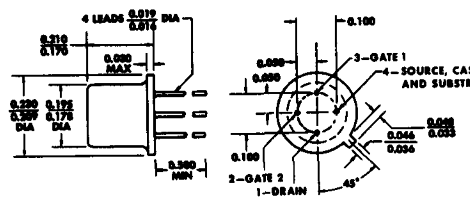
*mechanical data

THE SUBSTRATE AND SOURCE ARE IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain—Gate-One Voltage	30 V
Drain—Gate-Two Voltage	30 V
Drain-Source Voltage	25 V
Forward Gate-One-Terminal Current (See Note 1)	10 mA
Forward Gate-Two-Terminal Current (See Note 1)	10 mA
Reverse Gate-One-Terminal Current	−10 mA
Reverse Gate-Two-Terminal Current	−10 mA
Continuous Drain Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. Forward gate-terminal current is the current into a gate terminal with a forward gate-source voltage applied. This voltage is of such polarity that an increase in its magnitude causes the channel resistance to decrease.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.
3. Derate linearly to 175°C case temperature at the rate of 8 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP MN81

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS				MIN	MAX	UNIT
$V_{(BR)DS}$	Drain-Source Breakdown Voltage	I_D = 10 µA,	$V_{G1S} = V_{G2S}$ = −5 V			25		V
$V_{(BR)G1SSF}$	Gate-One–Source Forward Breakdown Voltage	I_{G1} = 10 mA,	$V_{G2S} = V_{DS}$ = 0,	See Note 4		6	30	V
$V_{(BR)G1SSR}$	Gate-One–Source Reverse Breakdown Voltage	I_{G1} = −10 mA,	$V_{G2S} = V_{DS}$ = 0,	See Note 4		−6	−30	V
$V_{(BR)G2SSF}$	Gate-Two–Source Forward Breakdown Voltage	I_{G2} = 10 mA,	$V_{G1S} = V_{DS}$ = 0,	See Note 4		6	30	V
$V_{(BR)G2SSR}$	Gate-Two–Source Reverse Breakdown Voltage	I_{G2} = −10 mA,	$V_{G1S} = V_{DS}$ = 0,	See Note 4		−6	−30	V
I_{G1SSF}	Gate-One-Terminal Forward Current	V_{G1S} = 5 V,	$V_{G2S} = V_{DS}$ = 0				10	nA
I_{G1SSR}	Gate-One-Terminal Reverse Current	V_{G1S} = −5 V,	$V_{G2S} = V_{DS}$ = 0				−10	nA
		V_{G1S} = −5 V,	$V_{G2S} = V_{DS}$ = 0,	T_A = 150°C			−10	µA
I_{G2SSF}	Gate-Two-Terminal Forward Current	V_{G2S} = 5 V,	$V_{G1S} = V_{DS}$ = 0				10	nA
I_{G2SSR}	Gate-Two-Terminal Reverse Current	V_{G2S} = −5 V,	$V_{G1S} = V_{DS}$ = 0				−10	nA
		V_{G2S} = −5 V,	$V_{G1S} = V_{DS}$ = 0,	T_A = 150°C			−10	µA
I_{DS}	Zero-Gate-One-Voltage Drain Current	V_{DS} = 15 V, V_{G2S} = 4 V,	V_{G1S} = 0, See Note 5		3N201 3N202	6	30	mA
					3N203	3	15	
$V_{G1S(off)}$	Gate-One–Source Cutoff Voltage	V_{DS} = 15 V,	V_{G2S} = 4 V,	I_D = 20 µA		−0.5	−5	V
$V_{G2S(off)}$	Gate-Two–Source Cutoff Voltage	V_{DS} = 15 V,	V_{G1S} = 0,	I_D = 20 µA		−0.2	−5	V
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	V_{DS} = 15 V, V_{G2S} = 4 V, See Note 6	V_{G1S} = 0, f = 1 kHz,		3N201 3N202	8	20	mmho
					3N203	7	15	
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	V_{DS} = 15 V, f = 1 MHz	V_{G2S} = 4 V,	I_D = 10 mA,		0.005	0.03	pF

NOTES: 4. All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage-limiting network is functioning properly.
5. This parameter must be measured using pulse techniques. t_w = 300 µs, duty cycle < 2%.
6. This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.

*3N201 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		3N201 MIN	3N201 MAX	UNIT
NF	Common-Source Spot Noise Figure	V_{DD} = 18 V, f = 200 MHz,	V_{GG} = 7 V, See Figure 1		4.5	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain			15	25	dB
BW	Bandwidth			5	9	MHz
$V_{GG(GC)}$	Gain-Control Gate-Supply Voltage	V_{DD} = 18 V, f = 200 MHz,	ΔG_{ps} = −30 dB†, See Figure 1	0	−3	V

†ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 7 volts.
*JEDEC registered data

*3N202 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		3N202 MIN	3N202 MAX	UNIT
$G_{ps(conv)}$	Small-Signal Conversion Power Gain	V_{DD} = 18 V, f_{RF} = 200 MHz,	f_{LO} = 245 MHz‡, See Figure 2	15	25	dB
BW	Bandwidth			4.5	7.5	MHz

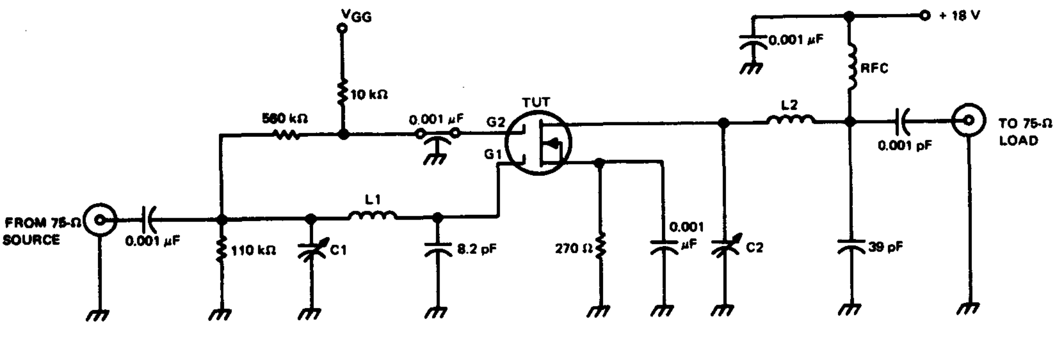
‡Amplitude at input from local oscillator is 3 volts rms.

*3N203 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		3N203 MIN	3N203 MAX	UNIT
NF	Common-Source Spot Noise Figure	V_{DD} = 18 V, f = 45 MHz,	V_{GG} = 6 V, See Figure 3		6	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain			20	30	dB
BW	Bandwidth			3	6	MHz
$V_{GG(GC)}$	Gain-Control Gate-Supply Voltage	V_{DD} = 18 V, f = 45 MHz,	ΔG_{ps} = −30 dB§, See Figure 3	0	−3	V

§ΔG_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 6 volts.

*PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

C1: Erie variable ceramic, 4–30 pF, set for ≈ 22 pF
C2: Erie variable ceramic, 4–30 pF, set for ≈ 10 pF
L1: 4T, #14 copper, 1/4" ID, 1/6" pitch
L2: 3T, #14 copper, 1/4" ID, 1/8" pitch
RFC: Delevan No. 153712, 1 µH

FIGURE 1—200-MHz POWER GAIN, GAIN-CONTROL VOLTAGE, AND NOISE FIGURE TEST CIRCUIT FOR 3N201

*JEDEC registered data

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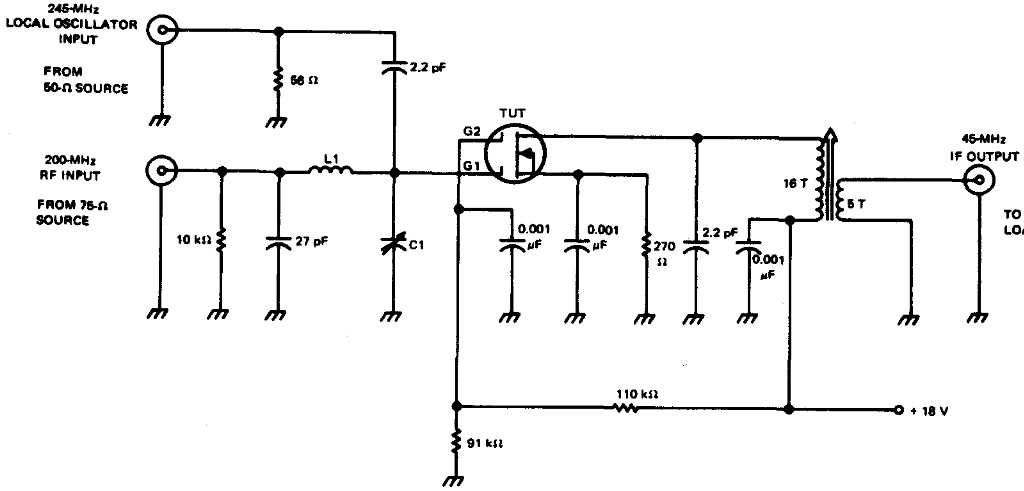
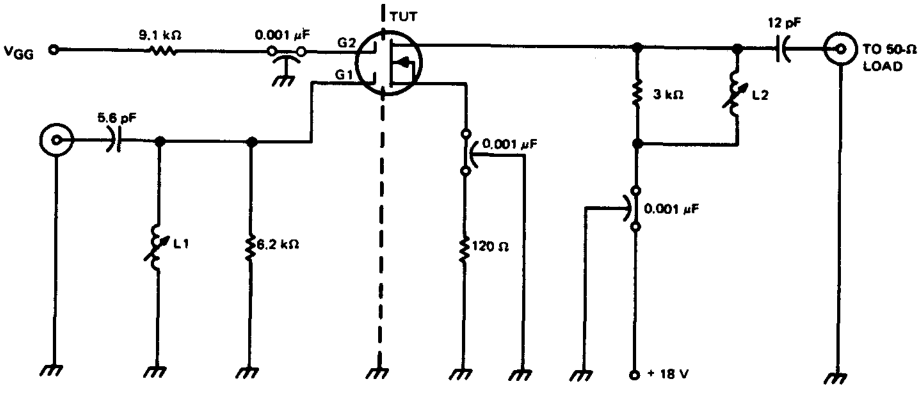
*PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

C1: Erie variable ceramic, 1.5–7 pF, set for ≈ 4.7 pF
L1: 4T, #14 copper, 1/4" ID, 1/6" pitch

FIGURE 2–200-MHz-to-45-MHz CIRCUIT FOR CONVERSION POWER GAIN FOR 3N202



CIRCUIT COMPONENT INFORMATION

L1: 14T, #30 copper, close-wound on 7/32" OD form with Arnold Engineering type "J" tuning core
L2: 10T, #30 copper, close-wound on 7/32" OD form with Arnold Engineering type "J" tuning core

FIGURE 3–45-MHz POWER GAIN, GAIN-CONTROL VOLTAGE, AND NOISE FIGURE TEST CIRCUIT FOR 3N203

*JEDEC registered data

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

3N201
RELATIVE SMALL-SIGNAL POWER-GAIN
vs
GAIN-CONTROL GATE-SUPPLY VOLTAGE

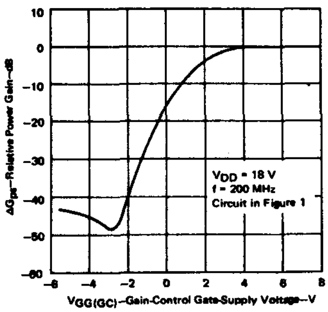


FIGURE 4

3N201
SMALL-SIGNAL COMMON-SOURCE INSERTION POWER GAIN
vs
DRAIN CURRENT

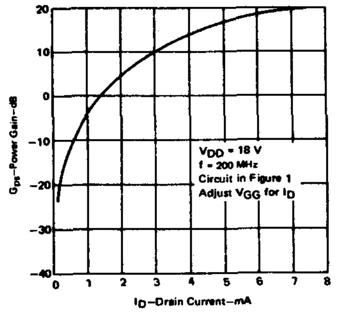


FIGURE 5

3N201
COMMON-SOURCE SPOT NOISE FIGURE
vs
GAIN-CONTROL GATE-SUPPLY VOLTAGE

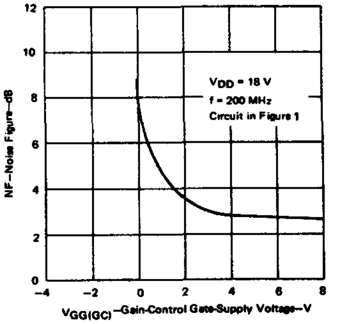


FIGURE 6

3N202
SMALL-SIGNAL CONVERSION POWER GAIN
vs
INPUT FROM LOCAL OSCILLATOR

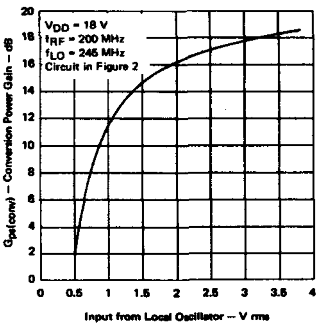


FIGURE 7

3N203
SMALL-SIGNAL COMMON-SOURCE INSERTION POWER GAIN
vs GAIN-CONTROL SUPPLY VOLTAGE

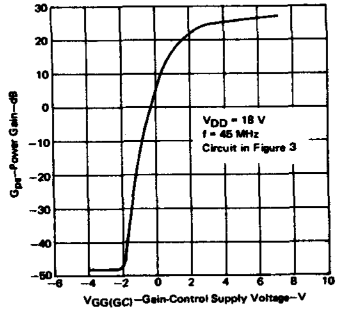


FIGURE 8

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 3N204, 3N205, 3N206
N-CHANNEL DUAL-GATE DEPLETION-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 7211717, MAY 1972

DEPLETION-TYPE MOS SILICON TRANSISTORS

- Monolithic Gate-Protection Diodes
- Low C_{rss} . . . 0.03 pF Max
- High $|y_{fs}|$ . . . 14,000 μmhos Typ

description

The 3N204, 3N205, and 3N206 are N-channel, depletion-type, dual-gate, metal-oxide-semiconductor transistors. They are protected from excessive input voltages by integrated back-to-back diodes between gates and source, thus eliminating precautionary handling procedures required by unprotected MOS transistors. These transistors are ideally suited for many applications which previously only vacuum tubes could fulfill.

The 3N204 is intended for use in VHF pre-amplifiers where linear, low-noise amplification is required. Its extremely low feedback capacitance permits high stable gain without the use of neutralization.

The 3N205 is intended for use as a VHF mixer and is well suited for TV tuners. Its use as a mixer minimizes cross-modulation distortion and provides low-noise operation.

The 3N206 is designed for application in tuned high-frequency amplifiers such as TV IF strips. Its extremely low feedback capacitance permits high stage gain and stability without the necessity for neutralization.

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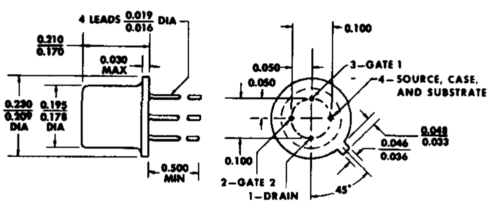
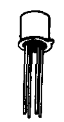
*mechanical data

THE SUBSTRATE AND SOURCE ARE IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED



ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain—Gate-One Voltage	30 V
Drain—Gate-Two Voltage	30 V
Drain-Source Voltage	25 V
Forward Gate-One-Terminal Current (See Note 1)	10 mA
Forward Gate-Two-Terminal Current (See Note 1)	10 mA
Reverse Gate-One-Terminal Current	−10 mA
Reverse Gate-Two-Terminal Current	−10 mA
Continuous Drain Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mW
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	1.2 W
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. Forward gate-terminal current is the current into a gate terminal with a forward gate-source voltage applied. This voltage is of such polarity that an increase in its magnitude causes the channel resistance to decrease.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.
3. Derate linearly to 175°C case temperature at the rate of 8 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

USES CHIP MN81

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS				MIN	MAX	UNIT
$V_{(BR)DS}$	Drain-Source Breakdown Voltage	$I_D = 10\ \mu A$,	$V_{G1S} = V_{G2S} = -5$ V			25		V
$V_{(BR)G1SSF}$	Gate-One–Source Forward Breakdown Voltage	$I_{G1} = 10$ mA,	$V_{G2S} = V_{DS} = 0$,	See Note 4		6	30	V
$V_{(BR)G1SSR}$	Gate-One–Source Reverse Breakdown Voltage	$I_{G1} = -10$ mA,	$V_{G2S} = V_{DS} = 0$,	See Note 4		−6	−30	V
$V_{(BR)G2SSF}$	Gate-Two–Source Forward Breakdown Voltage	$I_{G2} = 10$ mA,	$V_{G1S} = V_{DS} = 0$,	See Note 4		6	30	V
$V_{(BR)G2SSR}$	Gate-Two–Source Reverse Breakdown Voltage	$I_{G2} = -10$ mA,	$V_{G1S} = V_{DS} = 0$,	See Note 4		−6	−30	V
I_{G1SSF}	Gate-One-Terminal Forward Current	$V_{G1S} = 5$ V,	$V_{G2S} = V_{DS} = 0$				10	nA
I_{G1SSR}	Gate-One-Terminal Reverse Current	$V_{G1S} = -5$ V,	$V_{G2S} = V_{DS} = 0$				−10	nA
		$V_{G1S} = -5$ V,	$V_{G2S} = V_{DS} = 0$,	$T_A = 150°C$			−10	μA
I_{G2SSF}	Gate-Two-Terminal Forward Current	$V_{G2S} = 5$ V,	$V_{G1S} = V_{DS} = 0$				10	nA
I_{G2SSR}	Gate-Two-Terminal Reverse Current	$V_{G2S} = -5$ V,	$V_{G1S} = V_{DS} = 0$				−10	nA
		$V_{G2S} = -5$ V,	$V_{G1S} = V_{DS} = 0$,	$T_A = 150°C$			−10	μA
I_{DS}	Zero-Gate-One-Voltage Drain Current	$V_{DS} = 15$ V, $V_{G2S} = 4$ V,	$V_{G1S} = 0$, See Note 5		3N204 3N205	6	30	mA
					3N206	3	15	
$V_{G1S(off)}$	Gate-One–Source Cutoff Voltage	$V_{DS} = 15$ V,	$V_{G2S} = 4$ V,	$I_D = 20\ \mu A$		−0.5	−4	V
$V_{G2S(off)}$	Gate-Two–Source Cutoff Voltage	$V_{DS} = 15$ V,	$V_{G1S} = 0$,	$I_D = 20\ \mu A$		−0.2	−4	V
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{G2S} = 4$ V, See Note 6	$V_{G1S} = 0$, f = 1 kHz,		3N204 3N205	10	22	mmho
					3N206	7	17	
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 15$ V, f = 1 MHz	$V_{G2S} = 4$ V,	$I_D = 10$ mA,		0.005	0.03	pF

NOTES: 4. All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage-limiting network is functioning properly.

5. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

6. This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating.

*3N204 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	3N204 MIN	3N204 TYP	3N204 MAX	UNIT
F	Common-Source Spot Noise Figure	$V_{DD} = 18$ V, $V_{GG} = 7$ V, f = 200 MHz, See Figure 1			3.5	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain		20		28	dB
B	Bandwidth		7		12	MHz
$V_{GG(GC)}$	Gain-Control Gate-Supply Voltage	$V_{DD} = 18$ V, $\Delta G_{ps} = -30$ dB†, f = 200 MHz, See Figure 1	0		−2	V
F	Common-Source Spot Noise Figure	$V_{DS} = 15$ V, $V_{G2S} = 4$ V, $I_D = 10$ mA, f = 450 MHz, See Figures 2 and 4			5	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain		14			dB
F	Common-Source Spot Noise Figure	$V_{DS} = 15$ V, $V_{G2S} \approx 4$ V, $I_D = 10$ mA, f = 900 MHz, See Figures 3 and 5		7		dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain			12		dB

†ΔG_{ps} is defined as the change in G_{ps} from the value at $V_{GG} = 7$ volts.

*JEDEC registered data

*3N205 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		3N205 MIN	3N205 MAX	UNIT
$G_{ps(conv)}$	Small-Signal Conversion Power Gain	V_{DD} = 18 V,	f_{LO} = 245 MHz‡,	17	28	dB
B	Bandwidth	f_{RF} = 200 MHz,	See Figure 6	4	7	MHz

‡Amplitude at input from local oscillator is 3 volts rms.

*3N206 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS		3N206 MIN	3N206 MAX	UNIT
F	Common-Source Spot Noise Figure	V_{DD} = 24 V, f = 45 MHz,	V_{GG} = 6 V, See Figure 7		4	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain			25	35	dB
B	Bandwidth			3	6	MHz
$V_{GG(GC)}$	Gain-Control Gate-Supply Voltage	V_{DD} = 24 V, f = 45 MHz,	ΔG_{ps} = −30 dB §, See Figure 7		+0.6 −1.6	V

§G_{ps} is defined as the change in G_{ps} from the value at V_{GG} = 6 volts.

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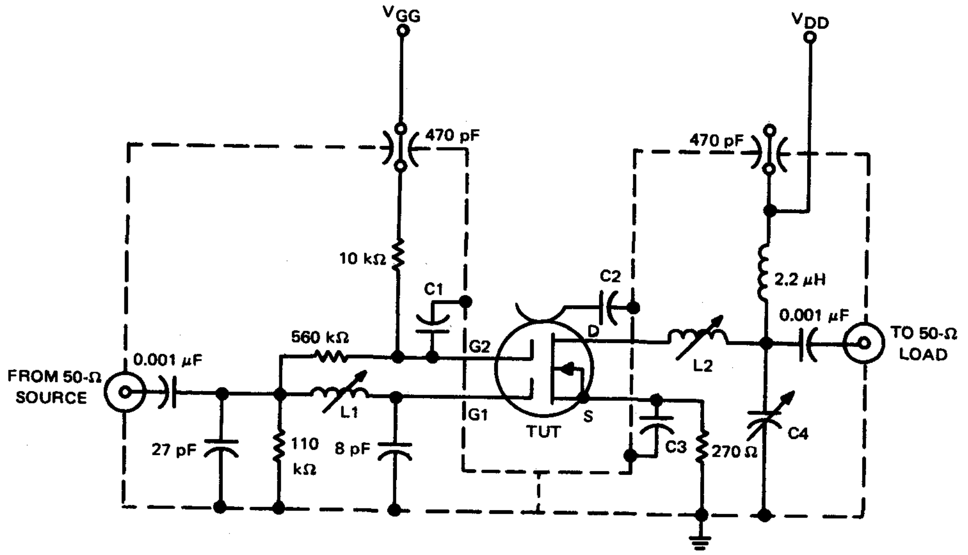
PARAMETER MEASUREMENT INFORMATION



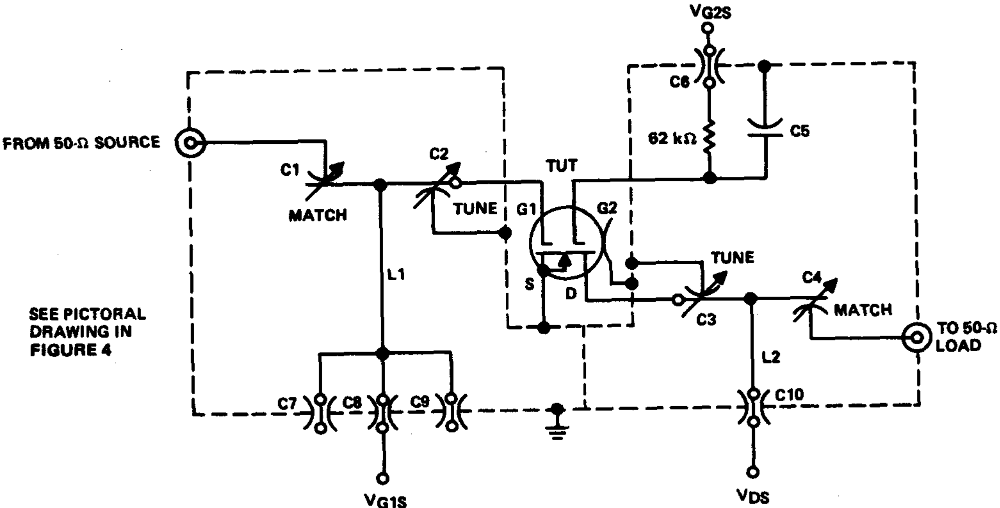
CIRCUIT COMPONENT INFORMATION

C1, C2, & C3: Leadless disc ceramic, 0.001 µF
C4: ARCO 462, 5-80 pF, or equivalent
L1: 3T #18, 3/16-inch-dia aluminum slug
L2: 9T #20, 3/16-inch-dia aluminum slug

FIGURE 1—200-MHz POWER GAIN, GAIN CONTROL VOLTAGE, AND NOISE FIGURE TEST CIRCUIT FOR 3N204*

*JEDEC registered data

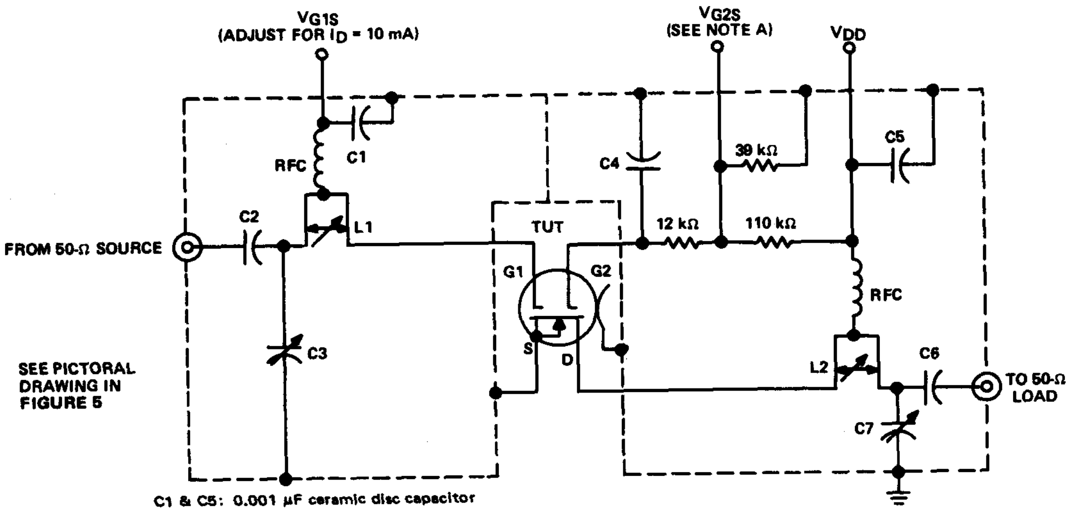
PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

C1 thru C4: See Figure 30, Note D
C5: 0.001 μF leadless disc capacitor
C6 thru C10: Allen-Bradley F5AU 0.001 μF feed-through capacitors
L1 & L2: See Figure 30

FIGURE 2—450-MHz POWER GAIN AND NOISE TEST CIRCUIT FOR 3N204*



C1 & C5: 0.001 μF ceramic disc capacitor
C2, C4, & C6: 0.001 μF leadless disc capacitor
C3 & C7: Johanson 3901, 1-15 pF, or equivalent
L1 & L2 are 1/4 inch slotted cyclinders, 3/16 inch inside diameter, with a shorting ring adjusted by a nylon screw. Minimum slot lengths are 3/4 inch for L1 and 1 inch for L2.
RFC: 10T #30, 3/16 inch dia, 5/16 inch in length

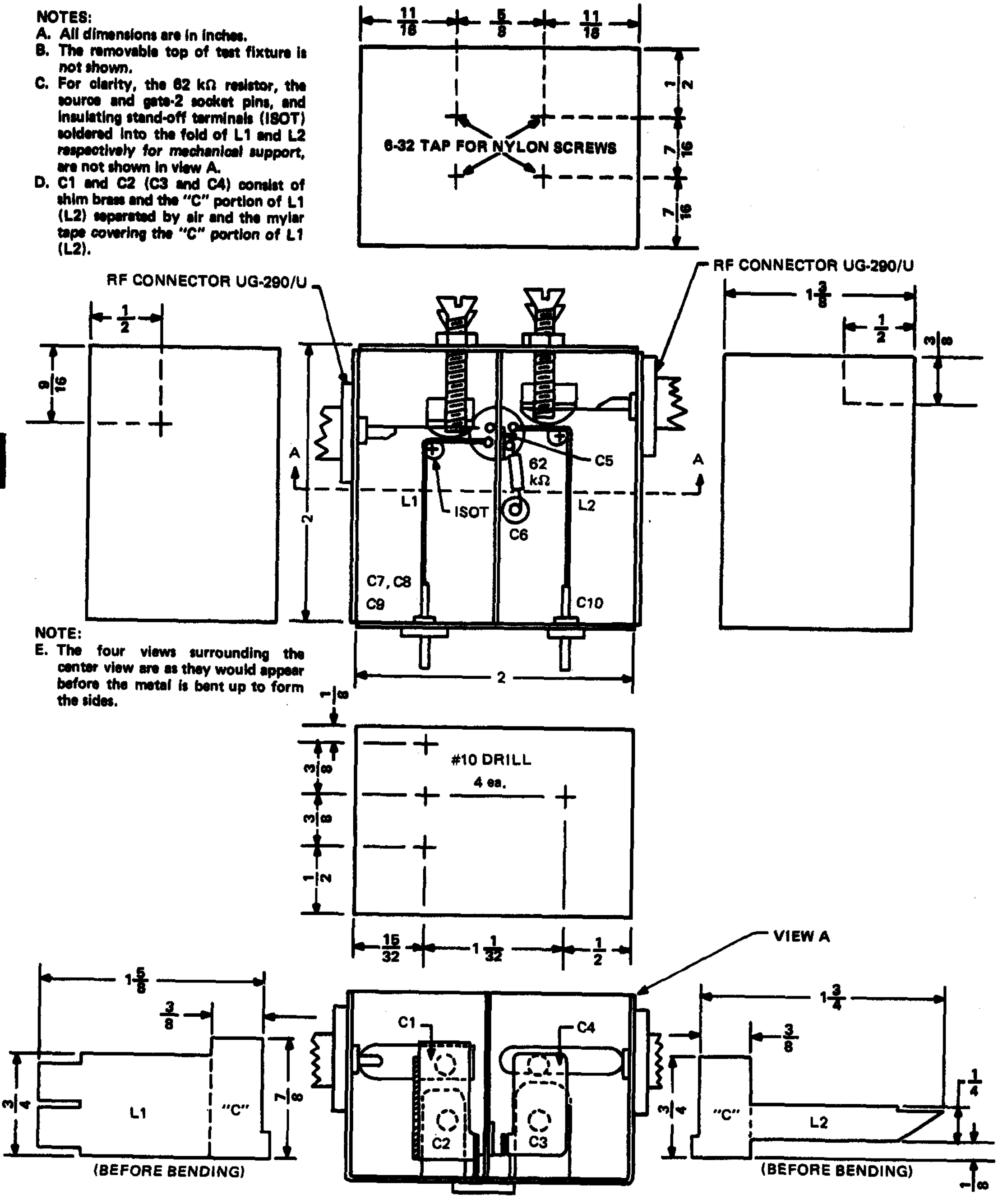
NOTE A: This terminal is provided for gain control, if desired. If not used for this purpose, it should be left open.

FIGURE 3—900-MHz POWER GAIN AND NOISE TEST CIRCUIT FOR 3N204

*JEDEC registered data

NOTES:
A. All dimensions are in inches.
B. The removable top of test fixture is not shown.
C. For clarity, the 62 kΩ resistor, the source and gate-2 socket pins, and insulating stand-off terminals (ISOT) soldered into the fold of L1 and L2 respectively for mechanical support, are not shown in view A.
D. C1 and C2 (C3 and C4) consist of shim brass and the "C" portion of L1 (L2) separated by air and the mylar tape covering the "C" portion of L1 (L2).

NOTE:
E. The four views surrounding the center view are as they would appear before the metal is bent up to form the sides.



*JEDEC registered data

FIGURE 4—450-MHz POWER GAIN AND NOISE TEST FIXTURE*

NOTES:
A. All dimensions are in inches.
B. The removable top of test fixture is not shown.
C. L1 and L2 are attached to the back of the test fixture by insulating stand-off terminals (ISOT) located as shown.
D. The four views surrounding the center view are as they would appear before the metal is bent up to form the sides.

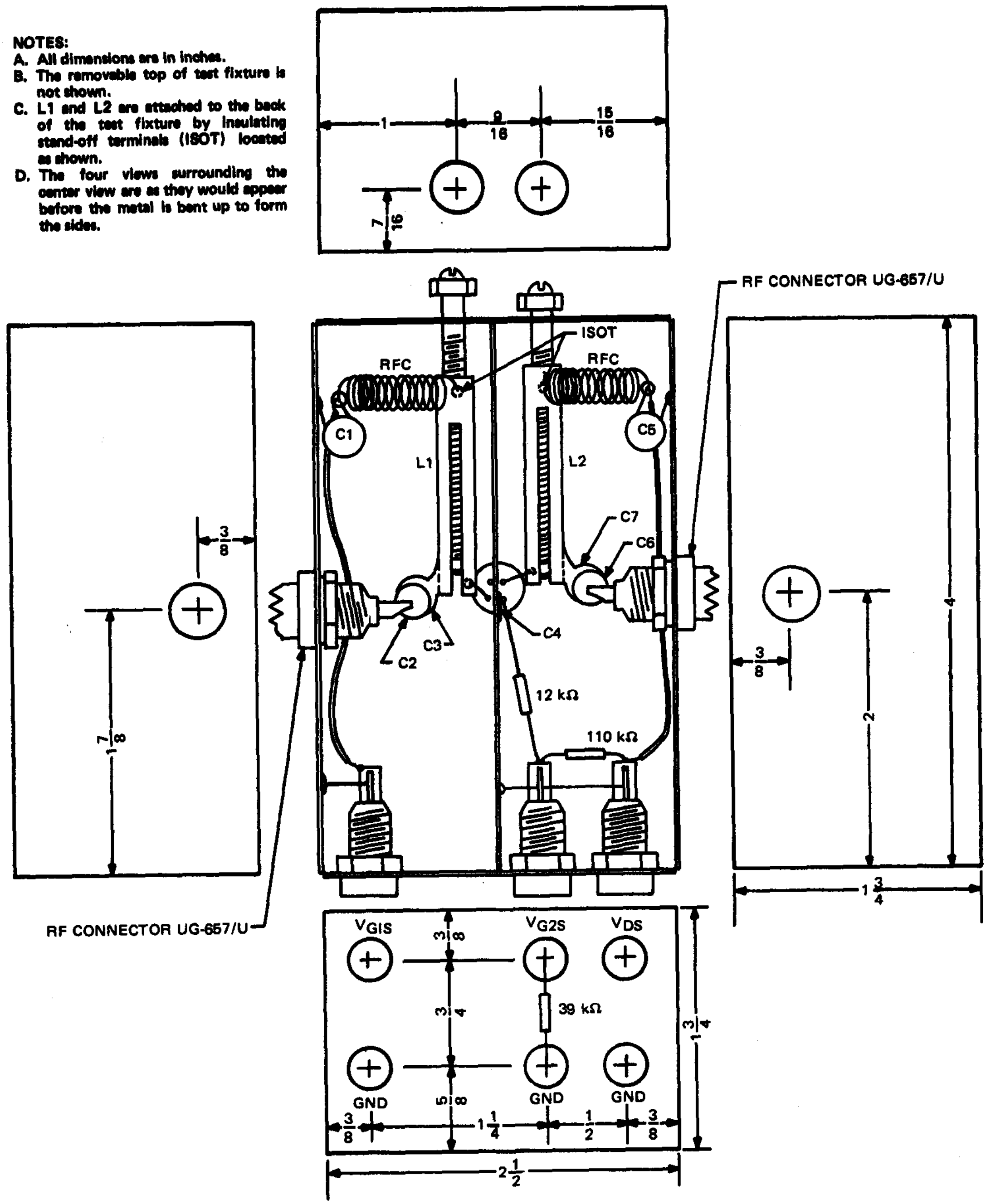
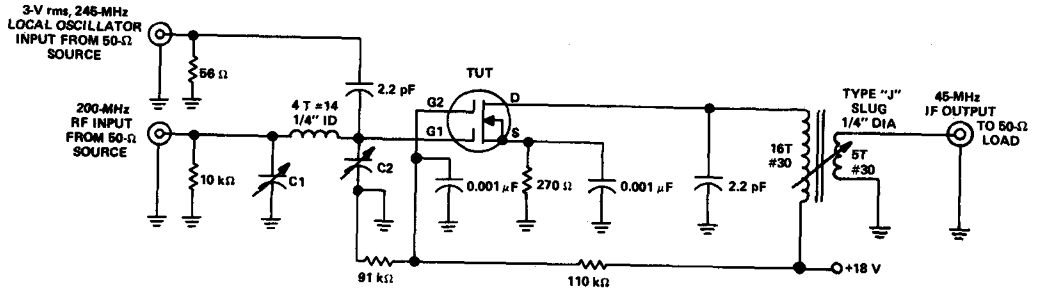


FIGURE 5—900-MHz POWER GAIN AND NOISE TEST FIXTURE

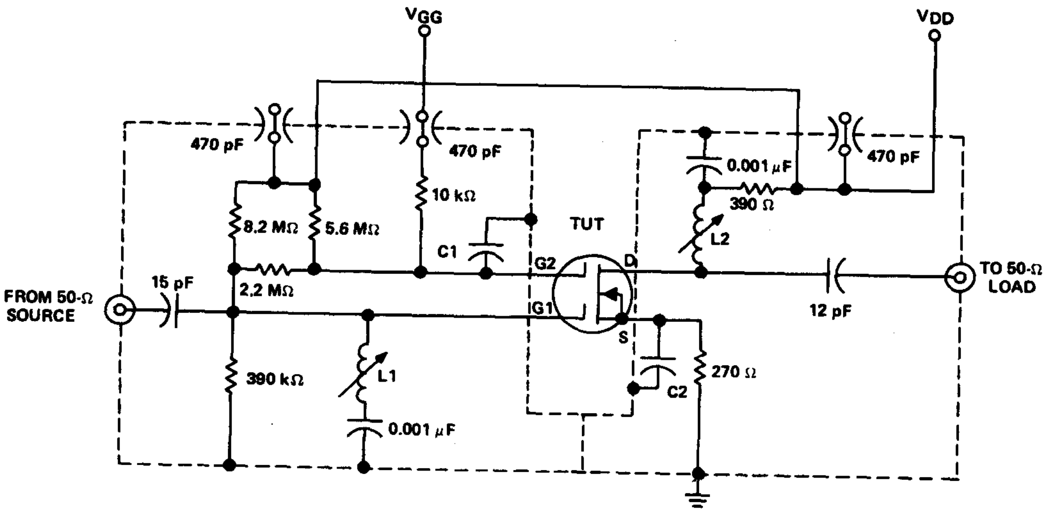
PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

C1: Arco 404 (or equivalent), 8 to 60 pF
C2: Arco 400 (or equivalent), 0.9 to 7 pF

FIGURE 6—200-MHz-to-45-MHz CIRCUIT FOR CONVERSION POWER GAIN FOR 3N206*



CIRCUIT COMPONENT INFORMATION

C1: Leadless disc ceramic, 0.001 μF
C2: Leadless disc ceramic, 0.01 μF
L1: 8T # 28, 5/32-inch-dia form, type "J" slug
L2: 9T # 28, 5/32-inch-dia form, type "J" slug

FIGURE 7—45-MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT FOR 3N206*

*JEDEC registered data

4

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

3N204
RELATIVE SMALL-SIGNAL POWER GAIN
vs
GAIN-CONTROL GATE-SUPPLY VOLTAGE

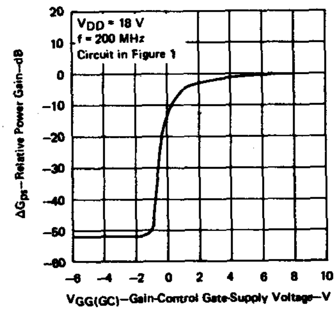


FIGURE 8

3N204
SMALL-SIGNAL COMMON-SOURCE INSERTION POWER GAIN
vs
DRAIN CURRENT

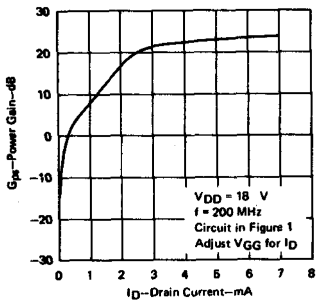


FIGURE 9

3N204
COMMON-SOURCE SPOT NOISE FIGURE
vs
GAIN-CONTROL GATE-SUPPLY VOLTAGE

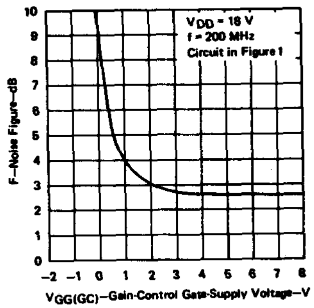


FIGURE 10

3N204
OPTIMUM SPOT NOISE FIGURE
vs
FREQUENCY

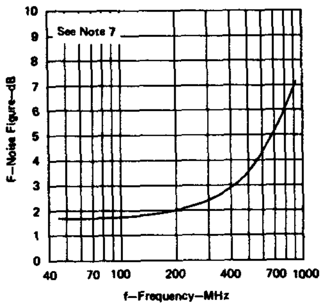


FIGURE 11

3N205
SMALL-SIGNAL CONVERSION POWER GAIN
vs
INPUT FROM LOCAL OSCILLATOR

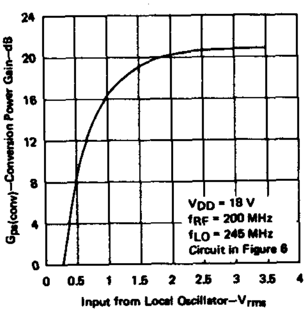


FIGURE 12

3N206
SMALL-SIGNAL COMMON-SOURCE INSERTION POWER GAIN
vs
GAIN-CONTROL GATE-SUPPLY VOLTAGE

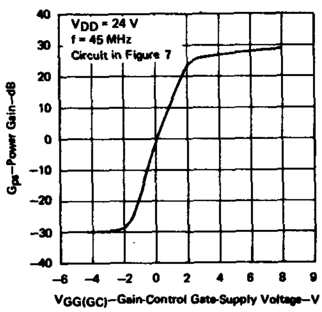


FIGURE 13

NOTE 7: Test conditions at 45 MHz, 200 MHz, 450 MHz, and 900 MHz are the conditions given in the tables of operating characteristics for 3N204 and 3N206.

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TYPE 3N207
DUAL P-CHANNEL ENHANCEMENT-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTOR

BULLETIN NO. DL-S 7311708, APRIL 1972—REVISED MARCH 1973

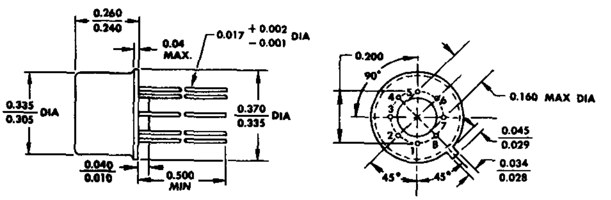
TWO ENHANCEMENT-TYPE† MOS SILICON TRANSISTORS WITHIN A SINGLE MONOLITHIC CHIP

For Applications Requiring Very High Input Impedance, Such as Series and Shunt Choppers, Multiplexers, and Commutators

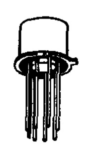
- **Designed to be Interchangeable with General Instrument Type MEM551**
- **Channel Cut Off with Zero Gate Voltage**
- **Substrate Connection Provides Flexibility in Biasing**
- **Similar Diode-Protected Version Available . . . 3N208**
- **Matched on V_{GS}**

*mechanical data

ALL LEADS INSULATED FROM CASE



1 DRAIN 1
2 SOURCE 1
3 GATE 1
4 SUBSTRATE
5 GATE 2
6 SOURCE 2
7 DRAIN 2
8 NO INTERNAL CONNECTION



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED
ALL JEDEC TO-76 DIMENSIONS AND NOTES ARE APPLICABLE

handling precautions

Curve-tracer testing and static-charge buildup are common causes of damage to insulated-gate devices. Permanent damage may result if either gate-voltage rating is exceeded even for extremely short time periods. Each transistor is protected during shipment by a gate-shorting device, which should be removed only during testing and after permanent mounting of the transistor. Personnel and equipment, including soldering irons, should be grounded.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRANSISTOR	TOTAL DEVICE
Drain-Gate Voltage	−25 V	
Drain-Source Voltage	−25 V	
Forward Gate-Source Voltage	−25 V	
Reverse Gate-Source Voltage	25 V	
Continuous Drain Current	−100 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW	600 mW
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTE 1: Derate linearly to 175°C free-air temperature at the rates of 2 mW/°C for each transistor and 4 mW/°C for the total device.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†Enhancement-mode operation entails the use of a forward gate-source voltage to increase drain current from I_{DSS}, the drain current at $V_{GS} = 0$, as opposed to depletion-mode operation wherein a reverse gate-source voltage is used to decrease drain current. An enhancement-type transistor is in the "off" state at $V_{GS} = 0$ and hence will not operate normally in the depletion mode.

USES CHIP MP94

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual transistor characteristics (see note 2)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -25$ V, $V_{DS} = 0$		−4	pA
		$V_{GS} = -25$ V, $V_{DS} = 0$, $T_A = 150°C$		−200	nA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 25$ V, $V_{DS} = 0$		4	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -20$ V, $V_{GS} = 0$		−10	nA
		$V_{DS} = -20$ V, $V_{GS} = 0$, $T_A = 150°C$		−10	μA
I_{SDS}	Zero-Gate-Voltage Source Current	$V_{SD} = -20$ V, $V_{GD} = 0$		−10	nA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10$ μA	−3	−6	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -15$ V, See Note 3	−1.5		mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = -15$ V, $I_D = 0$, f = 1 kHz		400	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -20$ V, $V_{GS} = 0$, f = 1 MHz		4	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = 0$, f = 1 MHz		2.5	pF
C_{ds}	Drain-Source Capacitance	$V_{DS} = -20$ V, $V_{GS} = 0$, f = 1 MHz, See Note 4		3	pF

transistor matching characteristics (see note 5)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$\lvert V_{GS1} - V_{GS2} \rvert$	Gate-Source Voltage Differential	$V_{DS} = -15$ V, $I_D = -250$ μA		200	mV

NOTES: 2. For all individual-transistor measurements except C_{ds}, the drain, source, and gate leads of the transistor not under test and the common substrate are grounded. For testing I_{SDS}, ground is the drain of the transistor under test but for all other measurements, it is the source.
3. This parameter must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
4. C_{ds} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The case and all terminals of both transistors except the drain and source of the transistor under test are connected to the guard terminal of the bridge.
5. Transistor matching characteristics are measured with both sources connected to the substrate.

*JEDEC registered data

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DUAL P-CHANNEL ENHANCEMENT-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTOR

BULLETIN NO. DL-S 7311709, APRIL 1972—REVISED MARCH 1973

TWO DIODE-PROTECTED ENHANCEMENT-TYPE† MOS SILICON TRANSISTORS WITHIN A SINGLE MONOLITHIC CHIP

For Applications Requiring Very High Input Impedance, Such as Series and Shunt Choppers, Multiplexers, and Commutators

- **Designed to be Interchangeable with General Instrument Type MEM550**
- **Channel Cut Off with Zero Gate Voltage**
- **Substrate Connection Provides Flexibility in Biasing**
- **Internally Connected Diode Protects Gate from Damage due to Overvoltage**
- **Version Available without Diode Protection . . . 3N207**

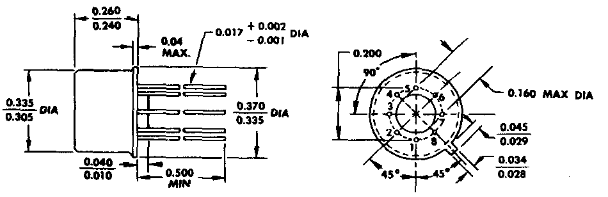
description

This device is designed for applications requiring very high input impedance, such as choppers, commutators, and logic switches. Each transistor is protected from excessive input voltage by a shunting diode connected from its gate to the substrate. This eliminates the need for most precautionary handling procedures associated with unprotected MOS devices.

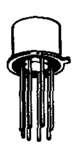
4

*mechanical data

ALL LEADS INSULATED FROM CASE



1 DRAIN 1
2 SOURCE 1
3 GATE 1
4 SUBSTRATE
5 GATE 2
6 SOURCE 2
7 DRAIN 2
8 NO INTERNAL CONNECTION



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED

ALL JEDEC TO-76 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRANSISTOR	TOTAL DEVICE
Drain-Gate Voltage	−25 V	
Drain-Source Voltage	−25 V	
Continuous Forward Gate-Terminal Current	−0.1 mA	
Continuous Reverse Gate-Terminal Current	10 mA	
Continuous Drain Current	−100 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW	600 mW
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←— 300°C —→	

NOTE 1: Derate linearly to 175°C free-air temperature at the rates of 2 mW/°C for each transistor and 4 mW/°C for the total device.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†Enhancement-mode operation entails the use of a forward gate-source voltage to increase drain current from I_{DSS}, the drain current at $V_{GS} = 0$, as opposed to depletion-mode operation wherein a reverse gate-source voltage is used to decrease drain current. An enhancement-type transistor is in the "off" state at $V_{GS} = 0$ and hence will not operate normally in the depletion mode. The protective shunting diode is reverse-biased by the application of forward gate-source voltage.

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*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS‡	MIN	MAX	UNIT
$V_{(BR)GSSF}$	Forward Gate-Source Breakdown Voltage	$I_G = -0.1$ mA, $V_{DS} = 0$, See Note 2	−30		V
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -15$ V, $V_{DS} = 0$		−1	nA
		$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 150°C$		−2	μA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -20$ V, $V_{GS} = 0$		−10	nA
		$V_{DS} = -20$ V, $V_{GS} = 0$, $T_A = 150°C$		−10	μA
I_{SDS}	Zero-Gate-Voltage Source Current	$V_{SD} = -20$ V, $V_{GD} = 0$		−10	nA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10$ μA	−3	−6	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -15$ V, See Note 3	−1.5		mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = -15$ V, $I_D = 0$, f = 1 kHz		400	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -20$ V, $V_{GS} = 0$, f = 1 MHz		4	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = 0$, f = 1 MHz		2.5	pF
C_{ds}	Drain-Source Capacitance	$V_{DS} = -20$ V, $V_{GS} = 0$, f = 1 MHz, See Note 4		3	pF

NOTES: 2. To ensure that the gate-shunting diode is functioning properly, this voltage is measured while the device is conducting rated forward gate-terminal current.
3. This parameter must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
4. C_{ds} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The case and all terminals of both transistors except the drain and source of the transistor under test are connected to the guard terminal of the bridge.

*JEDEC registered data

‡For all measurements except C_{ds}, the drain, source, and gate leads of the transistor not under test and the common substrate are grounded. For testing I_{SDS}, ground is the drain of the transistor under test but for all other measurements, it is the source.

4

BULLETIN NO. DL-S 7312009, MARCH 1973

DEPLETION-TYPE MOS SILICON TRANSISTORS

- Monolithic Gate-Protection Diodes
- Low C_{rss} . . . 0.05 pF Max
- High $|y_{fs}|$ . . . 30,000 μmhos Typ for 3N211 and 3N212

description

The 3N211, 3N212, and 3N213 are N-channel, depletion-type, dual-gate, metal-oxide-semiconductor transistors. They are protected from excessive input voltages by integrated back-to-back diodes between gates and source, thus eliminating precautionary handling procedures required by unprotected MOS transistors.

The 3N211 is intended for use in VHF pre-amplifiers where linear, low-noise amplification is required. Its extremely low feedback capacitance permits high stable gain without the use of neutralization.

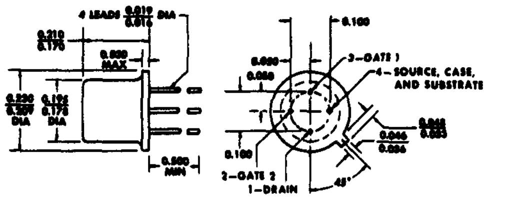
The 3N212 is intended for use as a VHF mixer and is well suited for TV tuners. Its use as a mixer minimizes cross-modulation distortion and provides low-noise operation.

The 3N213 is designed for application in tuned high-frequency amplifiers such as TV IF strips. Its extremely low feedback capacitance permits high stage gain and stability without the necessity for neutralization.

4

*mechanical data

THE SUBSTRATE AND SOURCE ARE IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	3N211 3N212	3N213
Drain—Gate-One Voltage	35 V	40 V
Drain—Gate-Two Voltage	35 V	40 V
Drain-Source Voltage	27 V	35 V
Forward Gate-One-Terminal Current (See Note 1)	←10 mA→	
Forward Gate-Two-Terminal Current (See Note 1)	←10 mA→	
Reverse Gate-One-Terminal Current	←−10 mA→	
Reverse Gate-Two-Terminal Current	←−10 mA→	
Continuous Drain Current	←50 mA→	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←360 mW→	
Continuous Device Dissipation at (or below) 25°C Case Temperature (See Note 3)	←1.2 W→	
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	←300°C→	

NOTES: 1. Forward gate-terminal current is the current into a gate terminal with a forward gate-source voltage applied. This voltage is of such polarity that an increase in its magnitude causes the channel resistance to decrease.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.
3. Derate linearly to 175°C case temperature at the rate of 8 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	3N211 MIN	3N211 MAX	3N212 MIN	3N212 MAX	3N213 MIN	3N213 MAX	UNIT
$V_{(BR)DS}$	Drain-Source Breakdown Voltage	$I_D = 10\ \mu A$, $V_{G1S} = V_{G2S} = -4$ V, $t = 5$ s	27		27		35		V
$V_{(BR)DS}$	Instantaneous Drain-Source Breakdown Voltage	$I_D = 10\ \mu A$, $V_{G1S} = V_{G2S} = -4$ V	25		25		30		V
$V_{(BR)G1SSF}$	Gate-One–Source Forward Breakdown Voltage	$I_{G1} = 10$ mA, $V_{G2S} = V_{DS} = 0$, See Note 4	6		6		6		V
$V_{(BR)G1SSR}$	Gate-One–Source Reverse Breakdown Voltage	$I_{G1} = -10$ mA, $V_{G2S} = V_{DS} = 0$, See Note 4	−6		−6		−6		V
$V_{(BR)G2SSF}$	Gate-Two–Source Forward Breakdown Voltage	$I_{G2} = 10$ mA, $V_{G1S} = V_{DS} = 0$, See Note 4	6		6		6		V
$V_{(BR)G2SSR}$	Gate-Two–Source Reverse Breakdown Voltage	$I_{G2} = -10$ mA, $V_{G1S} = V_{DS} = 0$, See Note 4	−6		−6		−6		V
I_{G1SSF}	Gate-One-Terminal Forward Current	$V_{G1S} = 5$ V, $V_{G2S} = V_{DS} = 0$		10		10		10	nA
I_{G1SSR}	Gate-One-Terminal Reverse Current	$V_{G1S} = -5$ V, $V_{G2S} = V_{DS} = 0$		−10		−10		−10	nA
		$V_{G1S} = -5$ V, $V_{G2S} = V_{DS} = 0$, $T_A = 150°C$		−10		−10		−10	µA
I_{G2SSF}	Gate-Two-Terminal Forward Current	$V_{G2S} = 5$ V, $V_{G1S} = V_{DS} = 0$		10		10		10	nA
I_{G2SSR}	Gate-Two-Terminal Reverse Current	$V_{G2S} = -5$ V, $V_{G1S} = V_{DS} = 0$		−10		−10		−10	nA
		$V_{G2S} = -5$ V, $V_{G1S} = V_{DS} = 0$, $T_A = 150°C$		−10		−10		−10	µA
I_{DS}	Zero-Gate-One-Voltage Drain Current	$V_{DS} = 15$ V, $V_{G1S} = 0$, $V_{G2S} = 4$ V, See Note 5	6	40	6	40	6	40	mA
$V_{G1S(off)}$	Gate-One–Source Cutoff Voltage	$V_{DS} = 15$ V, $V_{G2S} = 4$ V, $I_D = 20\ \mu A$	−0.5	−5.5	−0.5	−4	−0.5	−5.5	V
$V_{G2S(off)}$	Gate-Two–Source Cutoff Voltage	$V_{DS} = 15$ V, $V_{G1S} = 0$, $I_D = 20\ \mu A$	−0.2	−2.5	−0.2	−4	−0.2	−4	V
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{G1S} = 0$, $V_{G2S} = 4$ V, $f = 1$ kHz, See Note 6	17	40	17	40	15	35	mmho
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 15$ V, $V_{G2S} = 4$ V, $I_D = 1$ mA, $f = 1$ MHz	0.005	0.05	0.005	0.05	0.005	0.05	pF

NOTES: 4. All gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage-limiting network is functioning properly.
5. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
6. This parameter must be measured with bias voltages applied for less than 5 seconds to avoid overheating. The signal is applied to gate 1 with gate 2 at a-c ground.

*JEDEC registered data

4

*3N211 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	3N211 MIN	3N211 TYP	3N211 MAX	UNIT
F	Common-Source Spot Noise Figure	V_{DD} = 24 V, V_{GG} = 6 V, f = 45 MHz, See Figure 5			4	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain		29		37	dB
B	Bandwidth		3.5		6	MHz
$V_{GG(GC)}$	Gain-Control Gate-Supply voltage	V_{DD} = 24 V, ΔG_{ps} = −30 dB†, f = 45 MHz, See Figure 5			+1 −1	V
F	Common-Source Spot Noise Figure	V_{DD} = 18 V, V_{GG} = 7 V, f = 200 MHz, See Figure 6			3.5	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain		24		35	dB
B	Bandwidth		5		12	MHz
$V_{GG(GC)}$	Gain-Control Gate-Supply Voltage	V_{DD} = 18 V, ΔG_{ps} = −30 dB‡, f = 200 MHz, See Figure 6	0		−2	V
F	Common-Source Spot Noise Figure	V_{DS} = 15 V, V_{G2S} = 4 V, I_D = 15 mA, f = 450 MHz, See Figures 7 and 9		5		dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain			21		dB

†ΔG_{ps} at 45 MHz is defined as the change in G_{ps} from the value at V_{GG} = 6 volts.
‡ΔG_{ps} at 200 MHz is defined as the change in G_{ps} from the value at V_{GG} = 7 volts.

*3N212 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDTIONS	3N212 MIN	3N212 MAX	UNIT
$G_{ps(conv)}$	Small-Signal Conversion Power Gain	V_{DD} = 18 V, f_{LO} = 245 MHz§, f_{RF} = 200 MHz, See Figure 8	21	28	dB
B	Bandwidth		4	7	MHz

§Amplitude at input from local oscillator is adjusted for maximum $G_{ps(conv)}$.

*3N213 operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	3N213 MIN	3N213 MAX	UNIT
F	Common-Source Spot Noise Figure	V_{DD} = 24 V, V_{GG} = 6 V, f = 45 MHz, See Figure 5		4	dB
G_{ps}	Small-Signal Common-Source Insertion Power Gain		27	35	dB
B	Bandwidth		3.5	6	MHz
$V_{GG(GC)}$	Gain-Control Gate-Supply Voltage	V_{DD} = 24 V, ΔG_{ps} = −30 dB†, f = 45 MHz, See Figure 5		+1 −1	V

†ΔG_{ps} at 45 MHz is defined as the change in G_{ps} from the value at V_{GG} = 6 volts.

*JEDEC registered data

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

3N211
SMALL-SIGNAL COMMON-SOURCE INSERTION POWER GAIN
vs
GAIN-CONTROL GATE-SUPPLY VOLTAGE

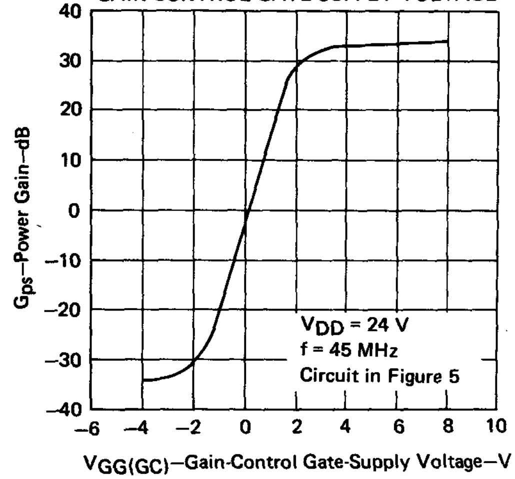


FIGURE 1

3N211
RELATIVE SMALL-SIGNAL POWER GAIN
vs
GAIN-CONTROL GATE-SUPPLY VOLTAGE

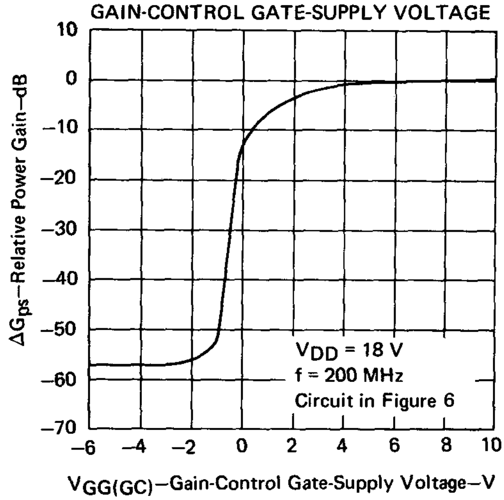


FIGURE 2

3N211
COMMON-SOURCE SPOT NOISE FIGURE
vs
GAIN-CONTROL GATE-SUPPLY VOLTAGE

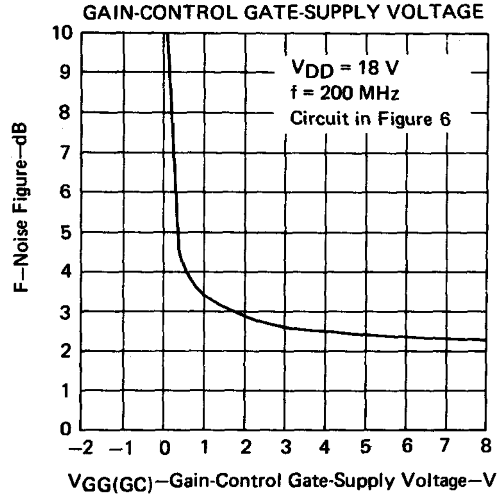


FIGURE 3

3N211
OPTIMUM SPOT NOISE FIGURE
vs
FREQUENCY

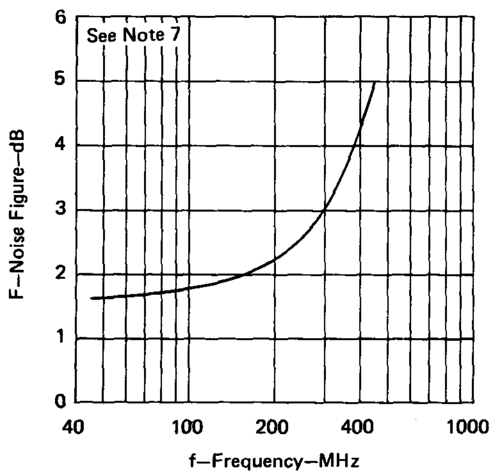
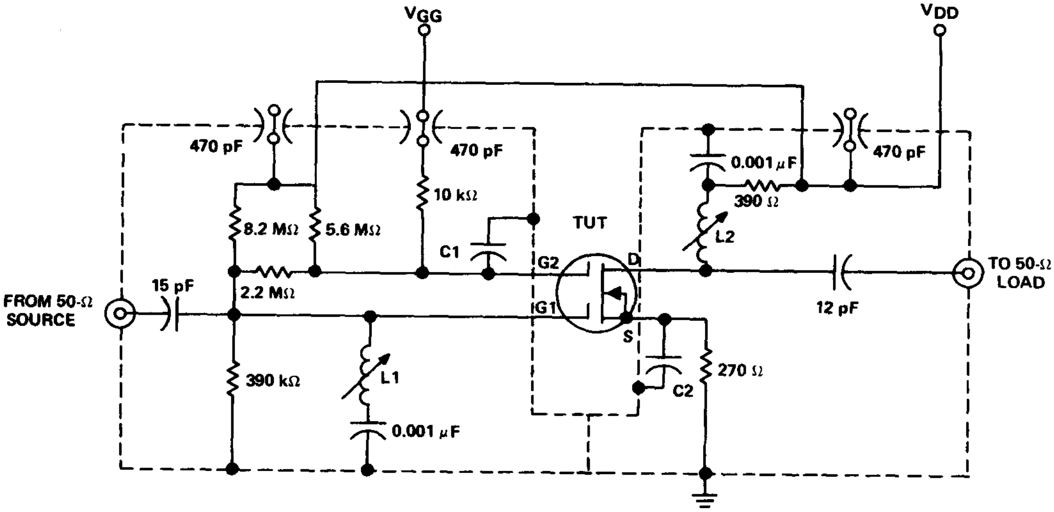


FIGURE 4

NOTE 7: Test conditions at 45 MHz, 200 MHz, and 450 MHz are the conditions given in the table of operating characteristics for 3N211.

4

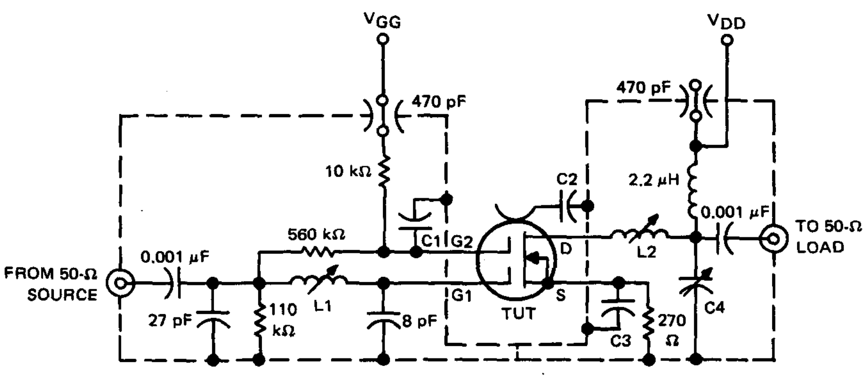
PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

C1: Leadless disc ceramic, 0.001 μF
C2: Leadless disc ceramic, 0.01 μF
L1: 8T # 28, 5/32-inch-dia form, type "J" slug
L2: 9T # 28, 5/32-inch-dia form, type "J" slug

FIGURE 5—45-MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT FOR 3N211 AND 3N213*



CIRCUIT COMPONENT INFORMATION

C1, C2, & C3: Leadless disc ceramic, 0.001 μF
C4: ARCO 462, 5-80 pF, or equivalent
L1: 3T #18, 3/16-inch-dia aluminum slug
L2: 8T #20, 3/16-inch-dia aluminum slug

FIGURE 6—200-MHz POWER GAIN, GAIN-CONTROL VOLTAGE, AND NOISE FIGURE TEST CIRCUIT FOR 3N211*

*JEDEC registered data

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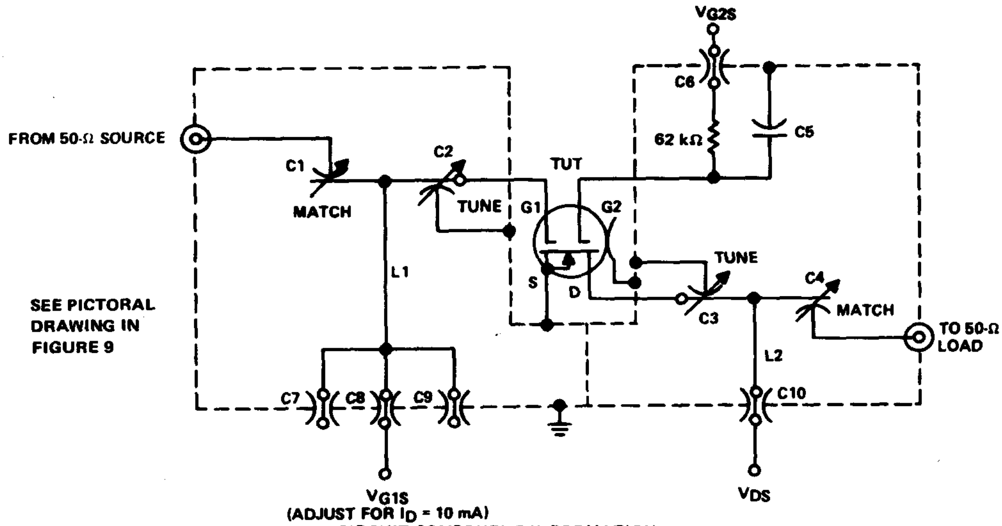
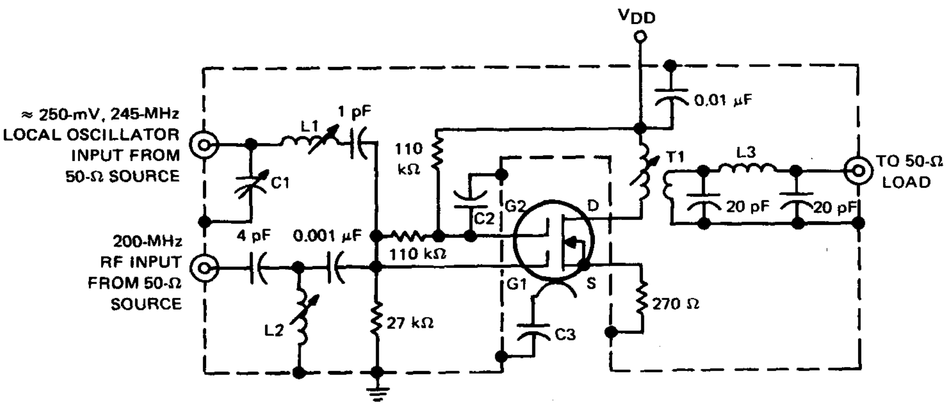
PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

C1 thru C4: See Figure 9, Note D
C5: 0.001 μF leadless disc capacitor
C6 thru C10: Allen-Bradley F5AU 0.001 μF feed-through capacitors
L1 & L2: See Figure 9

FIGURE 7—450-MHz POWER GAIN AND NOISE TEST CIRCUIT FOR 3N211



L1: 7T #34, 1/4-inch dia., aluminum slug
L2: 3T #20, 1/4-inch dia., aluminum slug
L3: 7T #24, 1/4-inch dia., air core

C1: Arco type 462, 5-80 pF
C2: 0.001 μF leadless disc
C3: 0.01 μF leadless disc

T1: Pri: 25T #30, close wound on 1/4-inch-dia form, type "J" slug
Sec: 4T #30, centered over primary

FIGURE 8—200-MHz-to-45-MHz CIRCUIT FOR CONVERSION POWER GAIN FOR 3N212*

*JEDEC registered data

NOTES:
A. All dimensions are in inches.
B. The removable top of test fixture is not shown.
C. For clarity, the 62 kΩ resistor, the source and gate-2 socket pins, and insulating stand-off terminals (ISOT) soldered into the fold of L1 and L2 respectively for mechanical support, are not shown in view A.
D. C1 and C2 (C3 and C4) consist of shim brass and the "C" portion of L1 (L2) separated by air and the mylar tape covering the "C" portion of L1 (L2).

NOTE:
E. The four views surrounding the center view are as they would appear before the metal is bent up to form the sides.

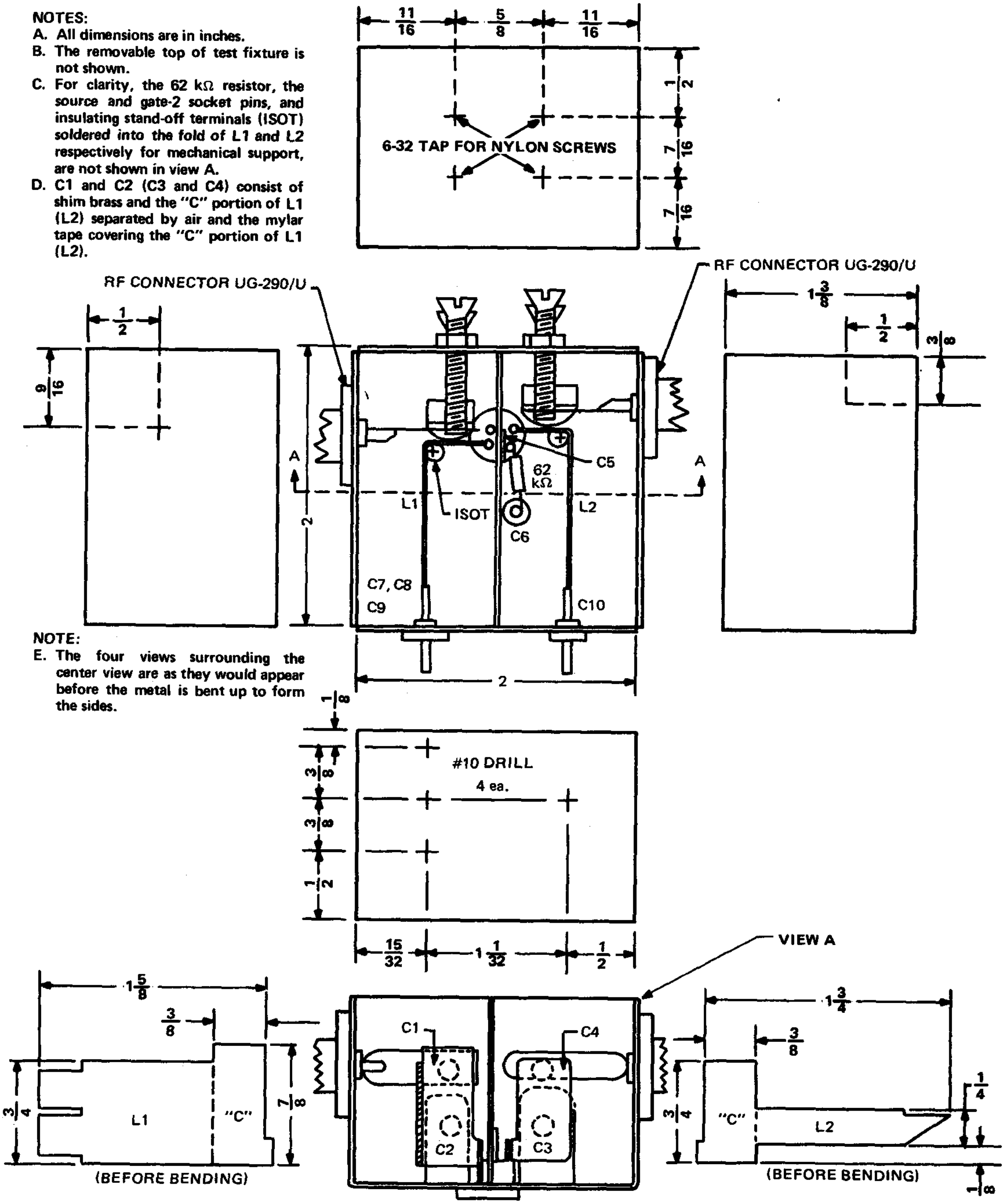


FIGURE 9—450-MHz POWER GAIN AND NOISE TEST FIXTURE

BULLETIN NO. DL-S 7311991, MARCH 1973

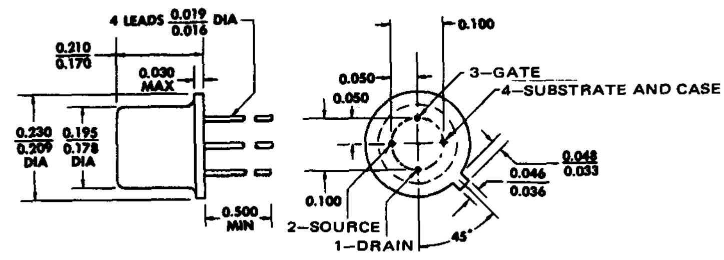
DIODE-PROTECTED DEPLETION-TYPE MOS SILICON TRANSISTORS

For Low-Power Chopper or Switching Applications

- Low $r_{ds(on)}$ . . . 20 Ω Max (3N214)
- Low C_{rss} . . . 2 pF Max
- Low C_{iss} . . . 6 pF Max
- Internally Connected Diode Protects Gate from Damage due to Overvoltage

*mechanical data

THE SUBSTRATE IS IN ELECTRICAL CONTACT WITH THE CASE



ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

ALL JEDEC TO-72 DIMENSIONS AND NOTES ARE APPLICABLE

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	20 V
Drain-Source Voltage	20 V
Drain-Substrate Voltage	20 V
Source-Substrate Voltage	20 V
Forward Gate-Terminal Current (See Note 1)	1 mA
Reverse Gate-Terminal Current	−1 mA
Continuous Drain Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	360 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

NOTES: 1. Forward gate-terminal current is the current into a gate terminal with a forward gate-source voltage applied. This voltage is of such polarity that an increase in its magnitude causes the channel resistance to decrease.
2. Derate linearly to 175°C free-air temperature at the rate of 2.4 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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TYPES 3N214 THRU 3N217
N-CHANNEL DEPLETION-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS		MIN	MAX	UNIT
$V_{(BR)GSSF}$	Gate-Source Forward Breakdown Voltage	$I_G = 1$ mA, $V_{DS} = 0$, $V_{US} = 0$, See Note 3		7		V
$V_{(BR)GSSR}$	Gate-Source Reverse Breakdown Voltage	$I_G = -1$ mA, $V_{DS} = 0$, $V_{US} = 0$, See Note 3		−7		V
I_{GSSF}	Gate-Terminal Forward Current	$V_{GS} = 7$ V, $V_{DS} = 0$, $V_{US} = 0$			10	nA
I_{GSSR}	Gate-Terminal Reverse Current	$V_{GS} = -7$ V, $V_{DS} = 0$, $V_{US} = 0$			10	nA
		$V_{GS} = -7$ V, $V_{DS} = 0$, $V_{US} = 0$, $T_A = 125°C$			500	
$I_{S(off)}$	Source Cutoff Current	$V_{SD} = 12$ V, $V_{GD} = -6$ V, $V_{UD} = 0$			1	µA
		$V_{SD} = 12$ V, $V_{GD} = -6$ V, $V_{UD} = 0$, $T_A = 125°C$			500	
		$V_{SD} = 12$ V, $V_{GD} = -6$ V, $V_{UD} = -6$ V			1	
		$V_{SD} = 12$ V, $V_{GD} = -6$ V, $V_{UD} = -6$ V, $T_A = 125°C$			500	
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = 0$			100	nA
		$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = 0$, $T_A = 125°C$			50	µA
		$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = -6$ V			100	nA
		$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = -6$ V, $T_A = 125°C$			50	µA
I_{USS}	Substrate Reverse Current	$V_{US} = -20$ V, $V_{DS} = 0$, $V_{GS} = 0$			−10	µA
$I_{D(on)}$	On-State Drain Current	$V_{DS} = 3$ V, $V_{GS} = 6$ V, $V_{US} = -6$ V, See Note 4		50		mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 6$ V, $I_D = 0$, $V_{US} = 0$, $f = 1$ kHz	3N214		20	Ω
			3N215		35	
			3N216		50	
			3N217		70	
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = 0$, $f = 1$ MHz			6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -6$ V, $V_{US} = 0$, $f = 1$ MHz			2	pF
C_{ds}	Drain-Source Capacitance	$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = 0$, $f = 1$ MHz, See Note 5			5	pF

NOTES: 3. Both gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage-limiting network is functioning properly.
4. This parameter must be measured using pulse techniques. $t_w = 300$ µs, duty cycle ≤ 2%.
5. C_{ds} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The gate and case are connected to the guard terminal of the bridge.

*JEDEC registered data

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

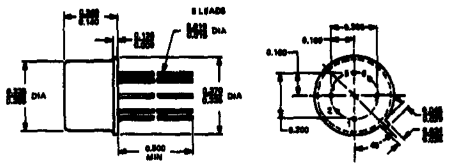
BULLETIN NO. DL-S 7211701, MARCH 1972

TWO MATCHED FIELD-EFFECT TRANSISTORS

- High $|y_{fs}|/C_{iss}$ Ratio (High-Frequency Figure-of-Merit)
- Low Input Capacitance, C_{iss}: 8 pF Max
- Low Differential Gate Current: 10 nA Max at T_A = 100°C
- Low Noise Figure: 5 dB Max at 10 Hz
- Recommended for Low-Level D-C Amplifiers, Sample-Hold Circuits, and Series-Shunt Choppers

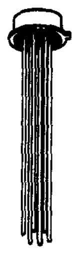
mechanical data

ALL LEADS INSULATED FROM CASE



Dimensions without tolerance designate true position. Leads having maximum diameter (0.019") measured in gaging plane 0.054" +0.001" −0.000" below the seating plane of the device shall be within 0.007" of their true positions relative to a maximum-width tab.

1. SOURCE 1
2. DRAIN 1
3. GATE 1
5. SOURCE 2
6. DRAIN 2
7. GATE 2



DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH TRIODE	TOTAL DEVICE
Drain-Gate Voltage	50 V	
Drain-Source Voltage	50 V	
Gate-Source Reverse Voltage	−50 V	
Drain-1—Drain-2 Voltage		±120 V
Lead-to-Case Voltage		±120 V
Continuous Gate Current	10 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	300 mW	600 mW
Storage Temperature Range	−65°C to 200°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 300°C →	

NOTE 1: Derate linearly to 175°C free-air temperature at the rates of 2 mW/°C for each triode and 4 mW/°C for total device.

USES CHIP JN51

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics (see note 2)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−50		V
I_{GSS}	Gate Cutoff Current	$V_{GS} = -30$ V, $V_{DS} = 0$		−0.25	nA
		$V_{GS} = -30$ V, $V_{DS} = 0$, $T_A = 150°C$		−250	
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$	0.5	8	mA
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 50\ \mu A$	−0.5	−4	V
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 0.5$ nA		−6	V
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$I_D = 0$, $V_{GS} = 0$, f = 1 kHz		500	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz	1500	6000	μmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz		25	μmho
C_{iss}	Small-Signal Common-Source Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		8	pF
C_{rss}	Small-Signal Common-Source Reverse Transfer Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz		4	pF
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz	1500		μmho

4

triode matching characteristics

PARAMETER		TEST CONDITIONS	TIS25		TIS26		TIS27		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$\lvert I_{GSS1} - I_{GSS2} \rvert$	Differential Gate Cutoff Current	$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$		10		10		10	nA
$\frac{I_{DSS1}}{I_{DSS2}}$	Zero-Gate-Voltage Drain Current Ratio	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	0.95	1	0.9	1	0.8	1	
$\lvert V_{GS1} - V_{GS2} \rvert$	Gate-Source-Voltage Differential	$V_{DS} = 15$ V, $I_D = 50\ \mu A$		8		16		32	mV
		$V_{DS} = 15$ V, $I_D = 500\ \mu A$		5		10		15	
$\lvert \Delta(V_{GS1} - V_{GS2}) \Delta T_A \rvert$	Gate-Source-Voltage-Differential Change with Temperature	$V_{DS} = 15$ V, $I_D = 500\ \mu A$, $T_{A(1)} = 25°C$, $T_{A(2)} = -40°C$		5		10		15	mV
		$V_{DS} = 15$ V, $I_D = 500\ \mu A$, $T_{A(1)} = 25°C$, $T_{A(2)} = 100°C$		5		10		15	
$\frac{\lvert y_{fs} \rvert_1}{\lvert y_{fs} \rvert_2}$	Small-Signal Common-Source Forward Transfer Admittance Ratio	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 3	0.95	1	0.9	1	0.8	1	

operating characteristics at 25°C free-air temperature

individual triode characteristics (see note 2)

PARAMETER		TEST CONDITIONS	TIS25	TIS26	UNIT
			MAX	MAX	
F	Spot Noise Figure	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 10 Hz, $R_G = 1$ MΩ, Noise Bandwidth = 5 Hz	5	5	dB
V_n	Equivalent Input Noise Voltage	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 10 Hz, Noise Bandwidth = 5 Hz	200	200	$nV/\sqrt{Hz}$

NOTES: 2. The terminals of the triode not under test are open-circuited for the measurement of these characteristics.
3. The lower of the two characteristic readings is taken as the numerator.

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BULLETIN NO. DL-S 7311580, NOVEMBER 1971—REVISED MARCH 1973

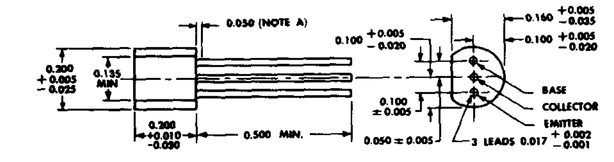
SILECT† TRANSISTORS‡
RECOMMENDED AS LOW-NOISE DESIGN REPLACEMENTS FOR GERMANIUM DRIFT TRANSISTORS IN:

- AM Radio RF and IF Converter Applications
- TV Video and AGC Amplifiers, Sync Amplifiers and Separators, and Emitter Followers

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

TIS37, TIS38

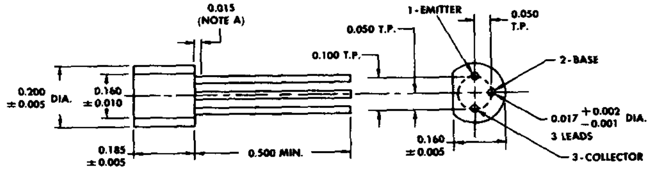


NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

ECB

TIS137, TIS138



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	TIS37 TIS137	TIS38 TIS138
Collector-Base Voltage	−35 V	−35 V
Collector-Emitter Voltage (See Note 1)	−32 V	−32 V
Emitter-Base Voltage	−6 V	−4 V
Continuous Collector Current	−50 mA	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP P24

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS37 TIS137 MIN	TIS37 TIS137 TYP	TIS37 TIS137 MAX	TIS38 TIS138 MIN	TIS38 TIS138 TYP	TIS38 TIS138 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−35			−35			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 3	−32			−32			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−6			−4			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -10$ V, $I_E = 0$			−100			−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -9$ V, $I_C = -1$ mA	45			25			
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -9$ V, $I_C = -1$ mA, f = 455 kHz	35		45	30		40	dB
		$V_{CE} = -9$ V, $I_C = -1$ mA, f = 10 MHz	18		30	14		26	dB
$\lvert y_{fe} \rvert$	Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = -9$ V, $I_C = -1$ mA, f = 455 kHz	32	35		32	35		mmho
f_T	Transition Frequency	$V_{CE} = -9$ V, $I_C = -1$ mA, See Note 4	80		320	50		200	MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -9$ V, $I_E = 0$, f = 1 MHz, See Note 5	0.5	1.1	1.7	0.5	1.1	1.7	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = -9$ V, $I_E = 1$ mA, f = 79.8 MHz		30	70		30	70	ps

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS37 TIS137 TYP	UNIT
NF	Spot Noise Figure	$V_{CE} = -9$ V, $I_C = -1$ mA, $R_G = 75\ \Omega$, f = 1 MHz	2.5	dB
		$V_{CE} = -9$ V, $I_C = -1$ mA, $R_G = 1\ k\Omega$, f = 1 MHz	1	dB

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

TIS37, TIS137
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

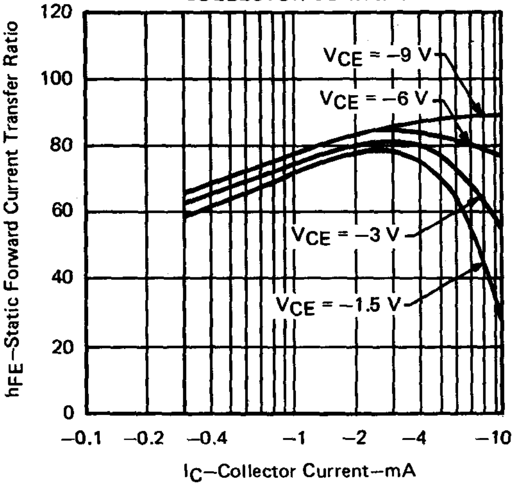


FIGURE 1

TIS37, TIS137
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR-EMITTER VOLTAGE

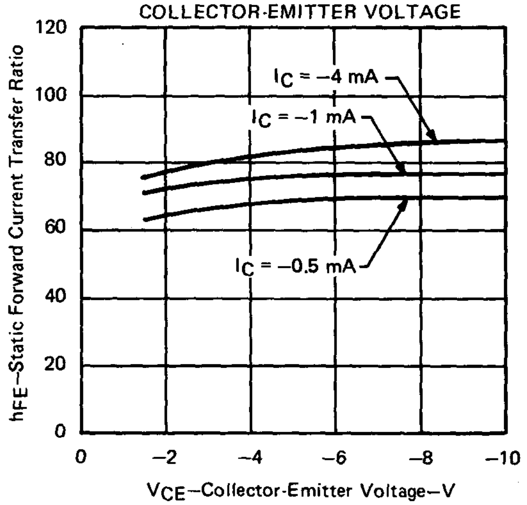


FIGURE 2

NOTES: 3. This parameter must be measured using pulse techniques, $t_w = 300\ \mu s$, duty cycle ≤ 2%.
4. To obtain f_T, the $\lvert h_{fe} \rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 10 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

BULLETIN NO. DL-S 6810706, FEBRUARY 1968

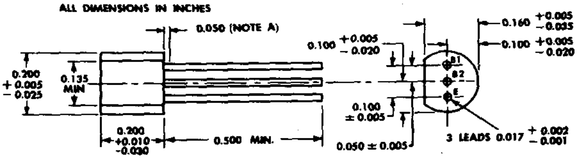
PLANAR UNIJUNCTION SILECT† TRANSISTOR‡ FOR APPLICATION IN SCR DRIVERS, MOTOR-SPEED CONTROLS, TIMERS, WAVEFORM GENERATORS, MULTIVIBRATORS, RING COUNTERS, ELECTRONIC ORGANS, AND MILITARY FUZES

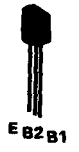
- Low Leakage Allows More Accurate Timing Circuit Design
- Provides Wider Range of Design Applications than Bar-Type Unijunction Transistors
- 2N4891 is Recommended for New Designs

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE





NOTE A: Lead diameter is not controlled in this area.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Emitter–Base-Two Reverse Voltage	−30 V
Interbase Voltage	See Note 1
Continuous Emitter Current	50 mA
Peak Emitter Current (See Note 2)	1 A
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	360 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 4)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. Interbase voltage is limited solely by power dissipation, $V_{B2-B1} = \sqrt{r_{BB} \cdot P_T}$. The r_{BB} range specified gives maximum values ranging from 35 V to 52 V.
2. This value applies for a capacitor discharge through the emitter—base-one diode. Current must fall to 0.37 A within 3 ms and pulse-repetition rate must not exceed 10 pps.
3. Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/deg.
4. Derate linearly to 150°C lead temperature at the rate of 4 mW/deg. Lead temperature is measured on the base-two lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

USES CHIP U42

TYPE TIS43
P-N PLANAR SILICON UNIJUNCTION TRANSISTOR

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
r_{BB}	Static Interbase Resistance	$V_{B2\text{-}B1} = 3\ V$, $I_E = 0$	4	9.1	kΩ
α_{rBB}	Interbase Resistance Temperature Coefficient	$V_{B2\text{-}B1} = 3\ V$, $I_E = 0$, $T_A = -65°C$ to $100°C$, See Note 5	0.1	0.9	%/deg
η	Intrinsic Standoff Ratio	$V_{B2\text{-}B1} = 10\ V$, See Figure 1	0.55	0.82	
$I_{B2(mod)}$	Modulated Interbase Current	$V_{B2\text{-}B1} = 10\ V$, $I_E = 50\ mA$	10		mA
I_{EB2O}	Emitter Reverse Current	$V_{B2\text{-}E} = 30\ V$, $I_{B1} = 0$		−10	nA
I_P	Peak-Point Emitter Current	$V_{B2\text{-}B1} = 25\ V$		5	µA
$V_{EB1(sat)}$	Emitter — Base-One Saturation Voltage	$V_{B2\text{-}B1} = 10\ V$, $I_E = 50\ mA$, See Note 6		4	V
I_V	Valley-Point Emitter Current	$V_{B2\text{-}B1} = 20\ V$	2		mA
V_{OB1}	Base-One Peak Pulse Voltage	See Figure 2	3		V

NOTES: 5. Temperature coefficient, α_{rBB}, is determined by the following formula:

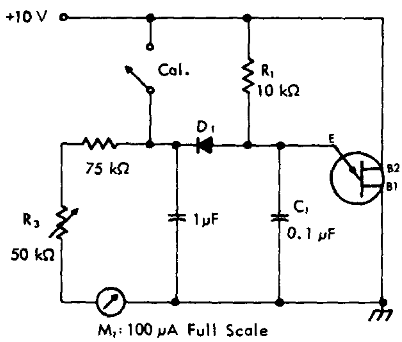
$$\alpha_{rBB} = \left[\frac{(r_{BB} @ 100°C) - (r_{BB} @ -55°C)}{(r_{BB} @ 25°C)}\right] \frac{100\%}{155\ deg}$$

To obtain r_{BB} for a given temperature $T_{A(2)}$, use the following formula:

$$r_{BB(2)} = [r_{BB} @ 25°C]\ [1 + (\alpha_{rBB}/100)\ (T_{A(2)} - 25°C)]$$

6. *This parameter is measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.*

PARAMETER MEASUREMENT INFORMATION



η — Intrinsic Standoff Ratio — This parameter is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta\ V_{B2B1} + V_F$, where V_F is about 0.56 volt at 25°C and decreases with temperature at about 2 millivolts/deg.

The circuit used to measure η is shown in the figure. In this circuit, R_1, C_1 and the unijunction transistor form a relaxation oscillator, and the remainder of the circuit serves as a peak-voltage detector with the diode D_1 automatically subtracting the voltage V_F. To use the circuit, the "cal" button is pushed, and R_3 is adjusted to make the current meter M_1 read full scale. The "cal" button then is released and the value of η is read directly from the meter, with $\eta = 1$ corresponding to full-scale deflection of 100 µA.

D_1: 1N457, or equivalent, with the following characteristics:
$V_F = 0.565\ V$ at $I_F = 50\ \mu A$,
$I_R \leq 2\ \mu A$ at $V_R = 20\ V$

FIGURE 1 — TEST CIRCUIT FOR INTRINSIC STANDOFF RATIO (η)

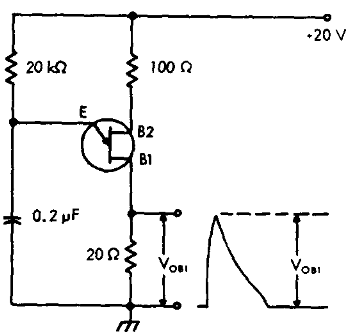


FIGURE 2 — V_{OB1} TEST CIRCUIT

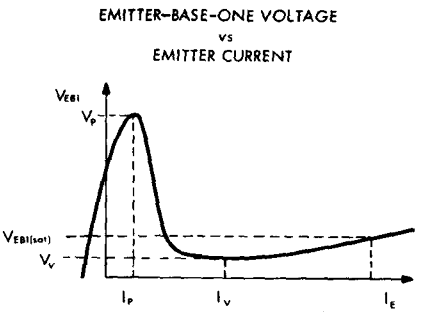


FIGURE 3 — GENERAL STATIC EMITTER CHARACTERISTIC CURVE

TEXAS INSTRUMENTS
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N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

BULLETIN NO. DL-S 698852, JUNE 1966—REVISED AUGUST 1969

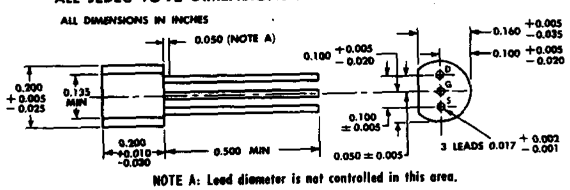
SILECT† FIELD-EFFECT TRANSISTORS‡

For Industrial and Consumer Small-Signal Applications

- Coded I_{DSS} Ranges for Precise Circuit Design
- Low C_{rss} . . . ≤ 3 pF
- High y_{fs}/C_{iss} Ratio (High-Frequency Figure-of-Merit)
- 2N5949 thru 2N5953 Are Recommended for New Designs

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.



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absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	25 V
Drain-Source Voltage	25 V
Reverse Gate-Source Voltage	−25 V
Forward Gate Current	10 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTE 1: Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

USES CHIP JN51

TYPES TIS58, TIS59
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS		TIS58 MIN	TIS58 TYP	TIS58 MAX	TIS59 MIN	TIS59 TYP	TIS59 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$		−25			−25			V
I_{GSS}	Gate Cutoff Current	$V_{GS} = -15$ V, $V_{DS} = 0$				−4			−4	nA
		$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$				−2			−2	μA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2		2.5		8	6		25	mA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 20$ nA		−0.5		−5	−1		−9	V
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$,	f = 1 kHz, See Note 2		4000			4800		μmho
		$V_{DS} = 15$ V, $I_D = 2$ mA (TIS58), $I_D = 5$ mA (TIS59)	f = 1 kHz	1300	2200	4000	2300	3500	5000	μmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance		f = 1 kHz			20			50	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance		f = 1 MHz			6			6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance		f = 1 MHz			3			3	pF
$Re(y_{fs})$	Small-Signal Common-Source Forward Transfer Conductance		f = 100 MHz	1000			2000			μmho

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PARAMETER COLOR-CODE INFORMATION

The TIS58 is furnished in color-coded I_{DSS} brackets, each having a 2-to-1 spread as shown in Table 1.

COLOR CODE	I_{DSS} BRACKET $V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2
Yellow	2.5 mA–5 mA
Green	4 mA–8 mA

TABLE 1 — TIS58

The TIS59 is furnished in color-coded I_{DSS} brackets, each having a 2.5-to-1 spread as shown in Table 2.

COLOR CODE	I_{DSS} BRACKET $V_{DS} = 15$ V, $V_{GS} = 0$, See Note 2
Yellow	6 mA–15 mA
Green	10 mA–25 mA

TABLE 2 — TIS59

NOTE 2: These parameters must be measured using pulse techniques. $t_p \approx 100$ ms, duty cycle $\leq 10\%$.

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SILECT† TRANSISTORS‡
FOR APPLICATION IN AM-FM RECEIVERS AND GENERAL-PURPOSE HIGH-FREQUENCY AMPLIFIERS

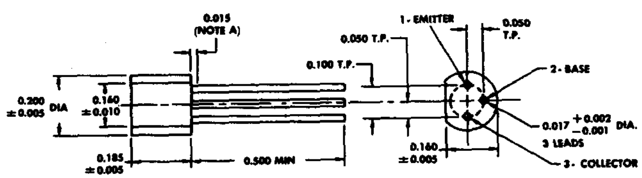
TIS62A Features:

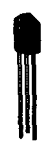
- f_T . . . 500 MHz Min
- Low $r_b'C_c$ . . . 20 ps Max
- F . . . 6 dB Max at 100 MHz

Rugged, One-Piece Construction with Standard TO-18 100-mil Pin Circle

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.





NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	30 V
Collector-Emitter Voltage (See Note 1)	12 V
Emitter-Base Voltage	3 V
Continuous Collector Current	30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 4 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N22

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS62A MIN	TIS62A MAX	TIS63A MIN	TIS63A MAX	TIS64A MIN	TIS64A MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 μA, I_E = 0	30		30		30		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 4 mA, I_B = 0, See Note 3	12		12		12		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 100 μA, I_C = 0	3		3		3		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 10 V, I_E = 0		100		100		100	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 4 mA	30	225	30	225	50	150	
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 4 mA, f = 455 kHz			27				dB
		V_{CE} = 10 V, I_C = 4 mA, f = 10 MHz			27				dB
		V_{CE} = 10 V, I_C = 4 mA, f = 100 MHz	5	18	5	18	5	18	
C_{cb}	Collector-Base Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz, See Note 4	0.4	1.3	0.4	1.3	0.4	1.3	pF
$r_b'C_c$	Collector-Base Time Constant	V_{CB} = 10 V, I_E = −4 mA, f = 79.8 MHz		20		20		20	ps

NOTES: 3. This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
4. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

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operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS62A TYP	TIS62A MAX	UNIT
F	Spot Noise Figure	V_{CE} = 10 V, I_C = 2 mA, R_G = 300 Ω, f = 100 MHz	4	6	dB

THERMAL INFORMATION

DISSIPATION DERATING CURVE

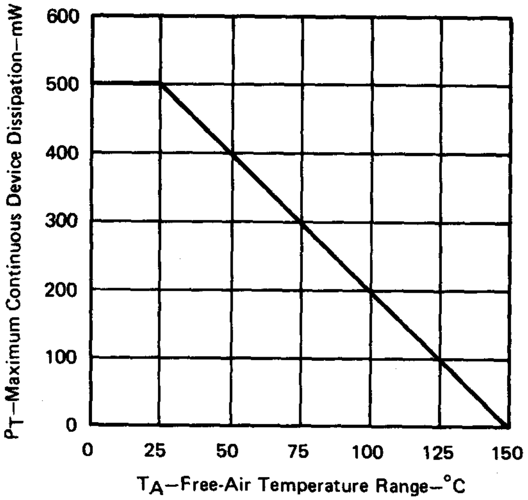


FIGURE 1

PRINTED IN U.S.A. 373

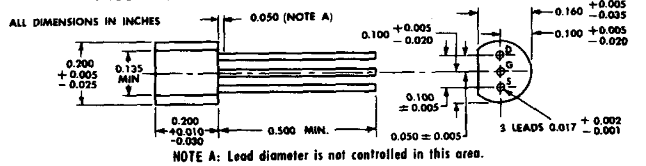
BULLETIN NO. DL-S 739669, MARCH 1967—REVISED MARCH 1973

SILECT† FIELD-EFFECT TRANSISTORS ‡
SUPPLIED AS MATCHED PAIRS

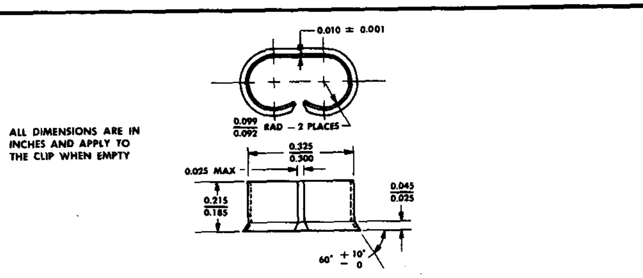
- **High y_{fs}/C_{iss} Ratio (High-Frequency Figure-of-Merit)**
- **Low Input Capacitance, C_{iss} . . . 8 pF Max**
- **Low Gate Reverse Current Differential . . . 10 nA Max at $T_A = 100°C$**
- **Recommended for Low-Cost, Low-Level D-C Amplifiers, Sample-Hold Circuits, and Series-Shunt Choppers**

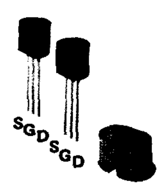
mechanical data

Each TIS69 or TIS70 comprises a matched pair of transistors. A clip is supplied with each transistor pair. These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTE A: Lead diameter is not controlled in this area.





absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	25 V
Reverse Gate-Source Voltage	−25 V
Continuous Forward Gate Current	30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTE 1: Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/°C.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

USES CHIP JN51

TEXAS INSTRUMENTS
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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

individual triode characteristics

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
I_{GSS}	Gate Reverse Current	$V_{GS} = -25$ V,	$V_{DS} = 0$			−1	μA
		$V_{GS} = -15$ V,	$V_{DS} = 0$			−2	nA
		$V_{GS} = -15$ V,	$V_{DS} = 0$,	$T_A = 100°C$		−2	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V,	$I_D = 2$ nA		−0.5	−5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 2	0.5	8	mA
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 kHz	1	6	mmho
$\lvert y_{os}\rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 kHz		35	μmho
C_{iss}	Small-Signal Common-Source Input Capacitance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 MHz		8	pF
C_{rss}	Small-Signal Common-Source Reverse Transfer Capacitance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 1 MHz		4	pF
$\lvert y_{fs}\rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 100 MHz	0.8		mmho

triode matching characteristics

PARAMETER		TEST CONDITIONS	TIS69 MIN	TIS69 MAX	TIS70 MIN	TIS70 MAX	UNIT
$\lvert I_{GSS1} - I_{GSS2}\rvert$	Gate-Reverse-Current Differential	$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$		10		10	nA
$\lvert V_{GS1} - V_{GS2}\rvert$	Gate-Source-Voltage Differential	$V_{DS} = 15$ V, $I_D = 50$ μA		16		32	mV
		$V_{DS} = 15$ V, $I_D = 500$ μA		10		15	mV
$\lvert\Delta(V_{GS1} - V_{GS2})_{\Delta T_A}\rvert$	Gate-Source-Voltage Differential Change with Temperature	$V_{DS} = 15$ V, $I_D = 500$ μA, $T_{A(1)} = 25°C$, $T_{A(2)} = -40°C$		10		15	mV
		$V_{DS} = 15$ V, $I_D = 500$ μA, $T_{A(1)} = 25°C$, $T_{A(2)} = 100°C$		10		15	mV
$\frac{I_{DSS1}}{I_{DSS2}}$	Zero-Gate-Voltage Drain Current Ratio	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	0.9	1	0.8	1	
$\frac{\lvert y_{fs}\rvert_1}{\lvert y_{fs}\rvert_2}$	Small-Signal Common-Source Forward Transfer Admittance Ratio	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz, See Note 3	0.9	1	0.8	1	

NOTES: 2. This parameter must be measured using pulse techniques. $t_w \approx 100$ ms, duty cycle ≤ 10%.
3. The lower of the two characteristic readings is taken as the numerator.

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TEXAS INSTRUMENTS INCORPORATED

POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

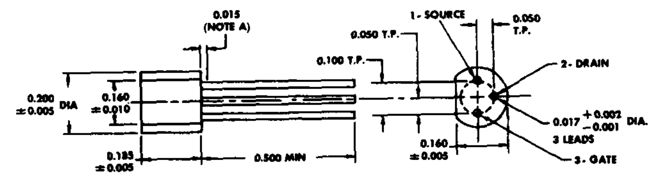
BULLETIN NO. DL-S 679709, MARCH 1967

SILECT† FIELD-EFFECT TRANSISTORS‡
FOR HIGH-SPEED COMMUTATOR AND CHOPPER APPLICATIONS

- **Low $r_{ds(on)}$: 25 Ω Max (TIS73)**
- **Low $I_{D(off)}$: 2 nA Max**
- **Low Drain-Gate Capacitance (C_{rss}): 8 pF Max**
- **Rugged, One-Piece Construction with Standard TO-18 100-mil Pin-Circle**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Drain-Gate Voltage	30 V
Drain-Source Voltage	30 V
Reverse Gate-Source Voltage	−30 V
Continuous Forward Gate Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	360 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 2)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2.88 mW/deg.
2. Derate linearly to 150°C lead temperature at the rate of 4 mW/deg. Lead temperature is measured on the gate lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

USES CHIP JN52

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TIS73 MIN	TIS73 MAX	TIS74 MIN	TIS74 MAX	TIS75 MIN	TIS75 MAX	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−30		−30		−30		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -15$ V, $V_{DS} = 0$		−2		−2		−2	nA
		$V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$		−5		−5		−5	μA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 15$ V, $V_{GS} = -10$ V		−2		−2		−2	nA
		$V_{DS} = 15$ V, $V_{GS} = -10$ V, $T_A = 100°C$		−5		−5		−5	μA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 4$ nA	−4	−10	−2	−6	−0.8	−4	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 3	50		20	100	8	80	mA
$V_{DS(on)}$	Drain-Source On-State Voltage	$I_D = 20$ mA, $V_{GS} = 0$		0.75					V
		$I_D = 10$ mA, $V_{GS} = 0$				0.5			V
		$I_D = 5$ mA, $V_{GS} = 0$						0.5	V
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, $f = 1$ kHz		25		40		60	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 0$, $V_{GS} = -10$ V, $f = 1$ MHz		18		18		18	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -10$ V, $f = 1$ MHz		8		8		8	pF

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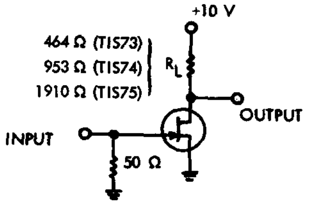
switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS73 MIN	TIS73 MAX	TIS74 MIN	TIS74 MAX	TIS75 MIN	TIS75 MAX	UNIT
$t_{d(on)}$	Turn-On Delay Time	$V_{DS} = 10$ V, $I_{D(on)}$† = 20 mA (TIS73), 10 mA (TIS74), 5 mA (TIS75),		6		6		10	ns
t_r	Rise Time	$V_{GS(on)} = 0$, $V_{GS(off)}$ = −10 V (TIS73), −6 V (TIS74), −4 V (TIS75)		3		4		10	ns
t_{off}	Turn-Off Time	See Figure 1		25		50		100	ns

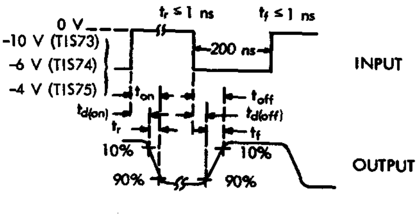
NOTE 3: These parameters must be measured using pulse techniques. $t_p \approx 100$ ms, duty cycle $\leq 10\%$.

†These are nominal values, exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 1

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, duty cycle $\approx 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 0.75$ ns, $R_{in} \geq 1$ MΩ, $C_{in} \leq 2.5$ pF.

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INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

PRINTED IN U.S.A.

BULLETIN NO. DL-S 7311254, AUGUST 1969—REVISED MARCH 1973

HIGH-FREQUENCY SILECT† TRANSISTORS‡
FOR TV TUNER AND IF APPLICATIONS

Featuring Low-Feedback Capacitance and Forward-AGC Characteristics

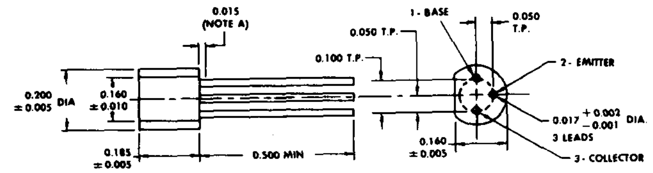
- **TIS84 for Tuner RF Amplifiers**
- **TIS108 for IF Amplifiers (Replaces TIS85)**

Rugged, One-Piece Construction with Standard TO-18 100-mil Pin Circle

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

Feedback capacitance is minimized by placing the emitter terminal between the base and collector terminals, thus optimizing compatability with advanced high-frequency design.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	40 V
Collector-Emitter Voltage (See Note 1)	30 V
Emitter-Base Voltage	4 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TIS84 MIN	TIS84 MAX	TIS108 MIN	TIS108 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	40		40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$, See Note 3	30		30		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10\ V$, $I_E = 0$		50		50	nA
		$V_{CB} = 10\ V$, $I_E = 0$, $T_A = 85°C$		5		5	µA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4\ V$, $I_C = 0$		10		10	µA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 4\ mA$	30		25		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10\ V$, $I_C = 4\ mA$		0.84		0.84	V

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 4 mW/°C.
3. This parameter must be measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

USES CHIP N17

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS84 MIN	TIS84 TYP	TIS84 MAX	TIS108 MIN	TIS108 TYP	TIS108 MAX	UNIT
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 4 mA, f = 100 MHz	3.5	6.5		3.5	6.5		
$\|y_{fe}\|$	Small-Signal Common-Emitter Forward Transfer Admittance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz	60	80					mmho
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz				80	105		mmho
ϕ_{yfe}	Phase Angle of Small-Signal Common-Emitter Forward Transfer Admittance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz	−50°	−60°	−80°				
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz				−10°	−18°	−25°	
C_{ies}	Parallel-Equivalent Common-Emitter Short-Circuit Input Capacitance†	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		11					pF
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					18		pF
C_{res}	Common-Emitter Short-Circuit Reverse Transfer Capacitance†	V_{CE} = 10 V, I_C = 1 mA, f = 0.1 MHz to 1 MHz		0.22	0.4		0.22	0.4	pF
C_{oes}	Parallel-Equivalent Common-Emitter Short-Circuit Output Capacitance†	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		1.1					pF
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					1.1		pF
$Re(h_{ie})$	Real Part of Small-Signal Common-Emitter Input Impedance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		25	60				Ω
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					50	80	Ω
$Re(y_{ie})$	Real Part of Small-Signal Common-Emitter Input Admittance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		14	40				mmho
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					3	6	mmho
$Re(y_{oe})$	Real Part of Small-Signal Common-Emitter Output Admittance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		0.2	0.5				mmho
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					0.05	0.2	mmho

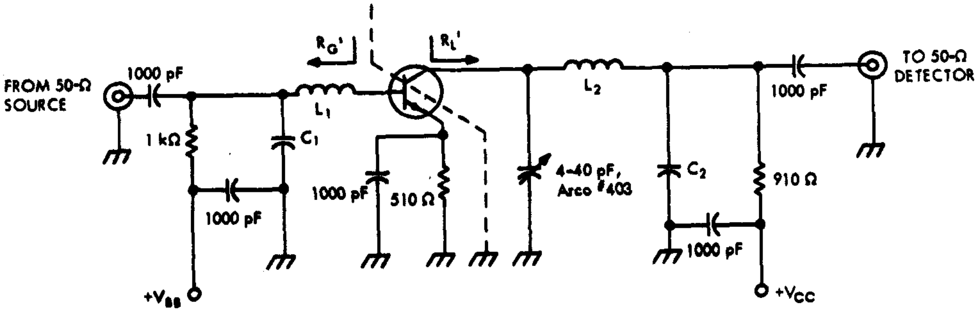
† C_{ies}, C_{res}, and C_{oes} are defined as the imaginary parts of the small-signal, common-emitter, short-circuit admittances divided by $2\pi f$.

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS84 MIN	TIS84 TYP	TIS84 MAX	TIS108 MIN	TIS108 TYP	TIS108 MAX	UNIT
NF	Spot Noise Figure	V_{CE} = 10 V, f = 200 MHz, I_C = 3 mA, R_G = 50 Ω,		2.8	3.3				dB
		V_{CE} = 10 V, f = 45 MHz, I_C = 3 mA, R_G = 50 Ω,					3	6	dB
G_{pe}	Unneutralized Small-Signal Common-Emitter Insertion Power Gain	V_{CC} = 12 V, R_G' = 150 Ω, See Figure 1, $I_C \approx$ 2.5 mA, R_L' = 1 kΩ, V_{BB} = 2.1 V, f = 200 MHz,	12	16	18				dB
		V_{CC} = 12 V, R_G' = 500 Ω, See Figure 1, $I_C \approx$ 4.5 mA, R_L' = 250 Ω, V_{BB} = 2.6 V, f = 45 MHz,				25	30	33	dB
$V_{BB(GC)}$	Gain-Control Base-Supply Voltage	V_{CC} = 12 V, R_G' = 150 Ω, R_L' = 1 kΩ, ΔG_{pe} = −30 dB‡, f = 200 MHz, See Figure 1	3.7		4.6				V
		V_{CC} = 12 V, R_G' = 500 Ω, R_L' = 250 Ω, ΔG_{pe} = −30 dB‡, f = 45 MHz, See Figure 1				3.5		4.5	V

‡ ΔG_{pe} is defined as the change in G_{pe} from the value at V_{BB} = 2.1 V at 200 MHz or from the value at V_{BB} = 2.6 V at 45 MHz.

PARAMETER MEASUREMENT INFORMATION



COMPONENTS FOR f = 45 MHz

C_1: 36 pF
C_2: 47 pF
L_1: 8 T #20 enameled copper wire, close-wound on ¼" diameter form
L_2: 10 T #20 enameled copper wire, close-wound on ¼" diameter form

COMPONENTS FOR f = 200 MHz

C_1: 18 pF
C_2: 270 pF
L_1: 2 T #20 enameled copper wire, ⅛" pitch, wound on 7/32" diameter form
L_2: 2 T #14 enameled copper wire, ⅛" pitch, wound on 7/32" diameter form

FIGURE 1 — POWER-GAIN AND GAIN-CONTROL-VOLTAGE TEST CIRCUIT

4

TYPICAL CHARACTERISTICS

TIS84
SPOT NOISE FIGURE
vs
COLLECTOR CURRENT

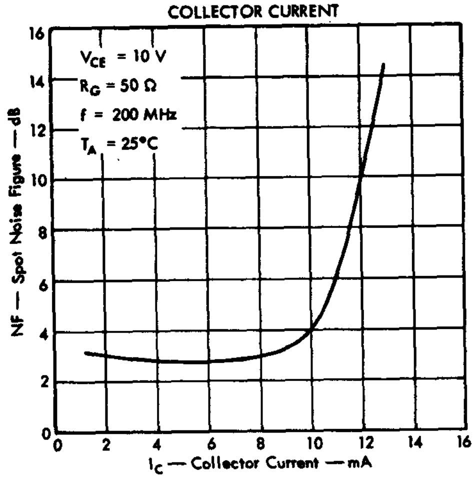


FIGURE 2

TIS84
RELATIVE SMALL-SIGNAL COMMON-EMITTER POWER GAIN
vs
GAIN-CONTROL BASE-SUPPLY VOLTAGE

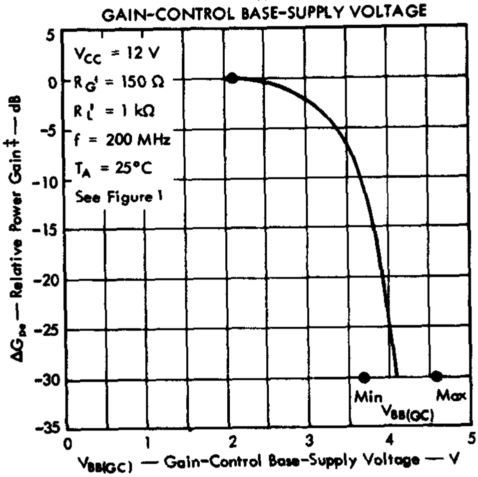


FIGURE 3

‡ΔG_{pe} is defined as the change in G_{pe} from the value at V_{BB} = 2.1 V at 200 MHz or from the value at V_{BB} = 2.6 V at 45 MHz.

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BULLETIN NO. DL-S 6810225, JUNE 1967—REVISED MAY 1968

HIGH-FREQUENCY SILECT† TRANSISTORS‡
DESIGNED FOR TV MIXER AND NON-AGC IF STAGES
Featuring Low Feedback Capacitance and Full Characterization to Simplify Circuit Design

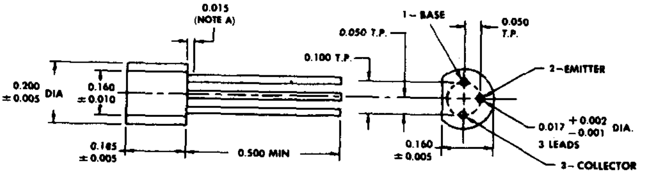
- TIS86 for Mixer
- TIS87 for Non-AGC IF Amplifier

Rugged, One-Piece Construction with Standard TO-18 100-mil Pin Circle

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

Feedback capacitance is minimized by placing the emitter terminal between the base and collector terminals, thus optimizing compatibility with advanced high-frequency design.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	TIS86	TIS87
Collector-Base Voltage	30 V	45 V
Collector-Emitter Voltage (See Note 1)	30 V	45 V
Emitter-Base Voltage	4 V	4 V
Continuous Collector Current	← 50 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←400 mW→	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	←700 mW→	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 260°C →	

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 3.2 mW/deg.
3. Derate linearly to 150°C lead temperature at the rate of 5.6 mW/deg. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

USES CHIP N16

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TIS86			TIS87			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	30			45			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 4	30			45			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ V, $I_E = 0$			100			100	nA
		$V_{CB} = 15$ V, $I_E = 0$, $T_A = 85°C$			10			10	µA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ V, $I_C = 0$			10			10	µA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA	40		200				
		$V_{CE} = 12$ V, $I_C = 12$ mA, See Note 4				30		150	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 12$ V, $I_C = 15$ mA, See Note 4			0.87			0.87	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1.5$ mA, $I_C = 15$ mA						0.5	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 100$ MHz	5						
		$V_{CE} = 12$ V, $I_C = 12$ mA, $f = 100$ MHz				5			
$\|y_{fe}\|$	Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 45$ MHz	90	115					mmho
		$V_{CE} = 12$ V, $I_C = 12$ mA, $f = 45$ MHz				130	200		
ϕ_{yfe}	Phase Angle of Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 45$ MHz	−7°	−15°	−20°				
		$V_{CE} = 12$ V, $I_C = 12$ mA, $f = 45$ MHz				−18°	−25°	−35°	
C_{ies}	Parallel-Equivalent Common-Emitter Short-Circuit Input Capacitance†	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 200$ MHz		9					pF
		$V_{CE} = 12$ V, $I_C = 12$ mA, $f = 45$ MHz					25		
C_{res}	Common-Emitter Short-Circuit Reverse Transfer Capacitance†	$V_{CE} = 10$ V, $I_C = 1$ mA, $f = 0.1$ MHz to 1 MHz		0.33	0.45		0.33	0.45	pF
C_{oes}	Parallel-Equivalent Common-Emitter Short-Circuit Output Capacitance†	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 45$ MHz		1.1					pF
		$V_{CE} = 12$ V, $I_C = 12$ mA, $f = 45$ MHz					1.1		
$Re(h_{ie})$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 200$ MHz		32	60				Ω
		$V_{CE} = 12$ V, $I_C = 12$ mA, $f = 45$ MHz					55	100	
$Re(y_{ie})$	Real Part of Small-Signal Common-Emitter Input Admittance	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 200$ MHz		8.5	30				mmho
		$V_{CE} = 12$ V, $I_C = 12$ mA, $f = 45$ MHz					5	12	
$Re(y_{oe})$	Real Part of Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 45$ MHz		0.02	0.15				mmho
		$V_{CE} = 12$ V, $I_C = 12$ mA, $f = 45$ MHz					0.07	0.2	

NOTE 4: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

†C_{ies}, C_{res}, and C_{oes} are defined as the imaginary parts of the small-signal, common-emitter, short-circuit admittances divided by $2\pi f$.

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS86		UNIT
			TYP	MAX	
NF	Spot Noise Figure	$V_{CE} = 10$ V, $I_C = 4$ mA, $R_G = 50\ \Omega$, $f = 200$ MHz	2.5	5	dB

TEXAS INSTRUMENTS
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BULLETIN NO. DL-S 7310224, JULY 1967—REVISED MARCH 1973

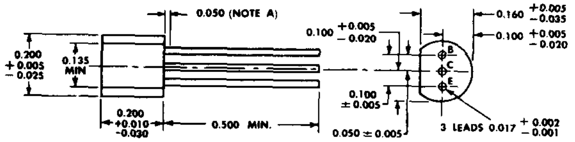
SILECT† COMPLEMENTARY TRANSISTORS‡

Available in Matched Complementary Pairs (TIS90M thru TIS93M) for Complementary-Symmetry or Other Class-B Audio-Amplifier Applications

- **Supplied in Color-Coded h_{FE} Brackets of 3-dB-Maximum Range**
- **1.6-W Rating at 25°C Case Temperature**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

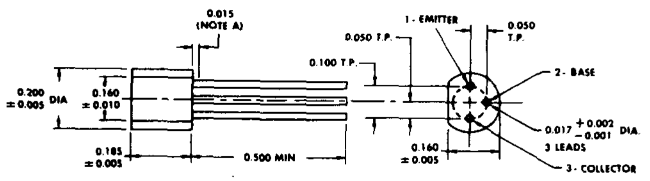


TIS90, TIS90M, TIS91, TIS91M

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

ECB



TIS92, TIS92M, TIS93, TIS93M

NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)§

Collector-Base Voltage	40 V
Collector-Emitter Voltage (See Note 1)	40 V
Emitter-Base Voltage	5 V
Continuous Collector Current	400 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	1.25 W
Continuous Device Dissipation at (or below) 25°C Case-and-Lead Temperature (See Note 4)	1.6 W
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.
4. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

§Voltages and currents apply to the n-p-n transistors. For the p-n-p transistors the values are the same, but the polarities are reversed.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

N-P-N TYPES USE CHIP N24
P-N-P TYPES USE CHIP P20

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†			N-P-N TIS90, TIS90M TIS92, TIS92M			P-N-P TIS91, TIS91M TIS93, TIS93M			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$			40			−40			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$,		See Note 5	40			−40			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$			5			−5			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20$ V,	$I_E = 0$				100			−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3$ V,	$I_C = 0$				100			−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 2$ V,	$I_C = 50$ mA,	See Note 5	100	160	300	100	160	300	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 2$ V,	$I_C = 50$ mA,	See Note 5	0.6	0.77	1	−0.6	−0.76	−1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ mA,	$I_C = 50$ mA,	See Note 5		0.04	0.25		−0.06	−0.25	V
		$I_B = 20$ mA,	$I_C = 200$ mA,	See Note 5		0.17			−0.23		V

NOTE 5: These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

†Test condition voltages and currents apply to the n-p-n transistors. For the p-n-p transistors the values are the same, but the polarities are reversed.

PARAMETER COLOR-CODE INFORMATION

To facilitate matching and identification these transistors are color-coded in h_{FE} brackets, each having a maximum spread of 3 dB as shown in the table below. No guarantee is made as to distribution of h_{FE} values, except that equal numbers of n-p-n and p-n-p devices will be shipped in any given bracket when matched complementary pairs are ordered.

COLOR CODE	YELLOW	GREEN	BLUE	VIOLET	GRAY
h_{FE} Range, $\lvert V_{CE}\rvert = 2$ V, $\lvert I_C\rvert = 50$ mA	100 - 125	115 - 150	140 - 190	170 - 235	215 - 300

ORDERING INFORMATION — To order matched complementary pairs, order the same quantity each of TIS90M and TIS91M or TIS92M and TIS93M. Devices may be ordered separately by specifying TIS90, TIS91, TIS92, or TIS93.

THERMAL INFORMATION

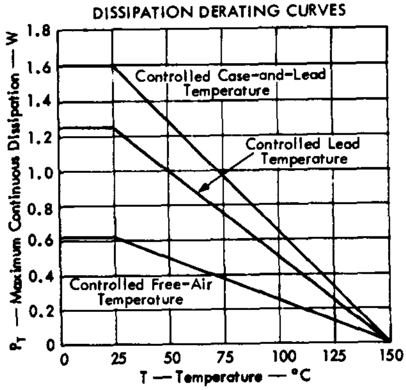

FIGURE 1

TEXAS INSTRUMENTS
INCORPORATED
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BULLETIN NO. DL-S 7310187, JUNE 1967—REVISED MARCH 1973

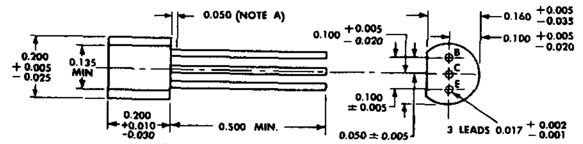
A COMPLETE FAMILY OF LOW-NOISE, LOW- TO MEDIUM-CURRENT SILECT† TRANSISTORS‡ FOR USE IN HI-FI AUDIO AMPLIFIERS AND GENERAL PURPOSE LOW-FREQUENCY APPLICATIONS

- High $V_{(BR)CEO}$ . . . 65 V Min (TIS96 and TIS99)
- Excellent h_{FE} Linearity to 100 mA

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

TIS94, TIS95, TIS96

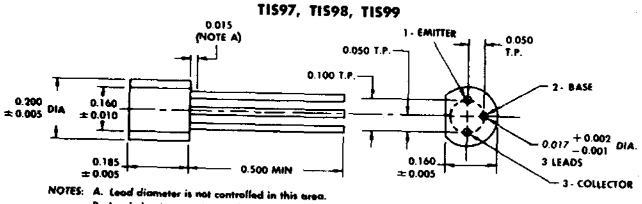


ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

ECB

TIS97, TIS98, TIS99



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	TIS94 TIS97	TIS95 TIS98	TIS96 TIS99
Collector-Base Voltage	60 V	80 V	80 V
Collector-Emitter Voltage (See Note 1)	40 V	60 V	65 V
Emitter-Base Voltage	6 V	6 V	6 V
Continuous Collector Current	←	200 mA	→
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	←	625 mW	→
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	←	1.25 W	→
Storage Temperature Range	←	−65°C to 150°C	→
Lead Temperature 1/16 Inch from Case for 10 Seconds	←	260°C	→

NOTES: 1. These values apply between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N21

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS94 TIS97 MIN	TYP	MAX	TIS95 TIS98 MIN	TYP	MAX	TIS96 TIS99 MIN	TYP	MAX	UNIT
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 4	40			60			65			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40$ V, $I_E = 0$			10			10			10	nA
		$V_{CB} = 60$ V, $I_E = 0$			10							μA
		$V_{CB} = 80$ V, $I_E = 0$						10			10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 6$ V, $I_C = 0$			20			20			20	nA
h_{FE}	Static Forward Current Transfer Ratio§	$V_{CE} = 5$ V, $I_C = 100$ μA	250	340	700							
		$V_{CE} = 5$ V, $I_C = 1$ mA				100	200	300				
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 4							60	125		
		$V_{CE} = 5$ V, $I_C = 100$ mA, See Note 4							55	110	300	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 100$ μA	0.45		0.65							V
		$V_{CE} = 5$ V, $I_C = 1$ mA				0.5		0.7				V
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 4							0.6		0.8	V
V_{CE}	Collector-Emitter Voltage	$I_B = 0.1$ mA, $I_C = 10$ mA, See Note 4						1				V
		$I_B = 2$ mA, $I_C = 100$ mA, See Note 4									2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 5$ mA, $I_C = 100$ mA, See Note 4						0.5			0.5	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ V, $I_C = 100$ μA, f = 1 kHz		115								kΩ
		$V_{CE} = 5$ V, $I_C = 1$ mA, f = 1 kHz					6.4					kΩ
		$V_{CE} = 5$ V, $I_C = 10$ mA, f = 1 kHz								0.5		kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 100$ μA, f = 1 kHz	250	440	800							
		$V_{CE} = 5$ V, $I_C = 1$ mA, f = 1 kHz				100	240	400				
		$V_{CE} = 5$ V, $I_C = 10$ mA, f = 1 kHz							60	130	500	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = 5$ V, $I_C = 100$ μA, f = 1 kHz		30×10^{-4}								
		$V_{CE} = 5$ V, $I_C = 1$ mA, f = 1 kHz					1.5×10^{-4}					
		$V_{CE} = 5$ V, $I_C = 10$ mA, f = 1 kHz								0.9×10^{-4}		
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 5$ V, $I_C = 100$ μA, f = 1 kHz		11								μmho
		$V_{CE} = 5$ V, $I_C = 1$ mA, f = 1 kHz					6					μmho
		$V_{CE} = 5$ V, $I_C = 10$ mA, f = 1 kHz								50		μmho
y_{fe}	Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = 5$ V, $I_C = 100$ μA, f = 1 kHz		3.8								mmho
		$V_{CE} = 5$ V, $I_C = 1$ mA, f = 1 kHz				30	38					mmho
		$V_{CE} = 5$ V, $I_C = 10$ mA, f = 1 kHz								260		mmho
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 10$ mA, f = 100 MHz	2			2			2			
C_{cb}	Collector-Base Capacitance	$V_{CB} = 5$ V, $I_E = 0$, f = 1 MHz, See Note 5	1		4	1		4	1		4	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, f = 1 MHz, See Note 5			16			16			16	pF

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS94, TIS97 MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 5$ V, $I_C = 30$ μA, $R_G = 10$ kΩ, f = 1 kHz, Noise Bandwidth = 100 Hz	2	dB
$\bar{F}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 100$ μA, $R_G = 10$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 6	3	dB

NOTES:
4. These parameters must be measured using pulse techniques. $t_w = 300$ μs, duty cycle ≤ 2%.
5. C_{cb} and C_{eb} are measured using three-terminal measurement techniques with the third electrode (emitter or collector, respectively) guarded.
6. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency rolloff of 6 dB/octave.

§The TIS96 and TIS99 are color-coded on h_{FE} measured at $V_{CE} = 5$ V, $I_C = 100$ mA. Each h_{FE} bracket has a 2-to-1 spread as follows: red, 55-110; orange, 90-180; yellow, 150-300. No particular h_{FE} distribution is implied by this coding system.

BULLETIN NO. DL-S 6810553, NOVEMBER 1968

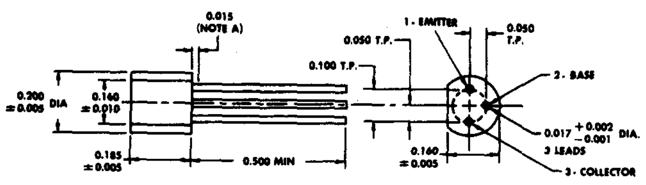
4

HIGH-VOLTAGE SILECT† TRANSISTORS‡ FOR VIDEO OUTPUT STAGES, AGC AMPLIFIERS, AND BURST AMPLIFIERS

- High $V_{(BR)CEO}$ . . . 180 V Min (TIS100)
- Low C_{cb} . . . 3 pF Max

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	TIS100	TIS101
Collector-Base Voltage	180 V	150 V
Collector-Emitter Voltage (See Note 1)	180 V	150 V
Emitter-Base Voltage	5 V	5 V
Continuous Collector Current	← 100 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 625 mW →	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	← 1.25 W →	
Continuous Device Dissipation at (or below) 25°C Case-and-Lead Temperature (See Note 4)	← 1.6 W →	
Storage Temperature Range	−65°C to 150°C	
Lead Temperature 1/16 Inch from Case for 60 Seconds	← 260°C →	

NOTES: 1. These values apply between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/deg.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/deg. Lead temperature is measured on the collector lead 1/16 inch from the case.
4. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/deg.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N27

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS100			TIS101			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	180			150			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 5	180			150			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 75$ V, $I_E = 0$			50			50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$			100			100	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA	20			20			
		$V_{CE} = 10$ V, $I_C = 25$ mA, See Note 5	30			30			
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 2.5$ mA, $I_C = 25$ mA, See Note 5			1			1	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 50$ V, $I_C = 2.5$ mA, $f = 20$ MHz	3			3			
		$V_{CE} = 15$ V, $I_C = 25$ mA, $f = 20$ MHz	4			4			
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 20$ V, $I_E = 0$, $f = 1$ MHz, See Note 6		2.8			2.8		pF
C_{cb}	Collector-Base Capacitance	$V_{CB} = 20$ V, $I_E = 0$, $f = 1$ MHz, See Note 6		1.7	3		1.7	3	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 1$ V, $I_C = 0$, $f = 1$ MHz, See Note 6		13			13		pF

NOTES: 5. These parameters must be measured using pulse techniques. $t_p = 300\ \mu s$, duty cycle $\leq 2\%$.

6. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} measurements are made with the third terminal floating.

THERMAL INFORMATION

SYMBOL DEFINITION

SYMBOL	DEFINITION	VALUE	UNIT
P_T	Transistor Power Dissipation		W
$R_{\theta J\text{-}L}$	Junction-to-Lead Thermal Resistance	100	°C/W
$R_{\theta L\text{-}HS}$	Lead-to-Heat-Sink Thermal Resistance	See	°C/W
$R_{\theta HS\text{-}A}$	Heat-Sink-to-Free-Air Thermal Resistance	Figure 1	°C/W
T_A	Free-Air Temperature		°C
T_J	Junction Temperature	<150	°C

The minimum heat-sink requirement may be calculated by the procedures used in the following example:

OPERATING CONDITIONS: $T_A = 60\,°C$

T_J (transistor design limit) = 150°C

$I_C \approx 8.5$ mA

$V_{CE} = 70$ V

Solution: $P_T \approx I_C \times V_{CE}$

$P_T \approx 8.5\ \text{mA} \times 70\ \text{V}$

$P_T \approx 0.6$ W

$$R_{\theta L\text{-}HS} + R_{\theta HS\text{-}A} = \frac{T_J - T_A}{P_T} - R_{\theta J\text{-}L}$$

$$R_{\theta L\text{-}HS} + R_{\theta HS\text{-}A} = \frac{150 - 60}{0.6} - 100$$

$$R_{\theta L\text{-}HS} + R_{\theta HS\text{-}A} = 50\ °C/W$$

Area = 0.85 in.[2] (from Figure 1)

TYPICAL LEAD-TO-HEAT-SINK-TO-FREE-AIR THERMAL RESISTANCE
vs
HEAT-SINK AREA

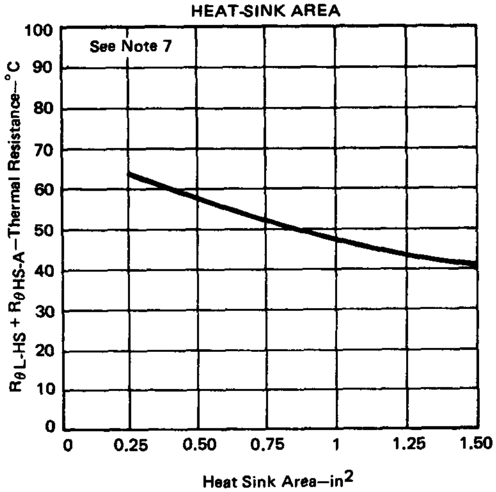


FIGURE 1

NOTE 7: The collector lead is soldered to the middle of an edge of a square heat sink made of 2-ounce copper bonded to 1/16-inch-thick XXXP Bakelite†

†Trademark of Union Carbide Corporation

TYPE TIS105
N-P-N SILICON TRANSISTOR

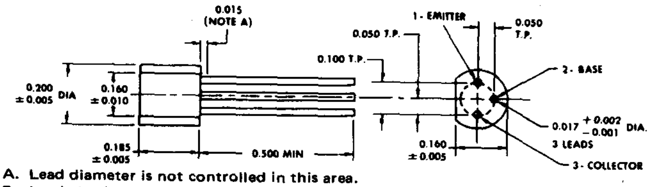
BULLETIN NO. DL-S 7311280, MARCH 1970—REVISED MARCH 1973

HIGH-FREQUENCY SILECT† TRANSISTOR‡
DESIGNED FOR TV MIXERS AND NON-AGC IF STAGES
Full Characterization to Simplify Circuit Design

- **Low Feedback Capacitance**
- **h_{FE} Linearity over Wide Current Range Minimizes Intermodulation Distortion**
- **Rugged, One-Piece Construction with Standard TO-18 100-mil Pin Circle**
- **1.25 W Rating at 25°C Lead Temperature**

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	45 V
Collector-Emitter Voltage (See Note 1)	45 V
Emitter-Base Voltage	4 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	1.25 W
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

USES CHIP N20

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		45			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$,	See Note 4	45			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30\ V$, $I_E = 0$				50	nA
		$V_{CB} = 30\ V$, $I_E = 0$,	$T_A = 85°C$			10	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4\ V$, $I_C = 0$				10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 15\ V$, $I_C = 10\ mA$	See Note 4	30		150	
		$V_{CE} = 15\ V$, $I_C = 30\ mA$		30		150	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 15\ V$, $I_C = 10\ mA$,	See Note 4			0.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1\ mA$, $I_C = 20\ mA$				0.5	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 15\ V$, $I_C = 10\ mA$,	$f = 100\ MHz$	3	6.5		
$\frac{f_{T(2)}}{f_{T(1)}}$	Ratio of Transition Frequencies	$V_{CE} = 15\ V$, $I_{C(1)} = 10\ mA$, $I_{C(2)} = 20\ mA$, See Note 5		0.75			
$\lvert y_{fe} \rvert$	Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = 15\ V$, $I_C = 10\ mA$,	$f = 45\ MHz$		240		mmho
ϕ_{yfe}	Phase Angle of Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = 15\ V$, $I_C = 10\ mA$,	$f = 45\ MHz$		40°		
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10\ V$, $I_E = 0$,	$f = 1\ MHz$, See Note 6		0.7	1	pF
C_{ies}	Parallel-Equivalent Common-Emitter Short-Circuit Input Capacitance†	$V_{CE} = 15\ V$, $I_C = 10\ mA$,	$f = 45\ MHz$		32		pF
C_{oes}	Parallel-Equivalent Common-Emitter Short-Circuit Output Capacitance†	$V_{CE} = 15\ V$, $I_C = 10\ mA$,	$f = 45\ MHz$		2.4		pF
$Re(y_{ie})$	Real Part of Small-Signal Common-Emitter Input Admittance	$V_{CE} = 15\ V$, $I_C = 10\ mA$,	$f = 45\ MHz$		11		mmho
		$V_{CE} = 15\ V$, $I_C = 10\ mA$,	$f = 200\ MHz$		25		
$Re(y_{oe})$	Real Part of Small-Signal Common-Emitter Output Admittance	$V_{CE} = 15\ V$, $I_C = 10\ mA$,	$f = 45\ MHz$		0.15		mmho

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
5. To obtain f_T, the $\lvert h_{fe} \rvert$ response is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.
6. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

†C_{ies} and C_{oes} are defined as the imaginary parts of the small-signal, common-emitter, short-circuit admittances divided by $2\pi f$.

operating characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	TYP	MAX	UNIT
Mixer Spot Noise Figure	$V_{CC} = 18\ V$, $I_C \approx 6.5\ mA$, $f_{RF} = 200\ MHz$, $f_{LO} = 245\ MHz$,	5.5	7	dB
Conversion Gain	Bandwidth = 4.5 MHz, See Figure 3	22		dB

TYPICAL CHARACTERISTICS

TRANSITION FREQUENCY
vs
COLLECTOR CURRENT

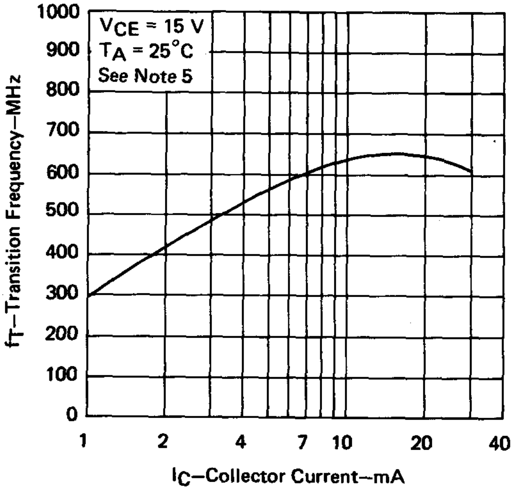


FIGURE 1

OUTPUT LINEARITY

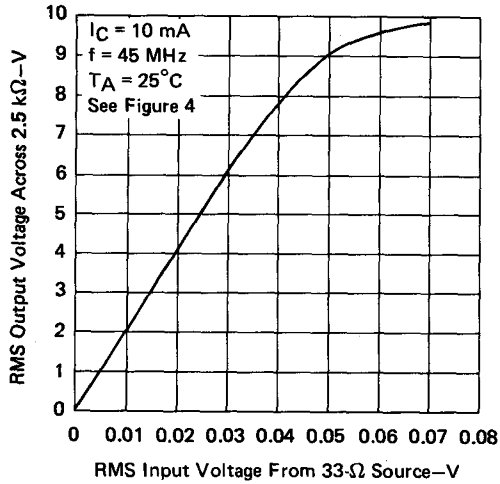
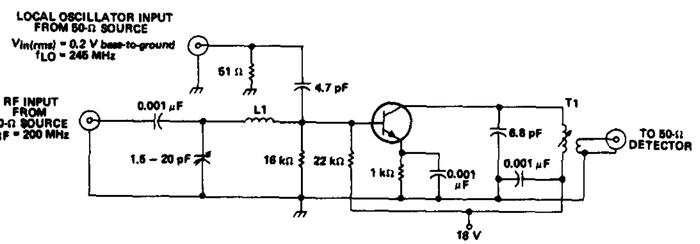


FIGURE 2

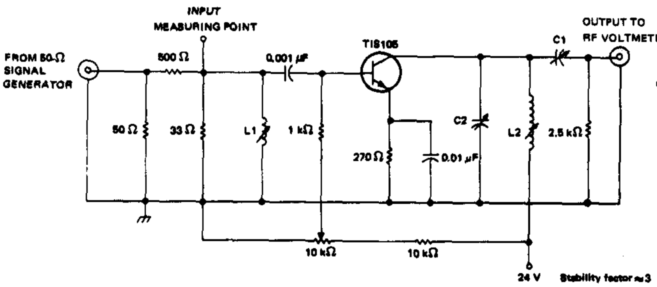
NOTE 5: To obtain f_T, the $|h_{fe}|$ response is extrapolated at the rate −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}|$ = 1.

PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION
L1—4T #22 AWG, 9/64" ID, 5/32" length
T1—PRI: 13T #26 AWG
SEC: 2T #26 AWG
CORE: Arnold Engineering Type J (or equivalent), 9/64" diameter

MIXER SPOT NOISE FIGURE AND CONVERSION GAIN TEST CIRCUIT
FIGURE 3



CIRCUIT COMPONENT INFORMATION
L1—Tunes Input to 45 MHz
C1—Adjusted for Power Match at 5-V RMS Output
C2 and L2—Adjusted for 4.5 MHz Bandwidth at 45 MHz

MEASUREMENT INFORMATION FOR FIGURE 2
FIGURE 4

TEXAS INSTRUMENTS
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BULLETIN NO. DL-S 7311254, AUGUST 1969—REVISED MARCH 1973

HIGH-FREQUENCY SILECT† TRANSISTORS‡
FOR TV TUNER AND IF APPLICATIONS

Featuring Low-Feedback Capacitance and Forward-AGC Characteristics

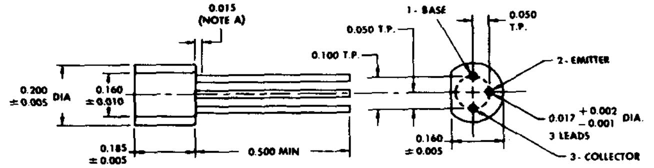
- **TIS84 for Tuner RF Amplifiers**
- **TIS108 for IF Amplifiers (Replaces TIS85)**

Rugged, One-Piece Construction with Standard TO-18 100-mil Pin Circle

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

Feedback capacitance is minimized by placing the emitter terminal between the base and collector terminals, thus optimizing compatability with advanced high-frequency design.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	40 V
Collector-Emitter Voltage (See Note 1)	30 V
Emitter-Base Voltage	4 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	500 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TIS84		TIS108		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	40		40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 3	30		30		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ V, $I_E = 0$		50		50	nA
		$V_{CB} = 10$ V, $I_E = 0$, $T_A = 85°C$		5		5	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ V, $I_C = 0$		10		10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA	30		25		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 4$ mA		0.84		0.84	V

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 4 mW/°C.
3. This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS84 MIN	TIS84 TYP	TIS84 MAX	TIS108 MIN	TIS108 TYP	TIS108 MAX	UNIT
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 10 V, I_C = 4 mA, f = 100 MHz	3.5	6.5		3.5	6.5		
$\|y_{fe}\|$	Small-Signal Common-Emitter Forward Transfer Admittance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz	60	80					mmho
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz				80	105		
ϕ_{yfe}	Phase Angle of Small-Signal Common-Emitter Forward Transfer Admittance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz	−50°	−60°	−80°				
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz				−10°	−18°	−25°	
C_{ies}	Parallel-Equivalent Common-Emitter Short-Circuit Input Capacitance†	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		11					pF
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					18		
C_{res}	Common-Emitter Short-Circuit Reverse Transfer Capacitance†	V_{CE} = 10 V, I_C = 1 mA, f = 0.1 MHz to 1 MHz		0.22	0.4		0.22	0.4	pF
C_{oes}	Parallel-Equivalent Common-Emitter Short-Circuit Output Capacitance†	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		1.1					pF
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					1.1		
$Re(h_{ie})$	Real Part of Small-Signal Common-Emitter Input Impedance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		25	60				Ω
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					50	80	
$Re(y_{ie})$	Real Part of Small-Signal Common-Emitter Input Admittance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		14	40				mmho
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					3	6	
$Re(y_{oe})$	Real Part of Small-Signal Common-Emitter Output Admittance	V_{CE} = 10 V, I_C = 4 mA, f = 200 MHz		0.2	0.5				mmho
		V_{CE} = 10 V, I_C = 4 mA, f = 45 MHz					0.05	0.2	

† C_{ies}, C_{res}, and C_{oes} are defined as the imaginary parts of the small-signal, common-emitter, short-circuit admittances divided by $2\pi f$.

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS84 MIN	TIS84 TYP	TIS84 MAX	TIS108 MIN	TIS108 TYP	TIS108 MAX	UNIT
NF	Spot Noise Figure	V_{CE} = 10 V, I_C = 3 mA, R_G = 50 Ω, f = 200 MHz		2.8	3.3				dB
		V_{CE} = 10 V, I_C = 3 mA, R_G = 50 Ω, f = 45 MHz					3	6	dB
G_{pe}	Unneutralized Small-Signal Common-Emitter Insertion Power Gain	V_{CC} = 12 V, $I_C \approx$ 2.5 mA, V_{BB} = 2.1 V, R_G' = 150 Ω, R_L' = 1 kΩ, f = 200 MHz, See Figure 1	12	16	18				dB
		V_{CC} = 12 V, $I_C \approx$ 4.5 mA, V_{BB} = 2.6 V, R_G' = 500 Ω, R_L' = 250 Ω, f = 45 MHz, See Figure 1				25	30	33	dB
$V_{BB(GC)}$	Gain-Control Base-Supply Voltage	V_{CC} = 12 V, R_G' = 150 Ω, R_L' = 1 kΩ, ΔG_{pe} = −30 dB‡, f = 200 MHz, See Figure 1	3.7		4.6				V
		V_{CC} = 12 V, R_G' = 500 Ω, R_L' = 250 Ω, ΔG_{pe} = −30 dB‡, f = 45 MHz, See Figure 1				3.5		4.5	V

‡ΔG_{pe} is defined as the change in G_{pe} from the value at V_{BB} = 2.1 V at 200 MHz or from the value at V_{BB} = 2.6 V at 45 MHz.

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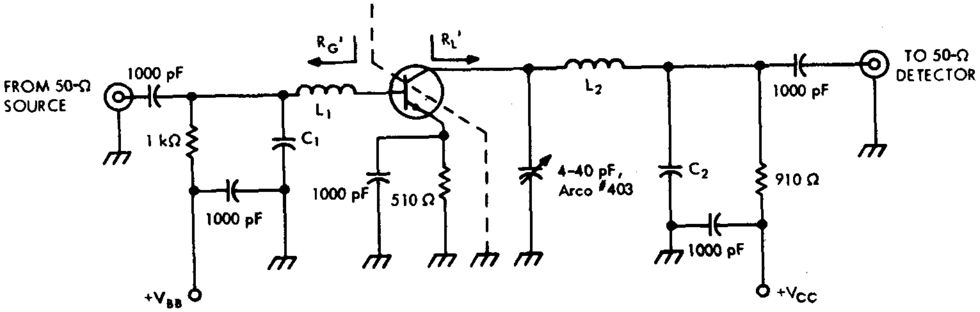
PARAMETER MEASUREMENT INFORMATION



COMPONENTS FOR f = 45 MHz

C_1: 36 pF
C_2: 47 pF
L_1: 8 T #20 enameled copper wire, close-wound on ¼" diameter form
L_2: 10 T #20 enameled copper wire, close-wound on ¼" diameter form

COMPONENTS FOR f = 200 MHz

C_1: 18 pF
C_2: 270 pF
L_1: 2 T #20 enameled copper wire, ⅛" pitch, wound on 7/32" diameter form
L_2: 2 T #14 enameled copper wire, ⅛" pitch, wound on 7/32" diameter form

FIGURE 1 — POWER-GAIN AND GAIN-CONTROL-VOLTAGE TEST CIRCUIT

TYPICAL CHARACTERISTICS

TIS108
RELATIVE SMALL-SIGNAL COMMON-EMITTER POWER GAIN
vs
GAIN-CONTROL BASE-SUPPLY VOLTAGE

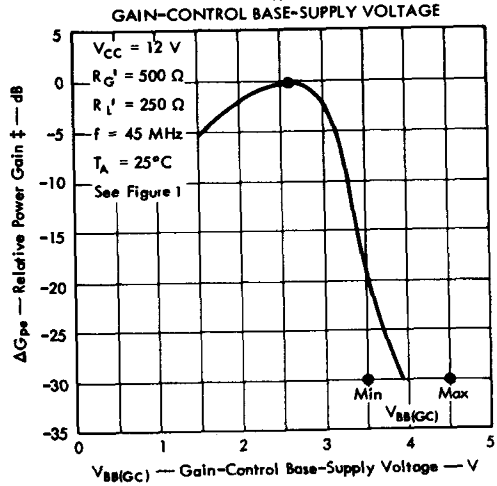


FIGURE 2

NOTE 3: This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
‡ΔG_{pe} is defined as the change in G_{pe} from the value at V_{BB} = 2.1 V at 200 MHz or from the value at V_{BB} = 2.6 V at 45 MHz.

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BULLETIN NO. DL-S 7311317, MAY 1970—REVISED MARCH 1973

SILECT† TRANSISTORS‡

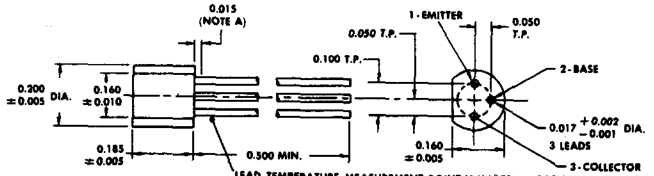
DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

featuring

- High f_T . . . . 350 MHz typ at 10 V, 20 mA
- Low $V_{CE(sat)}$ . . . . 0.13 V typ at 150 mA
- High Maximum I_C . . . . 800 mA
- A5T2222 Electrically Similar to 2N2222, 2N3116, and 2N4952
- TIS109 Processing Includes Operational Aging at 300 mW for 24 Hours
- TIS110 Electrically Similar to 2N4400
- TIS111 Electrically Similar to 2N4401

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T2222 TIS109	TIS110 TIS111
Collector-Base Voltage	60 V	60 V
Collector-Emitter Voltage (See Note 1)	30 V	40 V
Emitter-Base Voltage	5 V	6 V
Continuous Collector Current	← 800 mA →	
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 625 mW →	
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	← 1.25 W →	
Storage Temperature Range	← −65°C to 150°C →	
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 260°C →	

NOTES: 1. These values apply between 0 and 10 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments

‡U.S. Patent No. 3,439,238.

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A5T2222, TIS109

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		A5T2222 MIN	A5T2222 MAX	TIS109 MIN	TIS109 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$,	See Note 4	30		30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		5		5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 20\ V$, $I_E = 0$					100	nA
		$V_{CB} = 50\ V$, $I_E = 0$			10			nA
		$V_{CB} = 50\ V$, $I_E = 0$,	$T_A = 100°C$		3		3	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 3\ V$, $I_C = 0$			10		10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 100\ \mu A$		35		20		
		$V_{CE} = 10\ V$, $I_C = 1\ mA$		50		30		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$	See Note 4	75		40		
		$V_{CE} = 10\ V$, $I_C = 150\ mA$	See Note 4	100	300	100	400	
		$V_{CE} = 10\ V$, $I_C = 500\ mA$	See Note 4	30		20		
		$V_{CE} = 1\ V$, $I_C = 150\ mA$	See Note 4	50		35		
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$	See Note 4		1.3		1.3	V
		$I_B = 50\ mA$, $I_C = 500\ mA$	See Note 4		2.6		2.6	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$	See Note 4		0.4		0.4	V
		$I_B = 50\ mA$, $I_C = 500\ mA$	See Note 4		1.6		1.6	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 20\ mA$,	$f = 100\ MHz$	2.5		2.5		
f_T	Transition Frequency	$V_{CE} = 10\ V$, $I_C = 20\ mA$,	See Note 5	250		250		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$,	$f = 1\ MHz$		8		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$,	$f = 1\ MHz$		25		25	pF
$Re(h_{ie})$	Real Part of Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10\ V$, $I_C = 20\ mA$,	$f = 300\ MHz$		60		60	Ω

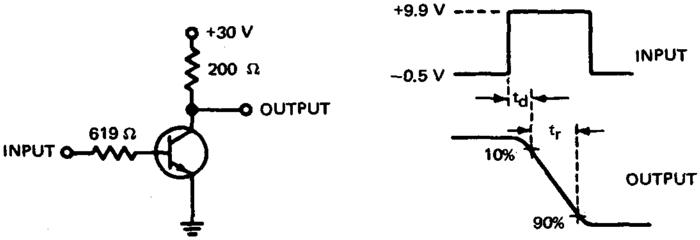
NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
5. To obtain f_T, the $|h_{fe}|$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS†	TYP	UNIT
t_d Delay Time	$V_{CC} = 30\ V$, $I_C = 150\ mA$, $I_{B(1)} = 15\ mA$,	5	ns
t_r Rise Time	$V_{BE(off)} = -0.5\ V$, See Figure 1	15	ns
t_s Storage Time	$V_{CC} = 30\ V$, $I_C = 150\ mA$, $I_{B(1)} = 15\ mA$,	190	ns
t_f Fall Time	$I_{B(2)} = -15\ mA$, See Figure 2	23	ns

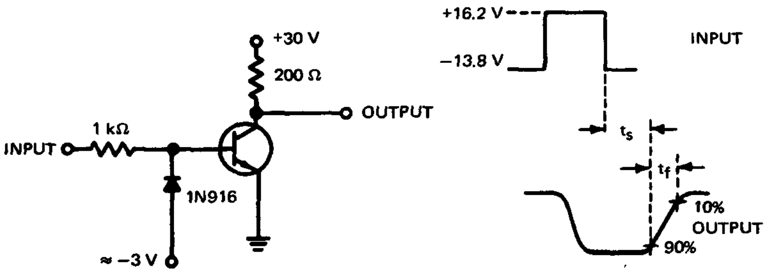
†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT | VOLTAGE WAVEFORMS

FIGURE 1–DELAY AND RISE TIMES



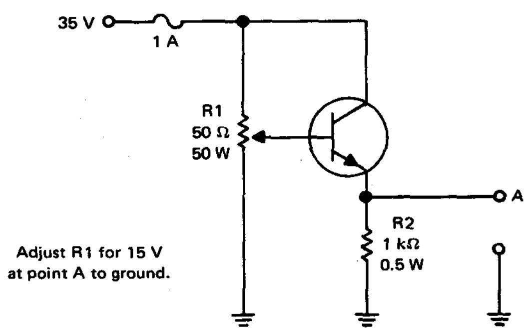
TEST CIRCUIT | VOLTAGE WAVEFORMS

FIGURE 2–STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: for figure 1, $t_r \leq 2$ ns, $t_w \leq 200$ ns, duty cycle $\leq 2\%$; for figure 2, $t_f \leq 5$ ns, $t_w \approx 100\ \mu s$, duty cycle $\leq 17\%$.
b. All waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 12$ pF.

TIS109 OPERATIONAL AGING

All TIS109 transistors are aged for a minimum of 24 hours in the circuit shown at the right. Total device dissipation is approximately 300 mW. All static characteristics are tested prior to and after aging. Dynamic characteristics are tested as necessary to guarantee the specified limits after aging.



NOMINAL CONDITIONS
$V_{CE} = 20$ V
$I_E = -15$ mA
$T_A = 25°C$

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TIS110, TIS111

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS110 MIN	TIS110 MAX	TIS111 MIN	TIS111 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	60		60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$	40		40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	6		6		V
I_{CEV}	Collector Cutoff Current	$V_{CE} = 35\ V$, $V_{BE} = -0.4\ V$		100		100	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = 35\ V$, $V_{BE} = -0.4\ V$		−100		−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1\ V$, $I_C = 100\ \mu A$			20		
		$V_{CE} = 1\ V$, $I_C = 1\ mA$	20		40		
		$V_{CE} = 1\ V$, $I_C = 10\ mA$, See Note 4	40		80		
		$V_{CE} = 1\ V$, $I_C = 150\ mA$, See Note 4	50	150	100	300	
		$V_{CE} = 2\ V$, $I_C = 500\ mA$, See Note 4	20		40		
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$, See Note 4	0.75	0.95	0.75	0.95	V
		$I_B = 50\ mA$, $I_C = 500\ mA$, See Note 4		1.2		1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$, See Note 4		0.4		0.4	V
		$I_B = 50\ mA$, $I_C = 500\ mA$, See Note 4		0.75		0.75	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	0.5	7.5	1	15	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	20	250	40	500	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 1\ mA$, $f = 1\ kHz$		8×10^{-4}		8×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	1	30	1	30	µmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 20\ mA$, $f = 100\ MHz$	2		2.5		
f_T	Transition Frequency	$V_{CE} = 10\ V$, $I_C = 20\ mA$, See Note 5	200		250		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 5\ V$, $I_E = 0$, $f = 1\ MHz$, See Note 6		6.5		6.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$, $f = 1\ MHz$, See Note 6		30		30	pF

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

5. To obtain f_T, the $\lvert h_{fe} \rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.

6. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

4

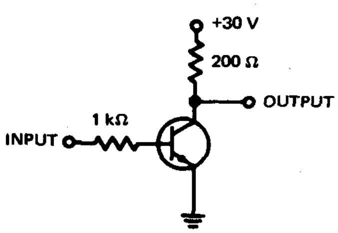
TIS110, TIS111

switching characteristics at 25°C free-air temperature

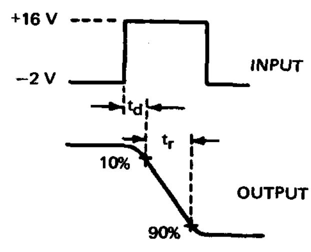
PARAMETER	TEST CONDITIONS†	MAX	UNIT
t_d Delay Time	$V_{CC} = 30$ V, $I_C = 150$ mA, $I_{B(1)} = 15$ mA,	15	ns
t_r Rise Time	$V_{BE(off)} = -2$ V, See Figure 3	20	ns
t_s Storage Time	$V_{CC} = 30$ V, $I_C = 150$ mA, $I_{B(1)} = 15$ mA,	230	ns
t_f Fall Time	$I_{B(2)} = -15$ mA, See Figure 4	60	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

PARAMETER MEASUREMENT INFORMATION

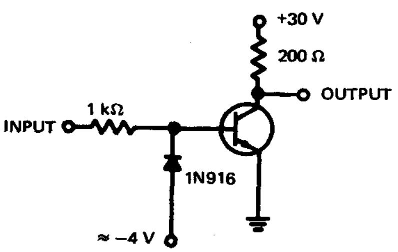


TEST CIRCUIT

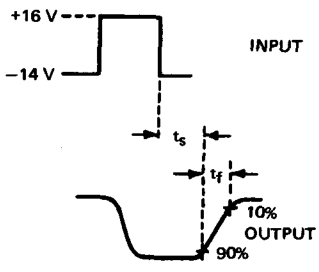


VOLTAGE WAVEFORMS

FIGURE 3—DELAY AND RISE TIMES



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 4—STORAGE AND FALL TIMES

NOTES: a. The input waveforms have the following characteristics: for figure 3, $t_r \leq 2$ ns, $t_w \leq 10$ μs, duty cycle ≤ 2%; for figure 4, $t_f \leq 5$ ns, $t_w \approx 10$ μs, duty cycle ≤ 2%.

b. All waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 12$ pF.

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PRINTED IN U.S.A. 570

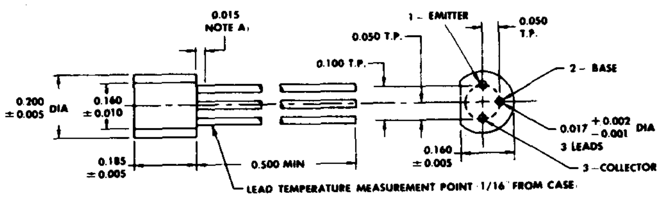
BULLETIN NO. DL-S 7311318, MARCH 1970–REVISED MARCH 1973

SILECT† TRANSISTORS‡
DESIGNED FOR HIGH-SPEED, MEDIUM-POWER SWITCHING AND GENERAL PURPOSE AMPLIFIER APPLICATIONS

- **A5T2907, A5T3644, and A5T3645 Electrically Similar to 2N2907, 2N3644, and 2N3645**
- **TIS112 Processing Includes Operational Aging at 300 mW for 24 Hours**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	A5T2907 TIS112	A5T3644	A5T3645
Collector-Base Voltage	−60 V	−45 V	−60 V
Collector-Emitter Voltage (See Note 1)	−40 V	−45 V	−60 V
Emitter-Base Voltage	−5 V	−5 V	−5 V
Continuous Collector Current	← −600 mA →		
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	← 625 mW →		
Continuous Device Dissipation at (or below) 25°C Case and Lead Temperature (See Note 3)	← 1.6 W →		
Storage Temperature Range	← −65°C to 150°C →		
Lead Temperature 1/16 Inch from Case for 10 Seconds	← 260°C →		

NOTES: 1. This value applies between 0 and 600 mA collector current when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.
3. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

†Trademark of Texas Instruments
‡U. S. Patent No. 3,439,238

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electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS			A5T2907 TIS112 MIN	A5T2907 TIS112 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$		−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ mA$,	$I_B = 0$,	See Note 4	−40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50\ V$,	$I_E = 0$			−20	nA
		$V_{CB} = -50\ V$,	$I_E = 0$,	$T_A = 125°C$		−10	μA
I_{CEV}	Collector Cutoff Current	$V_{CE} = -30\ V$,	$V_{BE} = 0.5\ V$			−50	nA
I_{BEV}	Base Cutoff Current	$V_{CE} = -30\ V$,	$V_{BE} = 0.5\ V$			50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10\ V$,	$I_C = -100\ \mu A$		35		
		$V_{CE} = -10\ V$,	$I_C = -1\ mA$		50		
		$V_{CE} = -10\ V$,	$I_C = -10\ mA$	See Note 4	75		
		$V_{CE} = -10\ V$,	$I_C = -150\ mA$	See Note 4	100	300	
		$V_{CE} = -10\ V$,	$I_C = -500\ mA$	See Note 4	30		
V_{BE}	Base-Emitter Voltage	$I_B = -15\ mA$,	$I_C = -150\ mA$	See Note 4		−1.3	V
		$I_B = -50\ mA$,	$I_C = -500\ mA$	See Note 4		−2.6	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15\ mA$,	$I_C = -150\ mA$	See Note 4		−0.4	V
		$I_B = -50\ mA$,	$I_C = -500\ mA$	See Note 4		−1.6	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10\ V$,	$I_C = -30\ mA$,	f = 100 MHz	2		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10\ V$,	$I_E = 0$,	f = 1 MHz		8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -2\ V$,	$I_C = 0$,	f = 1 MHz		30	pF

NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†	A5T2907 MAX	TIS112 MAX	UNIT
t_d	Delay Time	$I_C = -150\ mA$, $I_{B(1)} = -15\ mA$, $V_{BE(off)} = 0$, $R_L = 200\ \Omega$, See Figure 1	10	10	ns
t_r	Rise Time		40	40	ns
t_{on}	Turn-On Time		45	45	ns
t_s	Storage Time	$I_C = -150\ mA$, $I_{B(1)} = -13\ mA$, $I_{B(2)} = 17\ mA$, $R_L = 37\ \Omega$, See Figure 2	80	80	ns
t_f	Fall Time		30	70	ns
t_{off}	Turn-Off Time		100	140	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

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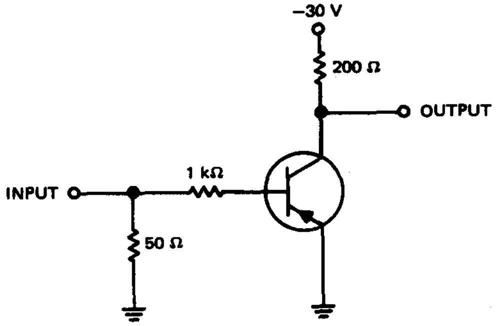
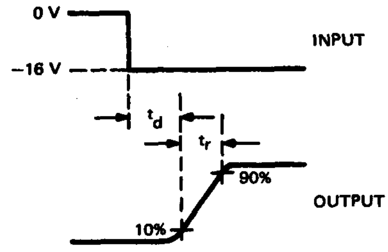
PARAMETER MEASUREMENT INFORMATION

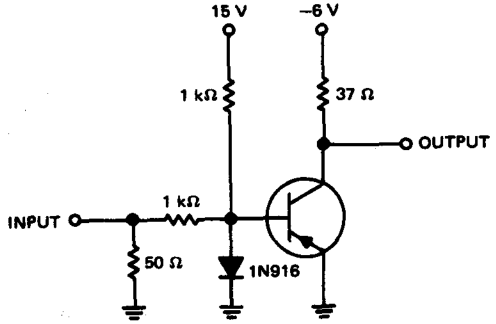


TEST CIRCUIT

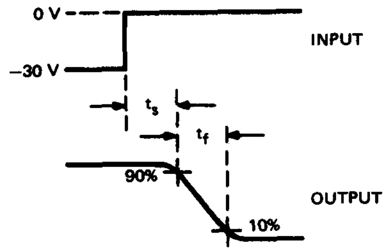


(See Notes A and B)
VOLTAGE WAVEFORMS

FIGURE 1—A5T2907 and TIS112



TEST CIRCUIT



(See Notes A and B)
VOLTAGE WAVEFORMS

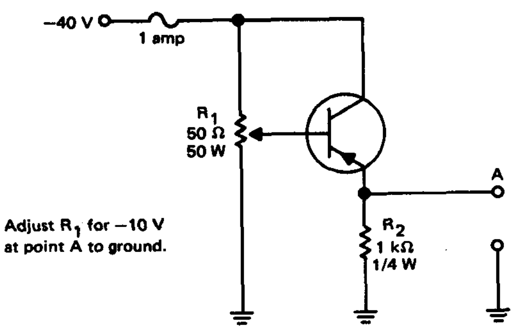
FIGURE 2—A5T2907 and TIS112

NOTES: A. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 2$ ns, $t_f \leq 2$ ns, $t_w = 200$ ns, PRR = 150 pps.

B. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 5$ ns, $R_{in} = 10\ M\Omega$, $C_{in} \leq 12$ pF.

TIS112 OPERATIONAL AGING

All TIS112 transistors are aged for a minimum of 24 hours in the circuit shown below. Total device dissipation is approximately 300 mW. All static characteristics are tested prior to and after aging. Dynamic characteristics are tested as necessary to guarantee the specified limits after aging.



NOMINAL CONDITIONS
$V_{CE} = -30$ V
$I_E = 10$ mA
$T_A = 25°C$

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BULLETIN NO. DL-S 7211738, MAY 1972

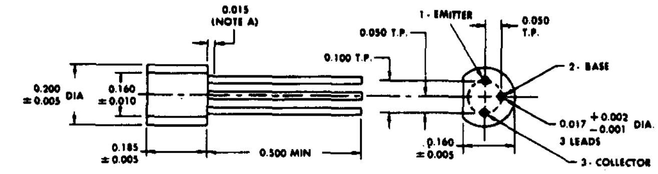
HIGH-FREQUENCY SILECT† TRANSISTORS‡ DESIGNED FOR COMMON-BASE VHF APPLICATIONS

- **Low Feedback Capacitance, C_{ce}**
- **Specified Forward-AGC Characteristics**

Rugged, One-Piece Construction with Standard TO-18 100-mil Pin Circle

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	40 V
Collector-Emitter Voltage (See Note 1)	30 V
Emitter-Base Voltage	4 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 3	30		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ V, $I_E = 0$		50	nA
		$V_{CB} = 10$ V, $I_E = 0$, $T_A = 85°C$		5	μA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ V, $I_C = 0$		10	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA	30		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 4$ mA		0.8	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA, f = 100 MHz	4.5		
C_{ce}	Collector-Emitter Capacitance	$V_{CE} = 10$ V, $I_B = 0$, f = 1 MHz, See Note 4		0.3	pF

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. *Derate linearly to 150°C free-air temperature at the rate of 2 mW/°C.*
3. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
4. C_{ce} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The base is connected to the guard terminal of the bridge.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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TEXAS INSTRUMENTS
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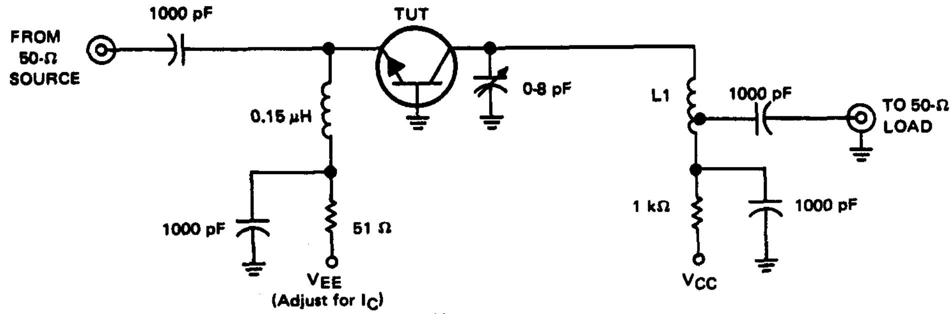
operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
F	Spot Noise Figure	$V_{CC} = 10$ V, $I_C = 3$ mA, $R_G = 50\ \Omega$, $f = 200$ MHz, See Figure 1		3.5	dB
G_{pb}	Unneutralized Small-Signal Common-Base Insertion Power Gain	$V_{CC} = 10$ V, $I_C = 3$ mA, $f = 200$ MHz, See Figure 1	17	23	dB
I_C	Collector Current for 30-dB Gain Reduction	$V_{CC} = 10$ V, $f = 200$ MHz, $\Delta G_{pb} = -30$ dB†, See Figure 1	5	7.5	mA

†ΔG_{pb} is defined as the change in G_{pb} from the value at $I_C = 3$ mA.

PARAMETER MEASUREMENT INFORMATION



L1: 6T #16, ¼ inch ID, tapped 3/4 turn from end nearer V_{CC}.

FIGURE 1—200 MHz POWER GAIN, NOISE FIGURE, AND GAIN CONTROL TEST CIRCUIT

TYPICAL CHARACTERISTICS

SMALL-SIGNAL COMMON-BASE INSERTION POWER GAIN vs COLLECTOR CURRENT

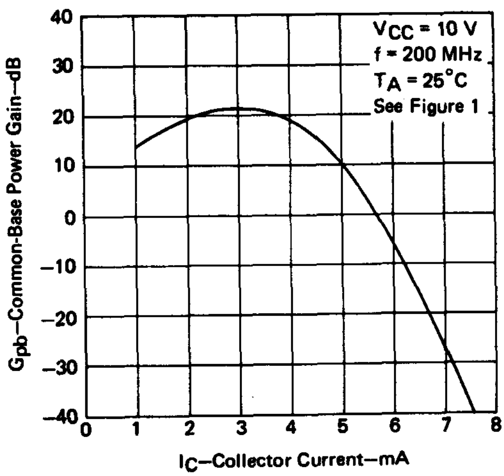


FIGURE 2

TEXAS INSTRUMENTS INCORPORATED
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BULLETIN NO. DL-S 7311992, MARCH 1973

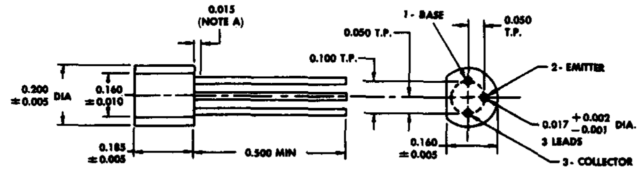
HIGH-FREQUENCY SILECT† TRANSISTOR‡ FOR USE IN VHF MIXERS AND NON-AGC IF AMPLIFIERS

- High f_T . . . 600 MHz Min
- Specified f_T vs I_C Characteristic
- Low C_{cb} . . . 0.36 pF Max
- Rugged, One-Piece Construction with Standard TO-18 100-Mil Pin Circle

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.

Feedback capacitance is minimized by placing the emitter terminal between the base and collector terminals, thus optimizing compatibility with advanced high-frequency design.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	45 V
Collector-Emitter Voltage (See Note 1)	40 V
Emitter-Base Voltage	4 V
Continuous Collector Current	50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	400 mW
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 3)	700 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 3.2 mW/°C.
3. Derate linearly to 150°C lead temperature at the rate of 5.6 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		45		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA,	$I_B = 0$,	See Note 4	40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$		4		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ V,	$I_E = 0$			50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 15$ V,	$I_C = 10$ mA,	See Note 4	25		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 3$ mA,	$I_C = 30$ mA,	See Note 4		0.5	V
$\|h_{fe}\|$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 15$ V,	$I_C = 10$ mA,	f = 100 MHz	6		
$\frac{f_{T(2)}}{f_{T(1)}}$	Ratio of Transition Frequencies	$V_{CE} = 15$ V, See Note 5	$I_{C(1)} = 15$ mA,	$I_{C(2)} = 20$ mA,	0.65		
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, See Note 6	$I_E = 0$,	f = 1 MHz,		0.36	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 15$ V,	$I_E = -4$ mA,	f = 79.8 MHz		10	ps

NOTES: 4. These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

5. To obtain f_T, the $|h_{fe}|$ response is extrapolated at the rate of −6 dB per octave from f = 100 MHz to the frequency at which $|h_{fe}| = 1$.

6. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			MIN	MAX	UNIT
F	Spot Noise Figure	$V_{CE} = 15$ V, f = 200 MHz	$I_C = 4$ mA,	$R_G = 50\ \Omega$,		5	dB
$G_{pe(conv)}$	Small-Signal Conversion Power Gain	$V_{CC} = 15$ V,	$I_C = 10$ mA,	$f_{LO} = 245$ MHz,	24		dB
B	Bandwidth	$f_{RF} = 200$ MHz,	See Figure 3		6		MHz
G_{pe}	Small-Signal Common-Emitter Insertion Power Gain	$V_{CC} = 15$ V, See Figure 4	$I_C = 10$ mA,	f = 45 MHz,	30		dB
B	Bandwidth				6		MHz

TYPICAL CHARACTERISTICS

SMALL-SIGNAL CONVERSION POWER GAIN
vs
COLLECTOR CURRENT

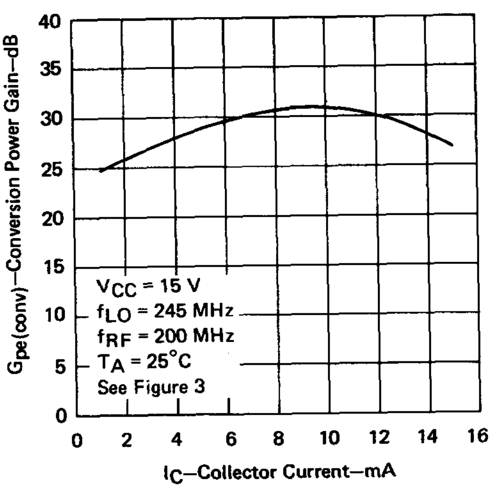


FIGURE 1

SMALL-SIGNAL COMMON-EMITTER
INSERTION POWER GAIN
vs
COLLECTOR CURRENT

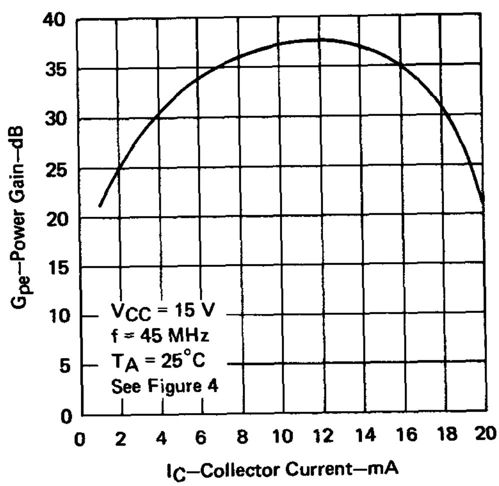
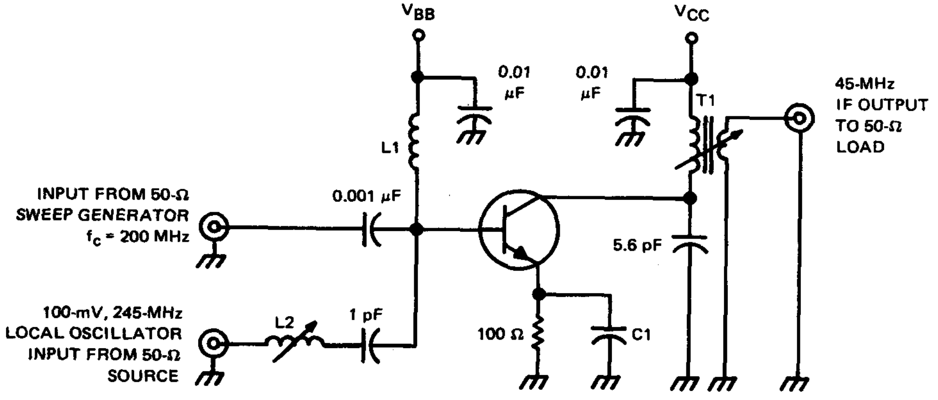


FIGURE 2

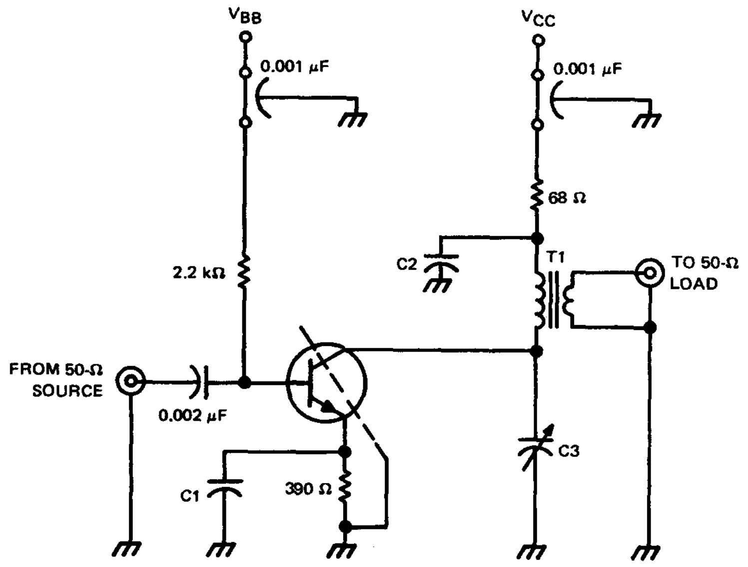
PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION

C1: Leadless disc ceramic, 0.001 pF
L1: 8T #26 close wound, 3/32-inch ID, air core
L2: 7T #30 wound on coil form 7/32-inch ID, aluminum core 5/16-inch long
T1: Primary: 20T #30 close wound
Secondary: 4T #30 close wound and centered on primary
7/32-inch-ID paper form, ferrite core

FIGURE 3—200-MHz-to-45-MHz CIRCUIT FOR CONVERSION POWER GAIN



CIRCUIT COMPONENT INFORMATION

C1, C2: Leadless disc ceramic, 0.001 µF
C3: Arco 427 (or equivalent), 55-300 pF
T1: Primary: 8T #26 double spaced
Secondary: 2T #26 double spaced
Core: Ferrite torroid, 5/16-inch OD, 5/32-inch ID

FIGURE 4—45-MHz POWER GAIN TEST CIRCUIT

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PRINTED IN U.S.A.

TYPE TIS128
P-N-P SILICON TRANSISTOR

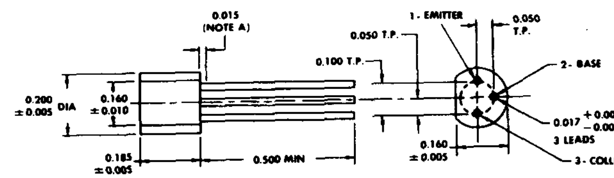
BULLETIN NO. DL-S 7312005, MARCH 1973

SILECT† VHF/UHF TRANSISTOR‡ WITH FORWARD-AGC CHARACTERISTICS DESIGNED FOR COMMON-BASE AMPLIFIER APPLICATIONS

- Low C_{ce} . . . 0.3 pF Max
- Low Noise at 850 MHz . . . 6.5 dB Max
- High Power Gain at 850 MHz . . . 10 dB Min

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	−60 V
Collector-Emitter Voltage (See Note 1)	−45 V
Emitter-Base Voltage	−4 V
Continuous Collector Current	−30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 3	−45		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -25$ V, $I_E = 0$		−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$		−100	μA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -2$ mA	30		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -2$ mA, f = 100 MHz	6.5		
C_{ce}	Collector-Emitter Capacitance	$V_{CE} = -10$ V, $I_B = 0$, f = 1 MHz, See Note 4		0.3	pF

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 2 mW/°C.
3. This parameter must be measured using pulse techniques. t_w = 300 μs, duty cycle < 2%.
4. C_{ce} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The base is connected to the guard terminal of the bridge.

†Trademark of Texas Instruments
‡U.S. Patent No. 3,439,238

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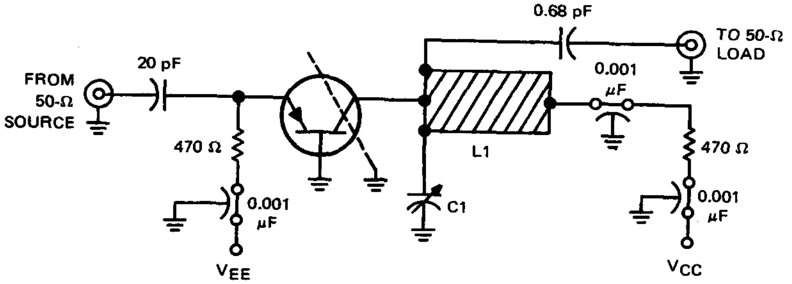
operating characteristics at 25°C free-air temperature

	PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
F	Spot Noise Figure	$V_{CC} = -10$ V, $I_C = -2$ mA, $R_G = 50\ \Omega$, f = 850 MHz, See Figure 1		6.5	dB
G_{pb}	Unneutralized Small-Signal Common-Base Insertion Power Gain	$V_{CC} = -10$ V, $I_C = -2$ mA, f = 850 MHz, See Figure 1	10		dB
B	Bandwidth		15		MHz
I_C	Collector Current for 30-dB Gain Reduction	$V_{CC} = -10$ V, f = 850 MHz, $\Delta G_{pb} = -30$ dB† See Figure 1	−4.5	−7	mA

†ΔG_{pb} is defined as the change in G_{pb} from the value at $I_C = -2$ mA.

PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION
L1: Silver-plated brass 1/32" thick, 1/2" wide, 1" long
C1: 0.8-10 pF, Johansen #4642, or equivalent

FIGURE 1—850-MHz POWER GAIN, NOISE FIGURE, AND GAIN-CONTROL TEST CIRCUIT

TYPICAL CHARACTERISTICS

SMALL-SIGNAL COMMON-EMITTER FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

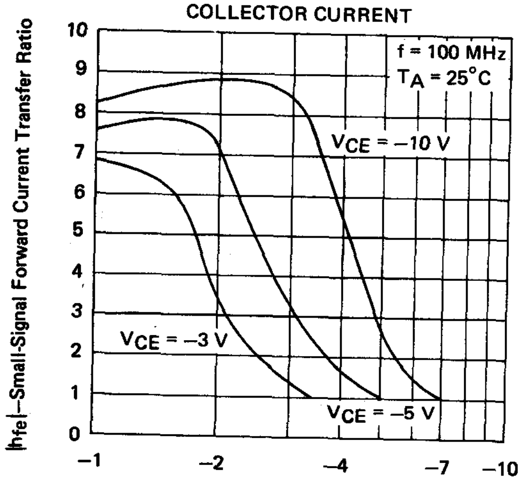


FIGURE 2

SMALL-SIGNAL COMMON-BASE INSERTION POWER GAIN
vs
COLLECTOR CURRENT

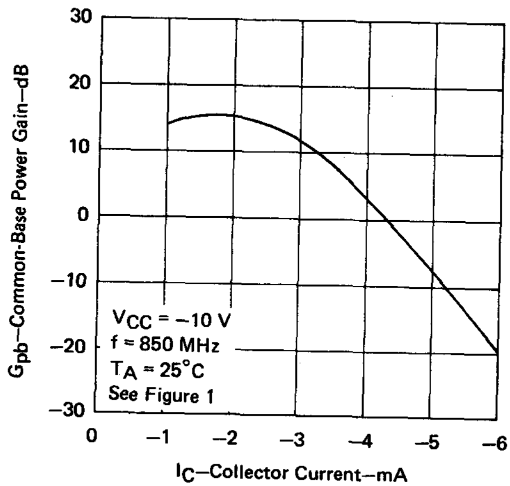


FIGURE 3

TYPE TIS129
N-P-N SILICON TRANSISTOR

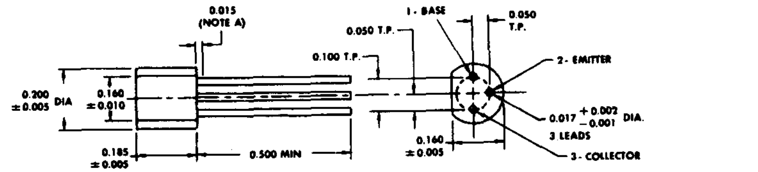
BULLETIN NO. DL-S 7312007, JUNE 1973

SILECT† VHF/UHF TRANSISTOR‡
DESIGNED FOR COMMON-BASE OSCILLATOR AND AMPLIFIER APPLICATIONS

- Low C_{ce} . . . 0.3 pF Max
- Specified f_T Ratio
- High f_T . . . 800 MHz Min
- Low $r_b'C_c$ . . . 9 ps Max

mechanical data

This transistor is encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. This device exhibits stable characteristics under high-humidity conditions and is capable of meeting MIL-STD-202C, Method 106B. The transistor is insensitive to light.



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Collector-Base Voltage	40 V
Collector-Emitter Voltage (See Note 1)	25 V
Emitter-Base Voltage	4 V
Continuous Collector Current	30 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	40		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA, $I_B = 0$, See Note 3	25		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	4		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 25$ V, $I_E = 0$		100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA	60		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 4$ mA		0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.4$ mA, $I_C = 4$ mA		0.5	V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA, $f = 400$ MHz	2		
$\frac{f_{T(2)}}{f_{T(1)}}$	Ratio of Transition Frequencies	$V_{CE} = 10$ V, $I_{C(1)} = 10$ mA, $I_{C(2)} = 15$ mA, $f = 400$ MHz, See Note 4	0.6		
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz, See Note 5		0.8	pF
C_{ce}	Collector-Emitter Capacitance	$V_{CE} = 10$ V, $I_B = 0$, $f = 1$ MHz, See Note 5		0.3	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 10$ V, $I_E = -10$ mA, $f = 79.8$ MHz		9	ps

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 2 mW/°C.
3. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
4. To obtain f_T, the $\lvert h_{fe} \rvert$ response is extrapolated at the rate of −6 dB per octave from f = 400 MHz to the frequency at which $\lvert h_{fe} \rvert = 1$.
5. C_{cb} and C_{ce} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or base, respectively) is connected to the guard terminal of the bridge.

USES CHIP N30

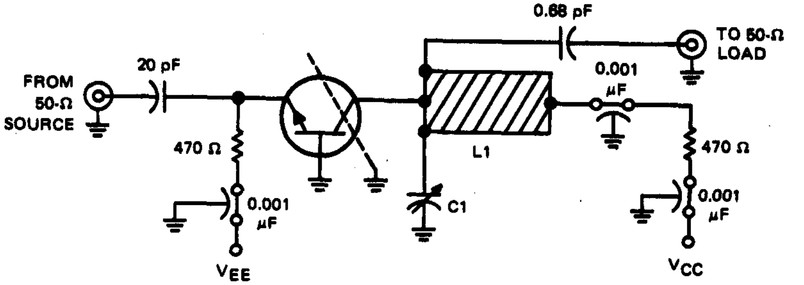
†Trademark of Texas Instruments ‡U.S. Patent No. 3,439,238

TYPE TIS129
N-P-N SILICON TRANSISTOR

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
G_{pb}	Unneutralized Small-Signal Common-Base Insertion Power Gain	V_{CC} = 10 V, I_C = 10 mA, f = 850 MHz, See Figure 1	10		dB
B	Bandwidth		15		MHz

PARAMETER MEASUREMENT INFORMATION



CIRCUIT COMPONENT INFORMATION
L1: Silver-plated brass 1/32" thick, 1/2" wide, 1" long
C1: 0.8-10 pF, Johansen #4642, or equivalent

FIGURE 1—850-MHz POWER-GAIN TEST CIRCUIT

TYPICAL CHARACTERISTICS

TRANSITION FREQUENCY
vs
COLLECTOR CURRENT

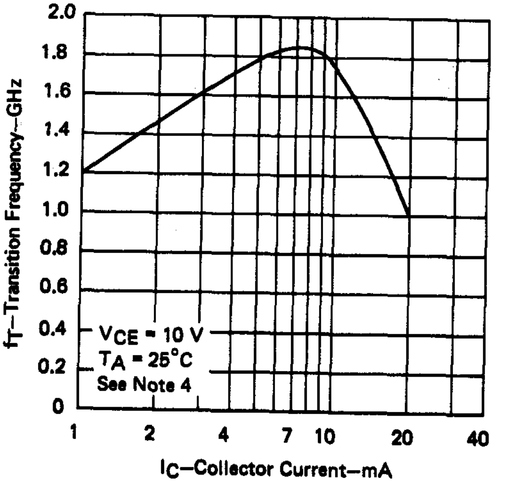


FIGURE 2

NOTE 4: To obtain f_T, the $|h_{fe}|$ response is extrapolated at the rate of −6 dB per octave from f = 400 MHz to the frequency at which $|h_{fe}|$ = 1.

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PRINTED IN U.S.A. 673

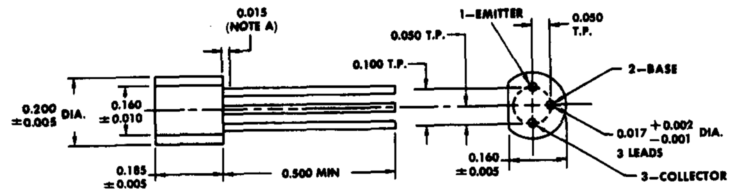
BULLETIN NO. DL-S 7311897, FEBRUARY 1973

SILECT† TRANSISTORS‡
FAST, HIGH-VOLTAGE, HIGH-CURRENT CORE DRIVERS
(Replacements for TIS113 thru TIS116)

- TIS133 Electrically Similar to 2N3724
- TIS135 Electrically Similar to 2N3725
- h_{FE} Guaranteed from 10 mA to 1 A
- Guaranteed Switching Times at 500 mA

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.



A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	TIS133 TIS134	TIS135	TIS136
Collector-Base Voltage	50 V	80 V	80 V
Collector-Emitter Voltage (See Note 1)	30 V	50 V	40 V
Emitter-Base Voltage	6 V	6 V	6 V
Continuous Collector Current	←	0.5 A	→
Peak Collector Current (See Note 2)	←	1.2 A	→
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	←	0.7 W	→
Continuous Device Dissipation at (or below) 25°C Lead Temperature (See Note 4)	←	1.25 W	→
Continuous Device Dissipation at (or below) 25°C Case-and-Lead Temperature (See Note 5)	←	1.6 W	→
Storage Temperature Range	←	−65°C to 150°C	→
Lead Temperature 1/16 Inch from Case for 10 Seconds	←	260°C	→

NOTES: 1. These values apply when the base-emitter diode is open-circuited.
2. This value applies for square-wave pulses. $t_w \leq 300$ μs, duty cycle $\leq 2\%$.
3. Derate linearly to 150°C free-air temperature at the rate of 5.6 mW/°C.
4. Derate linearly to 150°C lead temperature at the rate of 10 mW/°C. Lead temperature is measured on the collector lead 1/16 inch from the case.
5. This rating applies with the entire case (including the leads) maintained at 25°C. Derate linearly to 150°C case-and-lead temperature at the rate of 12.8 mW/°C.

†Trademark of Texas Instruments
‡U.S. Patent Number 3,439,238

USES CHIP N13

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TYPES TIS133 THRU TIS136
N-P-N SILICON TRANSISTORS

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TIS133		TIS134		TIS135		TIS136		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		50		50		80		80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$,	See Note 6	30		30		50		40		V
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ \mu A$, $V_{BE} = 0$		50				80				V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		6		6		6		6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40$ V, $I_E = 0$			1.7		1.7					μA
		$V_{CB} = 40$ V, $I_E = 0$,	$T_A = 85°C$		100		100					
		$V_{CB} = 60$ V, $I_E = 0$							1.7		1.7	
		$V_{CB} = 60$ V, $I_E = 0$,	$T_A = 85°C$						100		100	
I_{CES}	Collector Cutoff Current	$V_{CE} = 50$ V, $V_{BE} = 0$			10		10					μA
		$V_{CE} = 80$ V, $V_{BE} = 0$							10		10	
I_B	Base Current	$V_{CE} = 50$ V, $V_{BE} = 0$			−10		−10					μA
		$V_{CE} = 80$ V, $V_{BE} = 0$							−10		−10	
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V, $I_C = 10$ mA	See Note 6	30		25		30		25		
		$V_{CE} = 1$ V, $I_C = 100$ mA		60	150	50	150	60	150	50	150	
		$V_{CE} = 1$ V, $I_C = 100$ mA, $T_A = -55°C$		30		25		30		25		
		$V_{CE} = 1$ V, $I_C = 300$ mA		40		35		40		35		
		$V_{CE} = 1$ V, $I_C = 500$ mA		35		30		35		30		
		$V_{CE} = 1$ V, $I_C = 500$ mA, $T_A = -55°C$		20		15		20		15		
		$V_{CE} = 2$ V, $I_C = 800$ mA		25		20		20		17		
		$V_{CE} = 5$ V, $I_C = 1$ A		30		25		25		20		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA, $I_C = 10$ mA	See Note 6		0.76		0.76		0.76		0.76	V
		$I_B = 10$ mA, $I_C = 100$ mA			0.86		0.86		0.86		0.86	
		$I_B = 30$ mA, $I_C = 300$ mA			1		1		1		1	
		$I_B = 50$ mA, $I_C = 500$ mA		0.8	1	0.8	1	0.8	1	0.8	1.1	
		$I_B = 80$ mA, $I_C = 800$ mA			1.5		1.5		1.5		1.5	
		$I_B = 100$ mA, $I_C = 1$ A			1.7		1.7		1.7		1.7	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA	See Note 6		0.25		0.3		0.25		0.3	V
		$I_B = 10$ mA, $I_C = 100$ mA			0.3		0.4		0.3		0.4	
		$I_B = 30$ mA, $I_C = 300$ mA			0.5		0.6		0.5		0.6	
		$I_B = 50$ mA, $I_C = 500$ mA			0.65		0.72		0.65		0.72	
		$I_B = 80$ mA, $I_C = 800$ mA			0.8		0.85		0.8		0.85	
		$I_B = 100$ mA, $I_C = 1$ A			0.9		0.95		0.9		0.95	
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 50$ mA,	f = 100 MHz	2.5		2.5		2.5		2.5		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$,	f = 1 MHz		12		12		10		10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$,	f = 1 MHz		65		65		65		65	pF

NOTE 6: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

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switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS†		TIS133 MAX	TIS134 MAX	TIS135 MAX	TIS136 MAX	UNIT
t_d	Delay Time	V_{CC} = 30 V,	I_C = 500 mA,	10	10	10	10	ns
t_r	Rise Time	$I_{B(1)}$ = 50 mA,	$V_{BE(off)}$ = −3.8 V,	30	30	30	30	ns
t_{on}	Turn-On Time	See Figure 1		35	35	35	35	ns
t_s	Storage Time	V_{CC} = 30 V,	I_C = 500 mA,	50	50	50	50	ns
t_f	Fall Time	$I_{B(1)}$ = 50 mA,	$I_{B(2)}$ = −50 mA,	25	25	30	30	ns
t_{off}	Turn-Off Time	See Figure 1		60	60	60	60	ns

†Voltage and current values shown are nominal; exact values vary slightly with transistor parameters.

4

PARAMETER MEASUREMENT INFORMATION

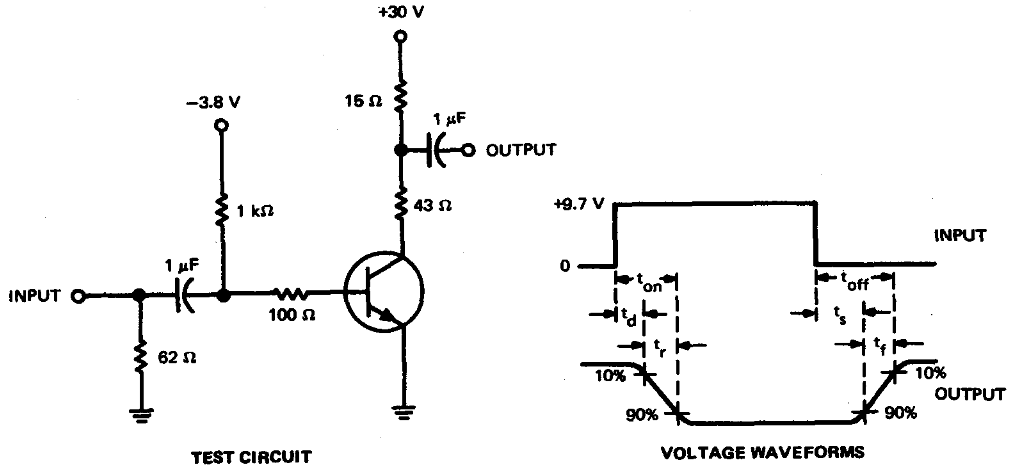

FIGURE 1—SWITCHING TIMES

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq$ 1 ns, $t_f \leq$ 1 ns, $t_w \approx$ 1 µs, duty cycle ≤ 2%.
b. The output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq$ 1 ns, $R_{in} \geq$ 100 kΩ, $C_{in} \leq$ 7 pF.

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BULLETIN NO. DL-S 7311580, NOVEMBER 1971—REVISED MARCH 1973

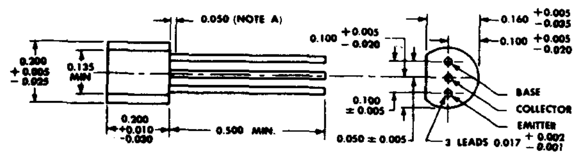
SILECT† TRANSISTORS‡ RECOMMENDED AS LOW-NOISE DESIGN REPLACEMENTS FOR GERMANIUM DRIFT TRANSISTORS IN:

- **AM Radio RF and IF Converter Applications**
- **TV Video and AGC Amplifiers, Sync Amplifiers and Separators, and Emitter Followers**

mechanical data

These transistors are encapsulated in a plastic compound specifically designed for this purpose, using a highly mechanized process developed by Texas Instruments. The case will withstand soldering temperatures without deformation. These devices exhibit stable characteristics under high-humidity conditions and are capable of meeting MIL-STD-202C, Method 106B. The transistors are insensitive to light.

TIS37, TIS38

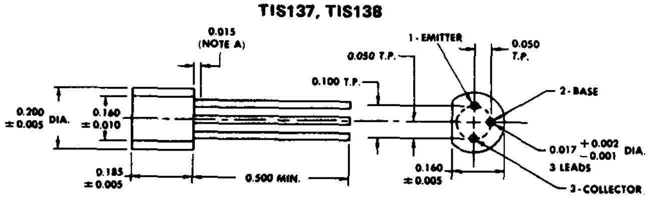


NOTES: A. Lead diameter is not controlled in this area.
B. All dimensions are in inches.

ALL JEDEC TO-92 DIMENSIONS AND NOTES ARE APPLICABLE

ECB

TIS137, TIS138



NOTES: A. Lead diameter is not controlled in this area.
B. Leads having maximum diameter (0.019) shall be within 0.007 of their true positions measured in the gaging plane 0.054 below the seating plane of the device relative to a maximum-diameter package.
C. All dimensions are in inches.

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	TIS37 TIS137	TIS38 TIS138
Collector-Base Voltage	−35 V	−35 V
Collector-Emitter Voltage (See Note 1)	−32 V	−32 V
Emitter-Base Voltage	−6 V	−4 V
Continuous Collector Current	−50 mA	−50 mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	625 mW	625 mW
Storage Temperature Range	−65°C to 150°C	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C	260°C

NOTES: 1. This value applies when the base-emitter diode is open-circuited.
2. Derate linearly to 150°C free-air temperature at the rate of 5 mW/°C.

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‡U.S. Patent No. 3,439,238

USES CHIP P24

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS37 TIS137 MIN	TIS37 TIS137 TYP	TIS37 TIS137 MAX	TIS38 TIS138 MIN	TIS38 TIS138 TYP	TIS38 TIS138 MAX	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−35			−35			V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 3	−32			−32			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−6			−4			V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -10$ V, $I_E = 0$			−100			−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -9$ V, $I_C = -1$ mA	45			25			
$\lvert h_{fe}\rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -9$ V, $I_C = -1$ mA, f = 455 kHz	35		45	30		40	dB
		$V_{CE} = -9$ V, $I_C = -1$ mA, f = 10 MHz	18		30	14		26	dB
$\lvert y_{fe}\rvert$	Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = -9$ V, $I_C = -1$ mA, f = 455 kHz	32	35		32	35		mmho
f_T	Transition Frequency	$V_{CE} = -9$ V, $I_C = -1$ mA, See Note 4	80		320	50		200	MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = -9$ V, $I_E = 0$, f = 1 MHz, See Note 5	0.5	1.1	1.7	0.5	1.1	1.7	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = -9$ V, $I_E = 1$ mA, f = 79.8 MHz		30	70		30	70	ps

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIS37 TIS137 TYP	UNIT
NF	Spot Noise Figure	$V_{CE} = -9$ V, $I_C = -1$ mA, $R_G = 75\ \Omega$, f = 1 MHz	2.5	dB
		$V_{CE} = -9$ V, $I_C = -1$ mA, $R_G = 1\ k\Omega$, f = 1 MHz	1	dB

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

TIS37, TIS137
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR CURRENT

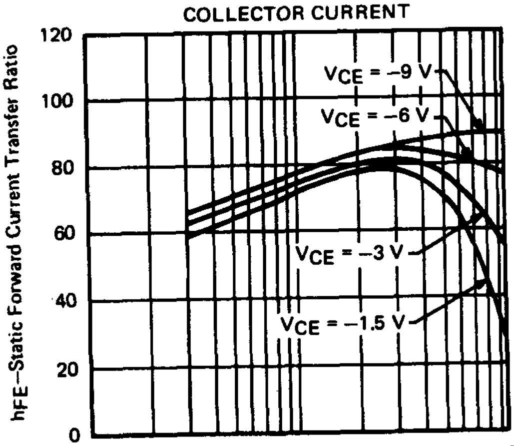


FIGURE 1

TIS37, TIS137
STATIC FORWARD CURRENT TRANSFER RATIO
vs
COLLECTOR-EMITTER VOLTAGE

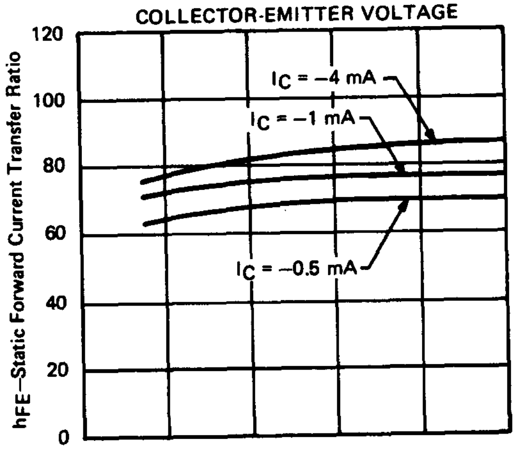
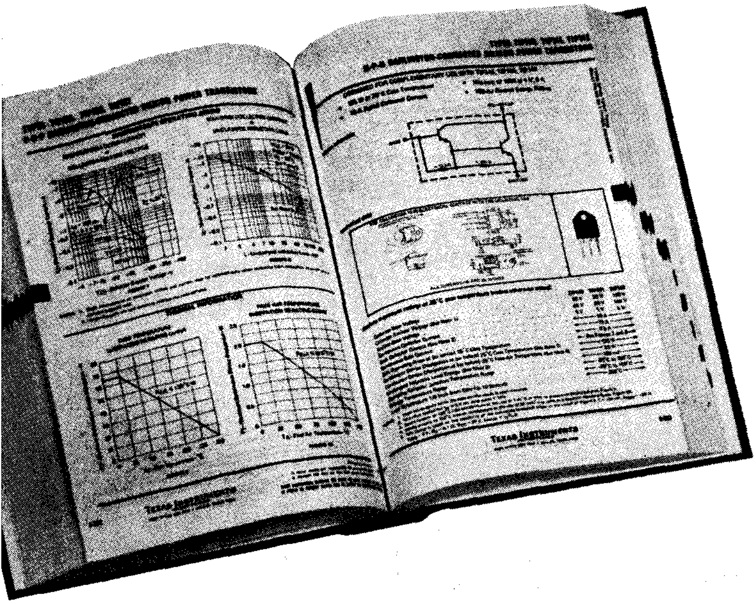


FIGURE 2

NOTES: 3. This parameter must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle < 2%.
4. To obtain f_T, the $\lvert h_{fe}\rvert$ response with frequency is extrapolated at the rate of −6 dB per octave from f = 10 MHz to the frequency at which $\lvert h_{fe}\rvert = 1$.
5. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.



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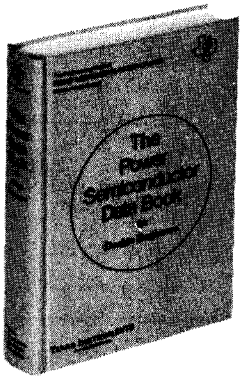

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Transistor Chip Characterization

TRANSISTOR CHIP CHARACTERIZATION

This section contains chip-characterization data for over fifty transistor-chip families. These data are applicable to all transistors types which have a chip reference in the lower right-hand corner of the first page of the data sheet. (Example: "USES CHIP N19" means that the types listed on that data sheet are made with chips of the N19 family.) Some data sheets do not have a chip reference. In general, these are either bar-type transistors (example: grown-junction devices) or chip-type transistors where the observed values of the characteristics of the basic chips are not applicable because of highly selective screening or special diffusions.

The characterization data are separated from the data sheets for several reasons:

- Redundant curves which would otherwise have to be repeated for many different types were eliminated. In this way one reference may apply to many type numbers.
- The amount of pertinent data for many type numbers is increased. Otherwise, each would have less characterization information because of space limitations.
- The user has more guidance in estimating whether to screen from off-the-shelf TI transistors for certain low-volume applications.
- The user now has adequate information about the distribution of transistor characteristic values to consider having TI do his screening for him on special order when the standard types do not quite fulfil the application needs.

However, the following points should be kept in mind:

- The high and low observed values shown do not modify guaranteed limits for specific devices and, in the case of breakdown voltages, do not justify operation in excess of absolute maximum ratings.
- Measurement of characteristics at high power levels is applicable only for devices rated for those power levels.
- Distribution of characteristic values for any particular lot of transistors is not guaranteed.
- The distributions and ranges of values are not fixed. (TI reserves the right to improve the products and modify the distributions without notice.)

Some notes on the data follow:

- "LOW TYP HIGH"–The "TYP" column heading should require no explanation other than saying that it is typical for the chip family. However, the "LOW" and "HIGH" deserve some definition. These values represent the approximate extremes (excluding distribution "freaks") observed in recent production history. These extremes may be purely distributional in nature (a tailing off of the "normal" curve) or wholely intentional (limits imposed on the chip-selection or transistor-screening steps).
- Since most of the families are aggregations of several subfamilies (usually modifications of diffusion profiles) the range of extreme values shown might seem usually broad.
- References to the availability of the chips in certain packages apply only to types listed in this book; many other chip-package combinations are available on special order.

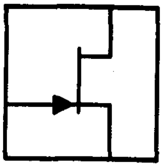
For referencing to standard types using each of these chips, see Transistor Selection Guides, Section 2.

Chip-family classes are as follows:

JN — Junction field-effect transistors, N-channel
JP — Junction field-effect transistors, P-channel
MN — Insulated-gate (MOS) field-effect transistors, N-channel
MP — Insulated-gate (MOS) field-effect transistors, P-channel
N — N-P-N multijunction transistors
P — P-N-P multijunction transistors
U — Unijunction transistors (chip type only) and programmable unijunction transistors

N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

- JN51 is a 17 X 17-mil, epitaxial, planar, expanded-contact chip
- Available in TO-18, TO-71, TO-72, a short-can version of TO-78, and *Silect*† packages
- For use in low-noise amplifier, mixer, switching, and chopper circuits



electrical and operating characteristics at 25°C free-air temperature

	PARAMETER	CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$,	$V_{DS} = 0$		−30♦	−75	−100	V
I_{GSS}	Gate Reverse Current	$V_{GS} = -15$ V,	$V_{DS} = 0$			−<0.1	−2	nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V,	$I_D = 0.5$ nA		−0.35	−3.5	−9	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V,	$I_D = 100\ \mu A$		−0.25	−3	−8	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 1	0.5	10	24	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{DS} = 0$,	$I_D = 0$,	f = 1 kHz	100	200	2000	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 0$,	$V_{GS} = 0$,	f = 1 kHz	2	4.8	7	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance					25	70	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, See Note 2	$V_{GS} = 0$,	f = 1 MHz,	3.5	4.7	6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance				0.9	1.4	2	pF
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 100 MHz		90	250	µmho
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance				1	4	7	mmho
g_{os}	Small-Signal Common-Source Output Conductance					60	150	µmho
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V,	$V_{GS} = 0$,	f = 200 MHz	2	4		mmho
g_{is}	Small-Signal Common-Source Input Conductance					0.5	1	mmho
g_{os}	Small-Signal Common-Source Output Conductance					0.15	0.3	mmho
F	Spot Noise Figure	$V_{DS} = 15$ V, $R_G = 1$ MΩ	$V_{GS} = 0$,	f = 10 Hz,		4.5	5	dB
		$V_{DS} = 15$ V, $R_G = 1$ MΩ	$V_{GS} = 0$,	f = 1 kHz,		0.2	2	
		$V_{DS} = 15$ V, $R_G = 1$ kΩ	$V_{GS} = 0$,	f = 100 MHz,		3	5	
V_n	Equivalent Input Noise Voltage	$V_{DS} = 15$ V,	$V_{GS} = 0$	f = 10 Hz		170	300	$nV/\sqrt{Hz}$
				f = 1 kHz		15	100	

†Trademark of Texas Instruments

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in *Silect* packages.

TYPICAL CHARACTERISTICS

I_{GSS} vs T_A

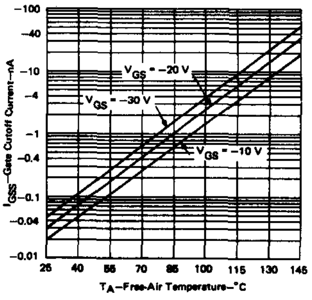


FIGURE 1

I_D vs V_{GS}

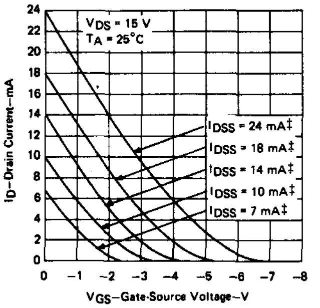


FIGURE 2

I_D vs V_{GS}

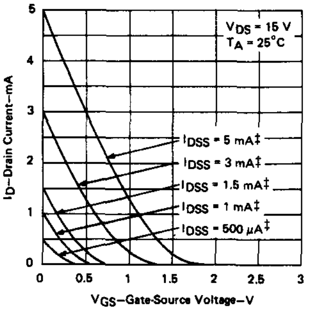


FIGURE 3

Correlation of
$|y_{fs}|$ and I_{DSS} with $V_{GS(100\ \mu A)}$

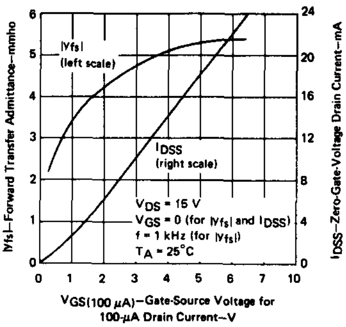


FIGURE 4

Normalized I_D
vs
Normalized V_{GS}

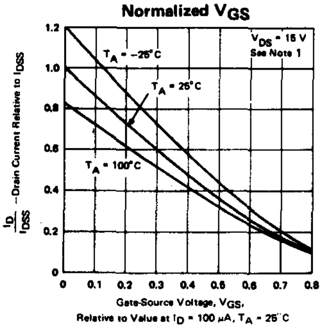


FIGURE 5

Normalized $|y_{fs}|$
vs
Normalized V_{GS}

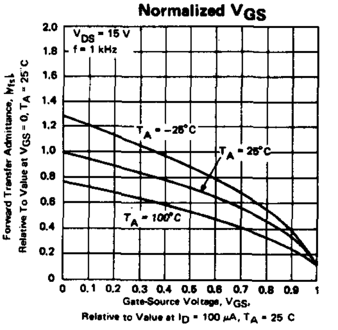


FIGURE 6

Correlation of
$I_{D(\alpha = 0)}$ with I_{DSS}

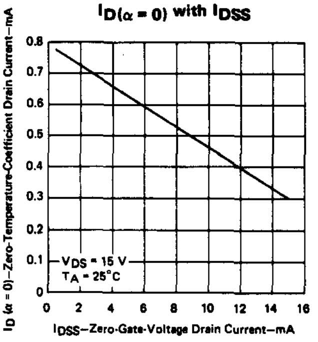


FIGURE 7

Correlation of
$|y_{os}|$ with I_{DSS}

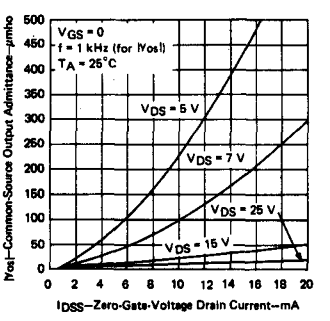


FIGURE 8

Normalized $|y_{os}|$
vs
Normalized I_D

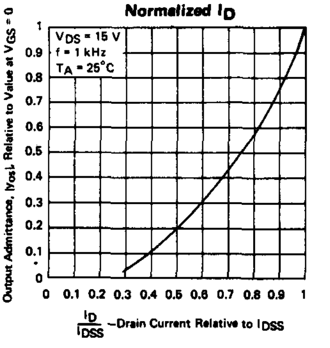


FIGURE 9

‡Data is for devices having indicated value of I_{DSS} at V_{DS} = 15 V, V_{GS} = 0, T_A = 25°C.
NOTE 1: This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

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TYPICAL CHARACTERISTICS

Correlation of
g_{is}, g_{fs}, g_{rs}, g_{os} with I_{DSS}

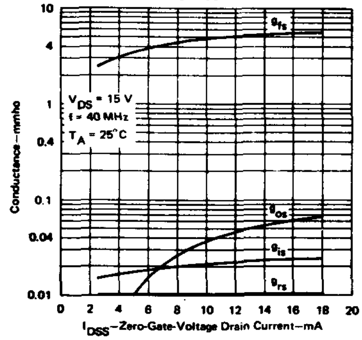


FIGURE 10

g_{is}, b_{is} vs f

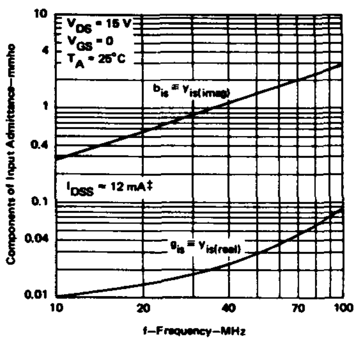


FIGURE 11

g_{fs}, b_{fs} vs f

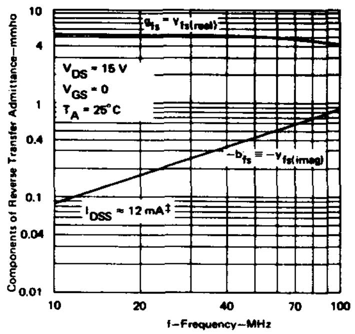


FIGURE 12

g_{rs}, b_{rs} vs f

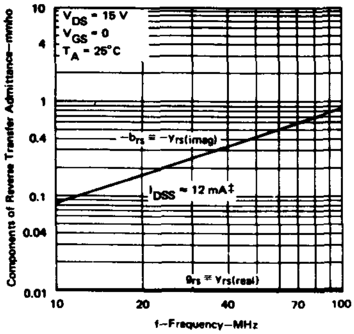


FIGURE 13

g_{os}, b_{os} vs f

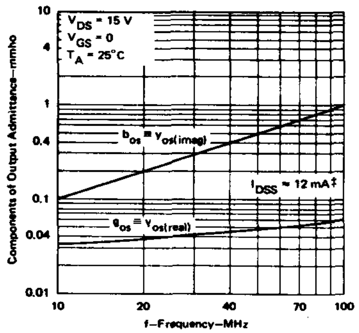


FIGURE 14

‡Data is for devices having indicated value of I_{DSS} at V_{DS} = 15 V, V_{GS} = 0, T_A = 25°C.

5

TYPICAL CHARACTERISTICS

C_{iss}, C_{rss} vs V_{GS}

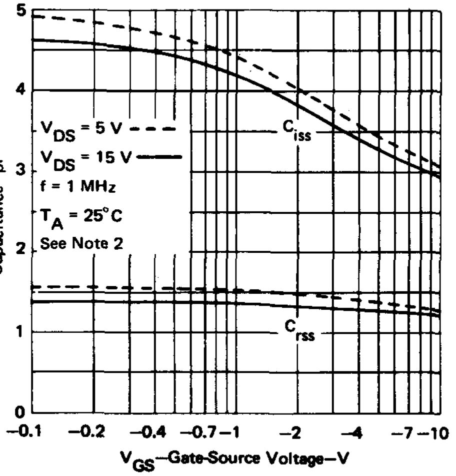


FIGURE 15

F vs f

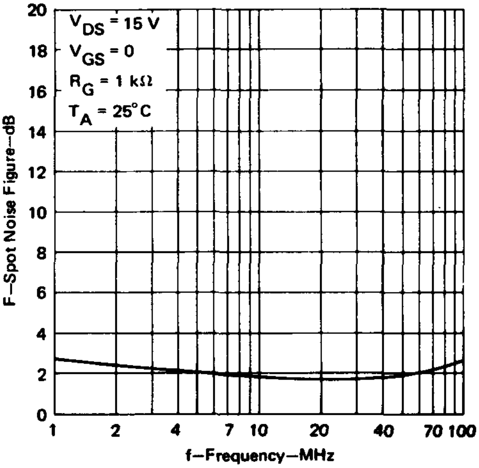


FIGURE 16

F vs I_D

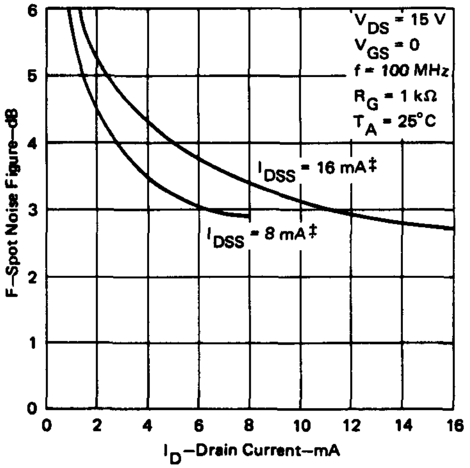


FIGURE 17

F vs R_G

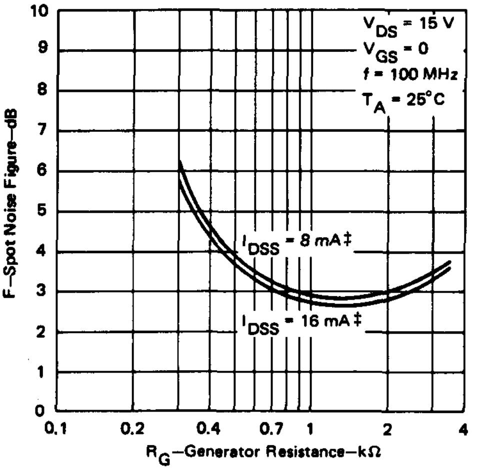


FIGURE 18

‡Data is for devices having indicated value of I_{DSS} at V_{DS} = 15 V, V_{GS} = 0, T_A = 25°C.
NOTE 2: Capacitance measurements were made using chips mounted in *Silect* packages.

TYPICAL CHARACTERISTICS

V_n vs f

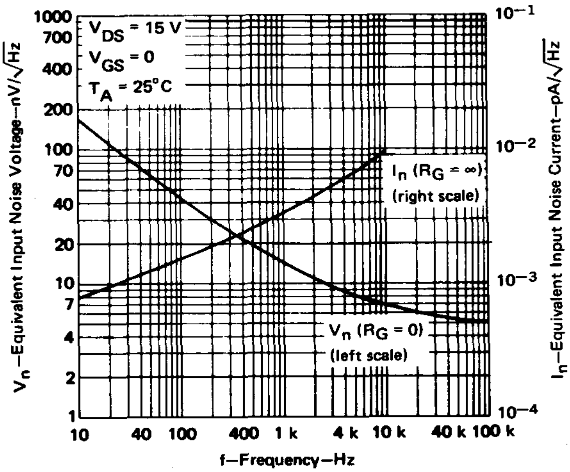


FIGURE 19

V_n vs I_D

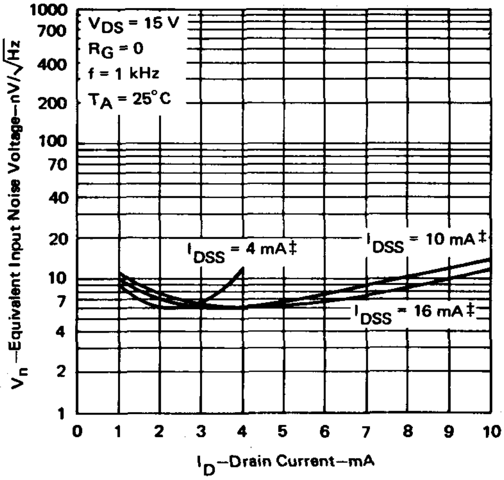


FIGURE 20

V_{nt}§ vs R_G

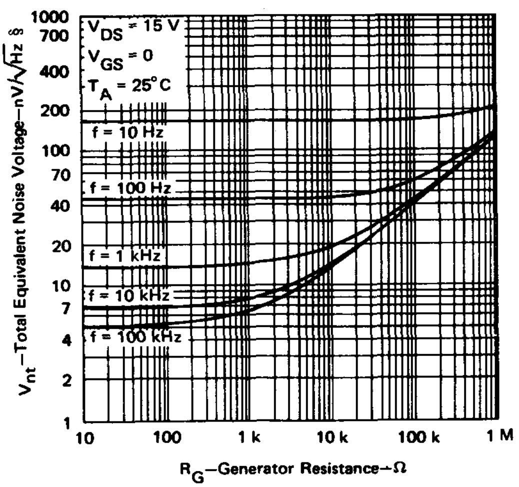


FIGURE 21

F vs f

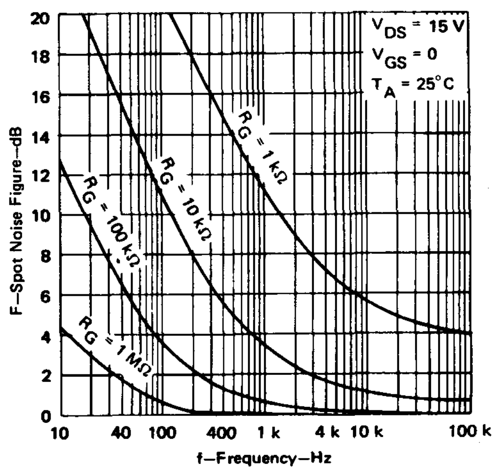
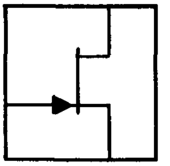


FIGURE 22

‡Data is for devices having the indicated value of I_{DSS} at V_{DS} = 15 V, V_{GS} = 0, T_A = 25°C.

§$V_{nt} = \sqrt{V_n^2 + 4\,k\,T_0\,B\,R_G}$ where k is Boltzmann's constant = 1.38 X 10^{-23} J/K, B is bandwidth = 1 Hz.

CHIP TYPE JN52
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS



- JN52 is a 19 X 19-mil, epitaxial, planar, expanded-contact chip
- Available in TO-18 and *Silect*† packages
- For use in chopper, commutator, and other switching circuits
- Lower-I_{DSS} devices also recommended for low-noise amplifier circuits

electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$,	$V_{DS} = 0$		−30♦	−45		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V,	$V_{DS} = 0$			−<0.01	−2	nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V,	$I_D = 1$ nA		−0.5	−4.5	−12	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V,	$I_D = 100\ \mu A$		−0.5	−4.0	−10	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 1	8	80	200	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, See Note 2	$V_{GS} = 0$,	f = 1 kHz,	20	30	40	mmho
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$,	$I_D = 0$,	f = 1 kHz	10	23	60	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{GS} = -10$ V, See Note 3	$V_{DS} = 0$,	f = 1 MHz,		8	15	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{GS} = -10$ V, See Note 3	$V_{DS} = 0$,	f = 1 MHz,		3.2	6	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 10$ V, $V_{GS(off)} = -10$ V,	$V_{GS(on)} = 0$, $R_L = 1$ kΩ	2N4856 Data Sheet Circuit		3		ns
t_r	Rise Time					1		ns
$t_{d(off)}$	Turn-Off Delay Time					10		ns
t_f	Fall Time					20		ns

additional characteristics at 25°C free-air temperature of devices having $I_{DSS} < 40$ mA

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V,	$V_{GS} = 0$,	See Note 1	8	30	40	mA
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, See Note 2	$V_{GS} = 0$,	f = 1 kHz,		70	125	μmho
V_n	Equivalent Input Noise Voltage	$V_{DS} = 15$ V,	$I_D = 1$ mA,	f = 1 kHz		1.5		$nV/\sqrt{Hz}$
		$V_{DS} = 15$ V,	$I_D = 1$ mA,	f = 10 Hz		5		$nV/\sqrt{Hz}$

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques, $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. To avoid overheating the transistor, these parameters were measured with bias conditions applied for less than five seconds.
3. Capacitance measurements were made using chips mounted in TO-18 packages.

TYPICAL CHARACTERISTICS

I_{GSS} vs T_A

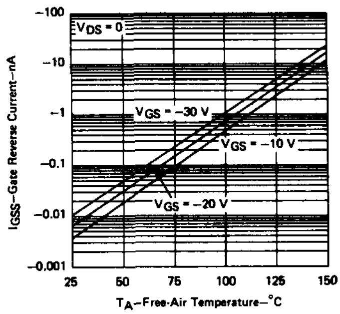


FIGURE 1

I_D vs V_{GS}

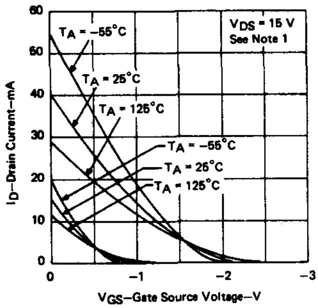


FIGURE 2

Correlation of
$|y_{fs}|$ and I_{DSS} with $V_{GS(100\ \mu A)}$

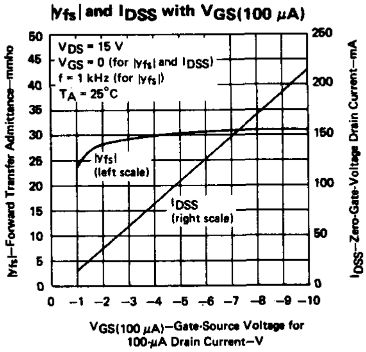


FIGURE 3

Normalized I_D
vs
Normalized V_{GS}
(Devices Having $V_{GS(100\ \mu A)}$ between −3 V and −10 V)

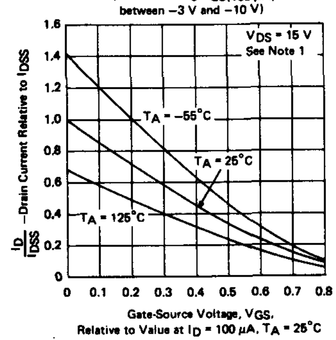


FIGURE 4

Normalized $|y_{fs}|$
vs
Normalized V_{GS}

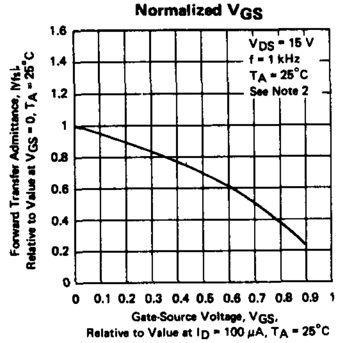


FIGURE 5

Correlation of
$r_{ds(on)}$ with $V_{GS(100\ \mu A)}$

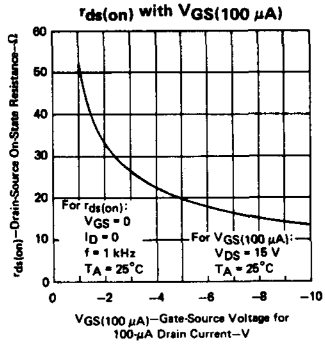


FIGURE 6

Normalized r_{ds}
vs
Normalized V_{GS}

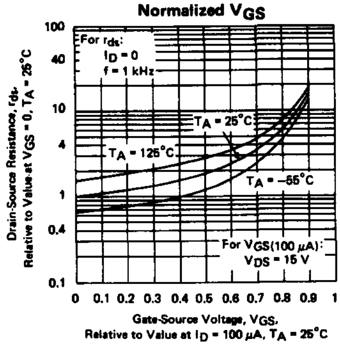


FIGURE 7

$|y_{os}|$ vs I_D

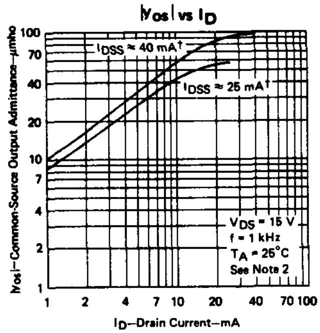


FIGURE 8

NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. To avoid overheating the transistor, these parameters were measured with bias conditions applied for less than five seconds.

†Data is for devices having the indicated value of I_{DSS} at V_{DS} = 15 V, T_A = 25°C.

CHIP TYPE JN52
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

TYPICAL CHARACTERISTICS

C_{iss} vs V_{GS}

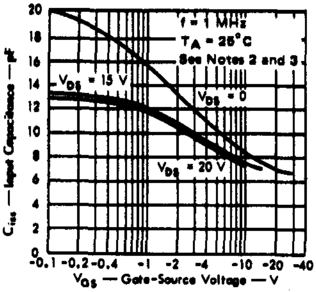


FIGURE 9

C_{rss} vs V_{DS}

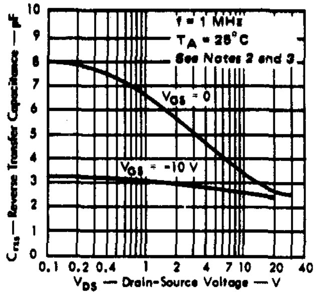


FIGURE 10

V_n vs f

(Devices Having I_{DSS} < 40 mA)

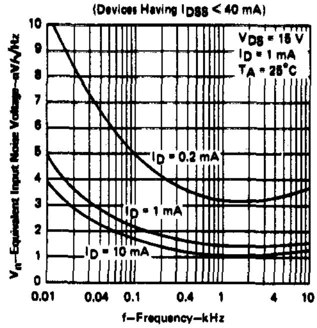


FIGURE 11

$t_{d(on)}$, t_r, $t_{d(off)}$, t_f vs R_L

(Devices Having $V_{GS(100\,\mu A)}$ between −4 V and −10 V)

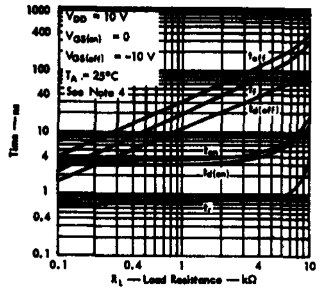


FIGURE 12

$V_{O(av)}$‡ vs t_r and t_f

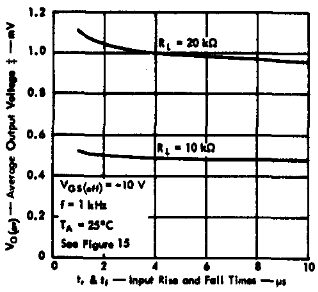


FIGURE 13

$V_{O(av)}$‡ vs f

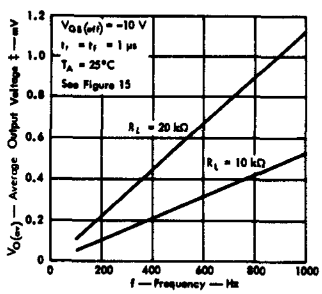
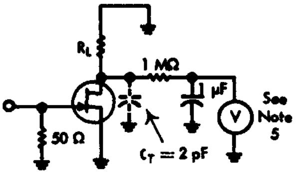
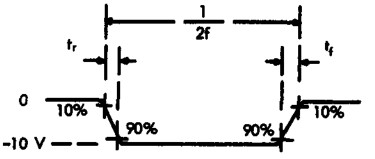


FIGURE 14



TEST CIRCUIT



INPUT VOLTAGE WAVEFORM

FIGURE 15—MEASUREMENT INFORMATION FOR FIGURES 13 and 14

NOTES:
2. To avoid overheating the transistor, these parameters were measured with bias conditions applied for less than five seconds.
3. *Capacitance measurements were made using chips mounted in TO-18 packages.*
4. These measurements were made in the switching circuit of Figure 1 of the 2N4856 data sheet varying R_L from 100 Ω to 10 kΩ. t_w = 1 µs, duty cycle ≤ 2%.
5. Voltmeter input resistance R_{in} ≥ 10 MΩ.

‡In the circuit of Figure 15, average output voltage results from capacitive feed-through of the gate-drive signal.

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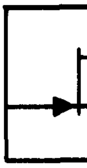
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

- JN53 is a 15 X 15-mil, epitaxial, planar, expanded-contact chip
- Available in TO-72 and *Silect*† packages
- For use in VHF/UHF amplifier, oscillator, and mixer circuits requiring low noise characteristics



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES			UNIT
			LOW	TYP	HIGH	
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−30♦	−45	−80	V
I_{GSS}	Gate Reverse Current	$V_{GS} = -20$ V, $V_{DS} = 0$		−<0.01	−1	nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 1$ nA	−0.5	−3	−8	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 100\ \mu A$	−0.3	−2.5	−7	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$, See Note 1	1	10	24	mA
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz	3	6	7	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 kHz	1	35	85	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 2		4	5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 2		0.8	1	pF
C_{oss}	Common-Source Short-Circuit Output Capacitance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 2		1	2	pF
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz		0.07	0.1	mmho
b_{is}	Small-Signal Common-Source Input Susceptance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz		2.5	3	mmho
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz	3	6	7	mmho
g_{os}	Small-Signal Common-Source Output Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz		0.01	0.1	mmho
b_{os}	Small-Signal Common-Source Output Susceptance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 100 MHz		0.7	1	mmho
g_{is}	Small-Signal Common-Source Input Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 400 MHz		0.25	1	mmho
b_{is}	Small-Signal Common-Source Input Susceptance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 400 MHz		8	12	mmho
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 400 MHz	2.5	5.5	7	mmho
g_{os}	Small-Signal Common-Source Output Conductance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 400 MHz		0.06	0.15	mmho
b_{os}	Small-Signal Common-Source Output Susceptance	$V_{DS} = 15$ V, $V_{GS} = 0$, f = 400 MHz		3	4	mmho
F	Spot Noise Figure	$V_{DS} = 15$ V, $I_D = 5$ mA, $R_G = 1\ k\Omega$, f = 100 MHz		1	2	dB
F	Spot Noise Figure	$V_{DS} = 15$ V, $I_D = 5$ mA, $R_G = 1\ k\Omega$, f = 400 MHz		2	4	dB

†Trademark of Texas Instruments

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in *Silect* packages.

TYPICAL CHARACTERISTICS

I_{GSS} vs T_A

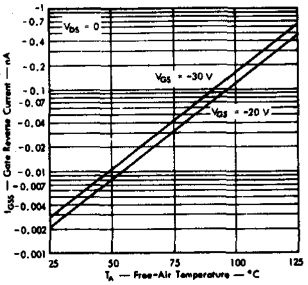


FIGURE 1

Correlation of I_{DSS} and $|y_{fs}|$ with $V_{GS(100\ \mu A)}$

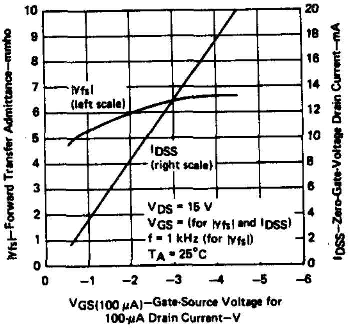


FIGURE 2

Normalized I_D
vs
Normalized V_{GS}
(Devices Having I_{DSS} Greater Than 3 mA)

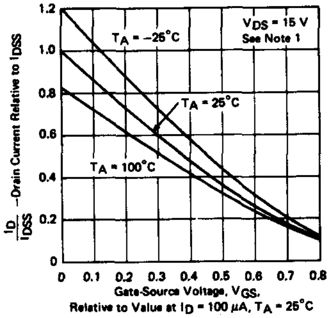


FIGURE 3

Normalized $|y_{fs}|$
vs
Normalized V_{GS}

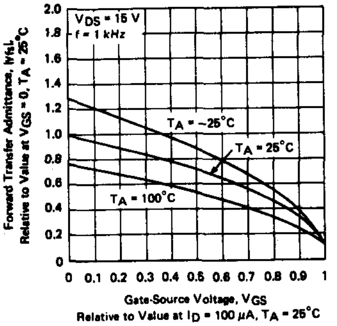


FIGURE 4

I_D vs V_{GS}

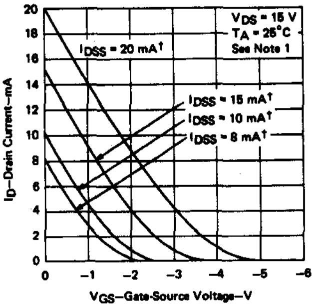


FIGURE 5

I_D vs V_{GS}

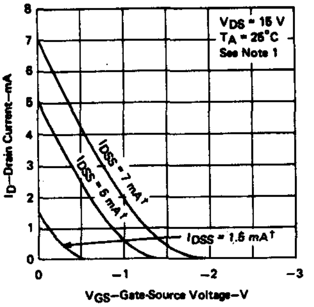


FIGURE 6

†Data is for devices having the indicated values of I_{DSS} at $V_{DS} = 15$ V, $V_{GS} = 0$, $T_A = 25°C$.
NOTE 1: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle = 2%.

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TYPICAL CHARACTERISTICS

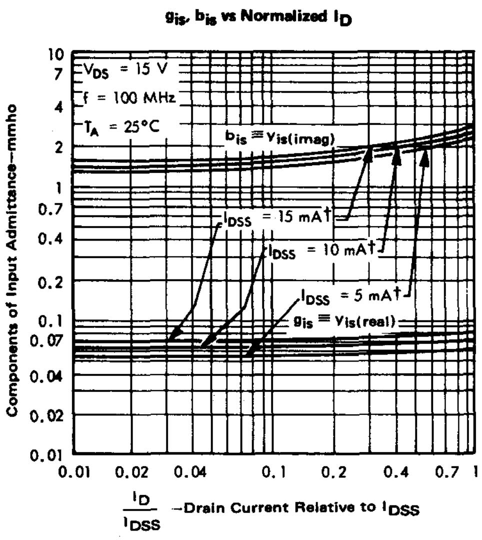


FIGURE 7

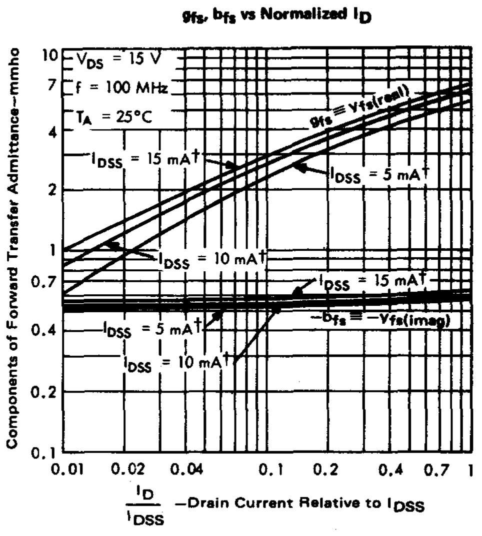


FIGURE 8

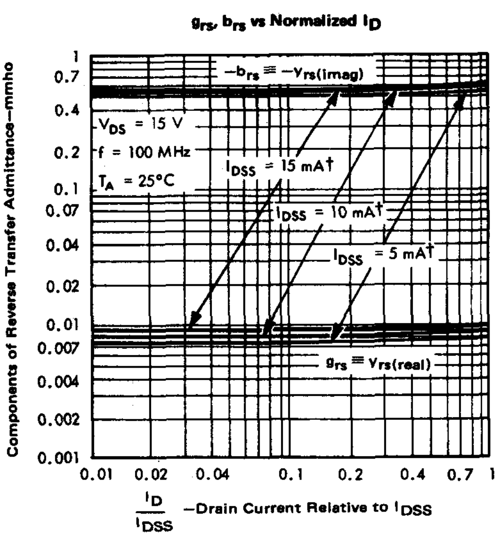


FIGURE 9

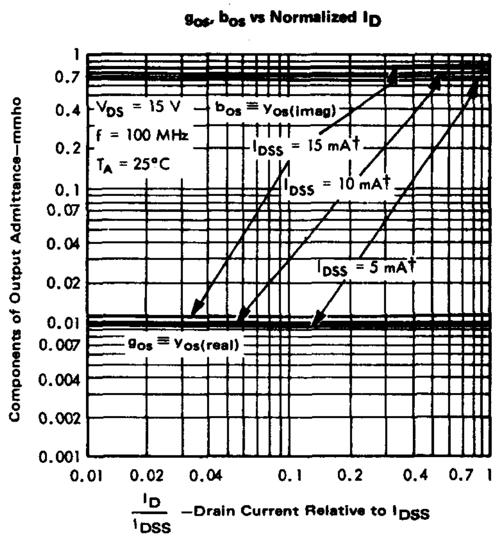


FIGURE 10

†Data is for devices having the indicated values of I_{DSS} at V_{DS} = 15 V, V_{GS} = 0, T_A = 25°C.

TYPICAL CHARACTERISTICS

g_{is}, b_{is} vs f

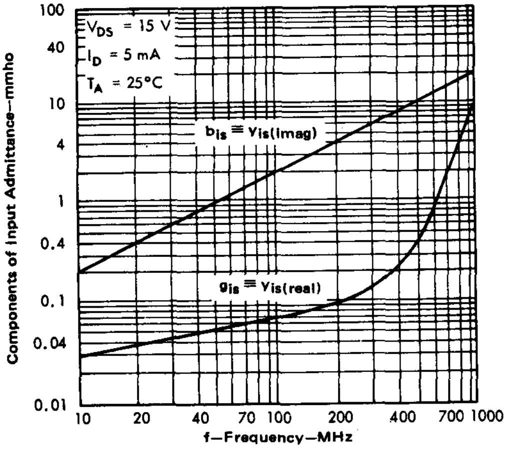


FIGURE 11

g_{fs}, b_{fs} vs f

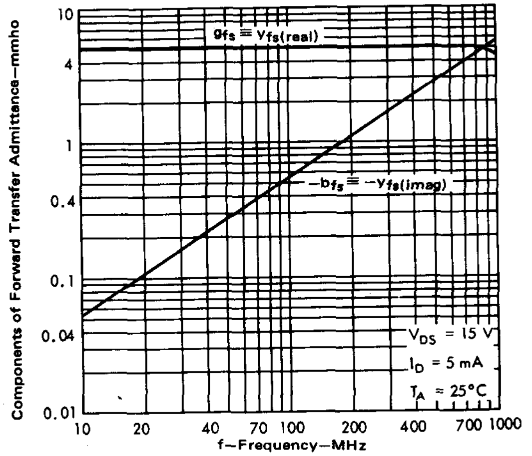


FIGURE 12

g_{rs}, b_{rs} vs f

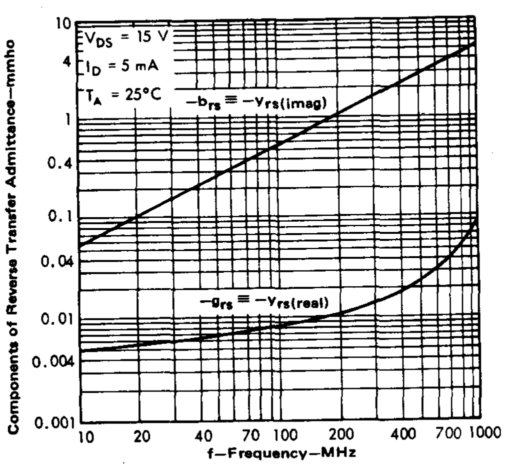


FIGURE 13

g_{os}, b_{os} vs f

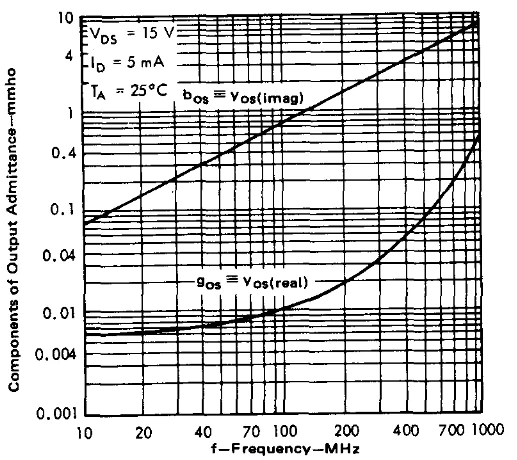


FIGURE 14

TYPICAL CHARACTERISTICS

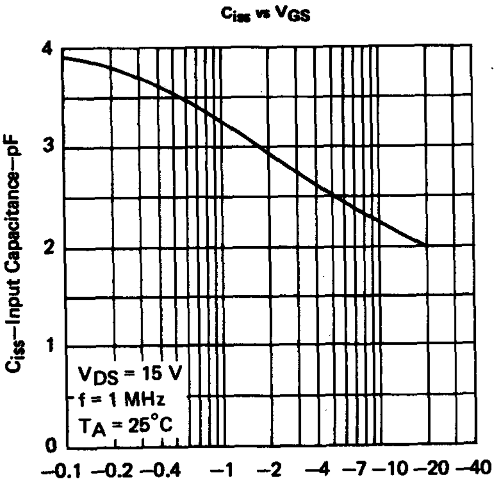


FIGURE 15

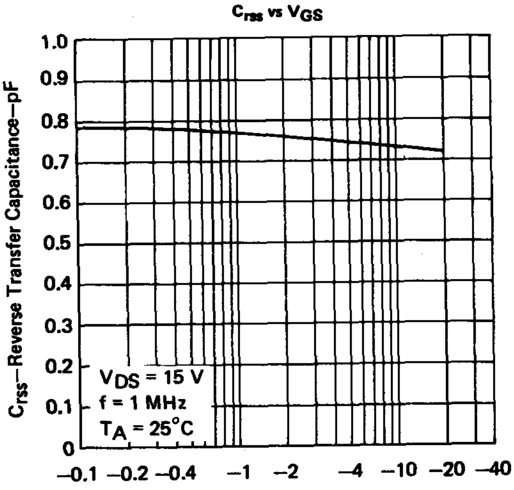


FIGURE 16

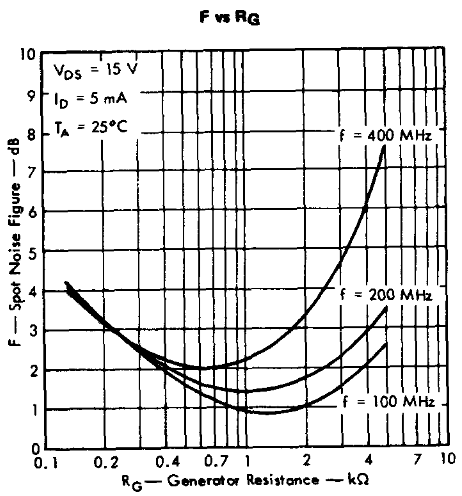


FIGURE 17

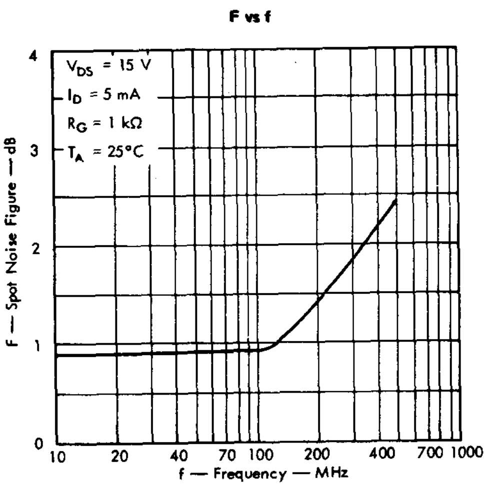
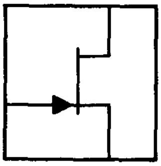


FIGURE 18

NOTE 2: Capacitance measurements were made using chips mounted in *Silect* packages.

CHIP TYPE JN54
N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

- **JN54 is a 26 X 26-mil, epitaxial, expanded-contact chip**
- **Available in TO-39 and *Silect*† packages**
- **For use in high-voltage amplifier circuits**



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -10\ \mu A$, $V_{DS} = 0$	−250♦	−350		V
I_{GSO}	Gate Reverse Current	$V_{GS} = -75$ V, $I_D = 0$		−<1	−3	nA
I_{GSS}	Gate Reverse Current	$V_{GS} = -40$ V, $V_{DS} = 0$		−<1	−2	nA
I_{DGO}	Drain Reverse Current	$V_{DG} = 200$ V, $I_S = 0$		<1	100	nA
$V_{GS(off)}$	Gate-Source Voltage	$V_{DS} = 30$ V, $I_D = 4$ nA	−2	−9	−20	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 30$ V, $V_{GS} = 0$, See Note 1	1	5.5	15	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$, $I_D = 0$, f = 1 kHz		1.0	2	kΩ
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 30$ V, $V_{GS} = 0$, f = 1 kHz	0.75	1.0	3	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance			27	100	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 30$ V, $V_{GS} = 0$, f = 1 MHz, See Note 2		7.5	10	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance			3.5	5	pF
V_n	Equivalent Input Noise Voltage	$V_{DS} = 30$ V, $V_{GS} = 0$, f = 1 kHz		0.25		$\frac{\mu V}{\sqrt{Hz}}$

†Trademark of Texas Instruments

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

NOTES: 1. *This parameter was measured using pulse techniques.* $t_w = 300\ \mu s$, *duty cycle* $\leq 2\%$.

2. Capacitance measurements were made using chips mounted in *Silect* packages.

TYPICAL CHARACTERISTICS

I_{GSO} vs T_A

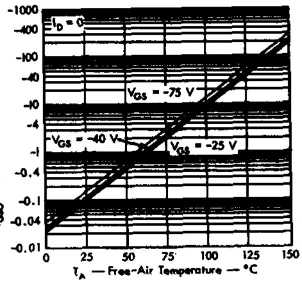


FIGURE 1

I_{GSS} vs T_A

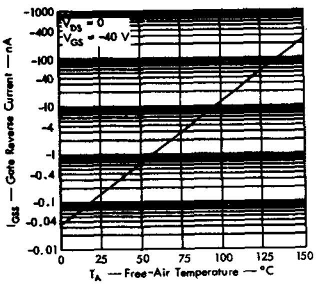


FIGURE 2

I_{DGO} vs T_A

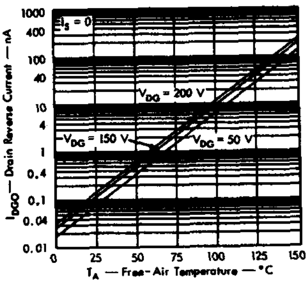


FIGURE 3

I_D vs V_{GS}

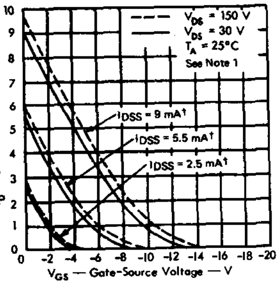


FIGURE 4

I_{DSS} vs T_A

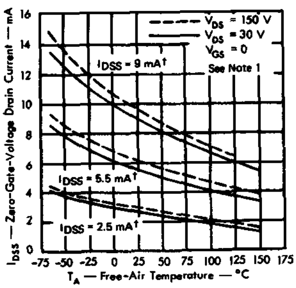


FIGURE 5

NOTE 1: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
†Data is for devices having the indicated value of I_{DSS} at $V_{DS} = 30$ V, $T_A = 25°C$.

TYPICAL CHARACTERISTICS

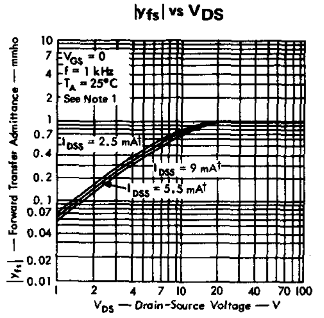


FIGURE 6

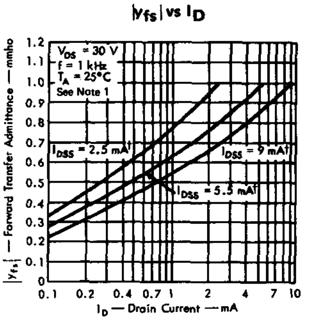


FIGURE 7

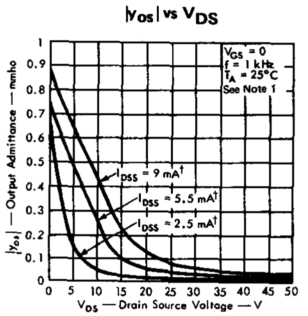


FIGURE 8

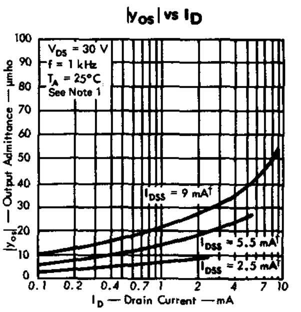


FIGURE 9

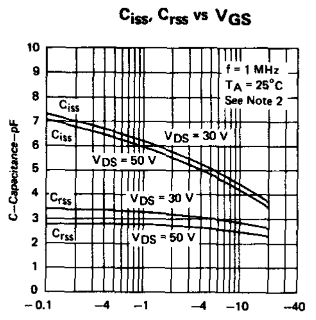


FIGURE 10

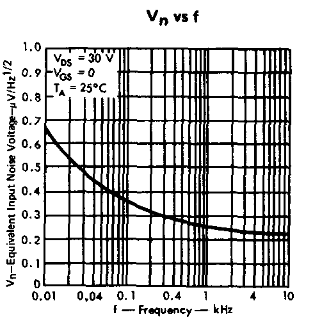


FIGURE 11

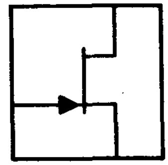
NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in *Silect* packages.

†Data is for devices having the indicated value of I_{DSS} at V_{DS} = 30 V, T_A = 25°C.

5

N-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

- JN55 is a 19 X 19-mil, epitaxial, planar, expanded-contact chip
- Available in TO-72 packages
- For extremely low-noise preamplifier and amplifier circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES			UNIT
			LOW	TYP	HIGH	
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = -1\ \mu A$, $V_{DS} = 0$	−20♦	−35		V
I_{GSS}	Gate Reverse Current	$V_{GS} = -10$ V, $V_{DS} = 0$		−<0.1	−0.5	nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 10$ V, $I_D = 0.5$ nA	−0.5		−5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 10$ V, $V_{GS} = 0$, See Note 1	5		50	mA
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 10$ V, $I_D = 5$ mA, f = 1 kHz	15	20	30	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = 10$ V, $I_D = 5$ mA, f = 1 kHz			75	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 10$ V, $I_D = 5$ mA, f = 1 MHz, See Note 2		15	25	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 10$ V, $I_D = 5$ mA, f = 1 MHz, See Note 2		3.5	5	pF
F	Spot Noise Figure	$V_{DS} = 10$ V, $I_D = 5$ mA, $R_G = 10\ k\Omega$, f = 10 Hz		0.25	2.5	dB
V_n	Equivalent Input Noise Voltage	$V_{DS} = 10$ V, $I_D = 5$ mA, f = 10 Hz		3	10	$nV/\sqrt{Hz}$
		f = 1 kHz		1.5	8	

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-72 packages.

TYPICAL CHARACTERISTICS

I_{GSS} vs T_A

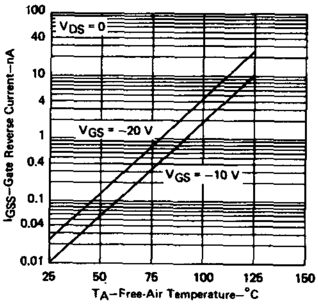


FIGURE 1

I_D vs V_{GS}

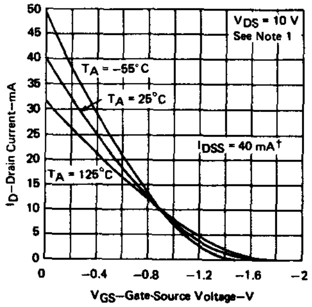


FIGURE 2

I_D vs V_{GS}

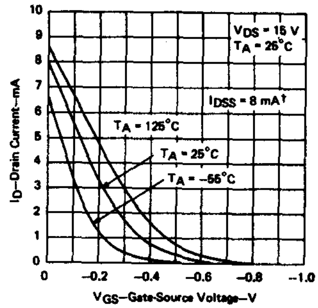


FIGURE 3

$|y_{fs}|$ vs I_D

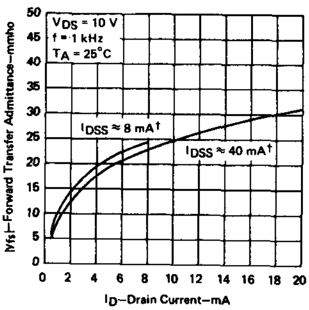


FIGURE 4

$|y_{os}|$ vs I_D

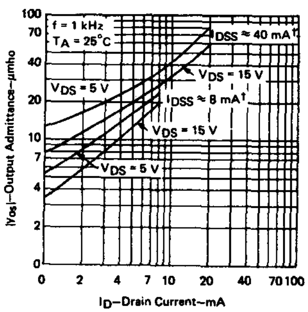


FIGURE 5

C_{iss} vs V_{GS}

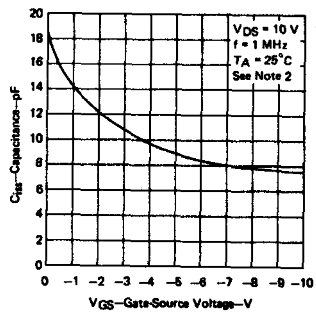


FIGURE 6

C_{rss} vs V_{GS}

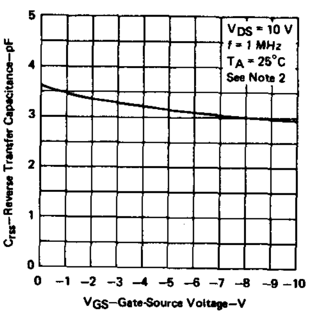


FIGURE 7

F vs f

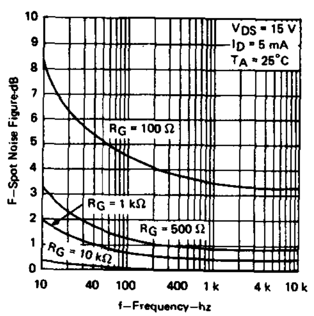


FIGURE 8

V_n vs f

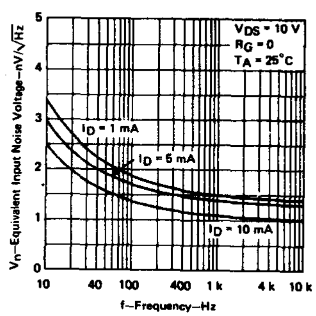


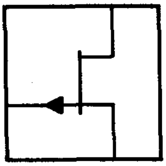
FIGURE 9

†Data is for devices having the indicated value of I_{DSS} at V_{DS} = 10 V, V_{GS} = 0, and T_A = 25°C

NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in TO-72 packages.

CHIP TYPE JP71
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

- JP71 is a 17 X 17-mil, epitaxial, planar, expanded-contact chip
- Available in TO-5, TO-18, TO-72, and *Silect*† packages
- For use in low-noise amplifier circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES			UNIT
			LOW	TYP	HIGH	
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 10\ \mu A$, $V_{DS} = 0$	30♦	50		V
I_{GSS}	Gate Reverse Current	$V_{GS} = 15$ V, $V_{DS} = 0$		<0.1	2	nA
V_{GS}	Gate-Source Voltage	$V_{DS} = -15$ V, $I_D = -100\ \mu A$	0.5	3	9	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V, $V_{GS} = 0$, See Note 1	−0.3	−6	−15	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{DS} = 0$, $V_{GS} = 0$, f = 1 kHz		300	2000	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 1 kHz	1	3	4	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 1 kHz		7	75	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 2	3.5	5.5	7	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 1 MHz, See Note 2		1.2	2	pF
F	Spot Noise Figure	$V_{DS} = -15$ V, $V_{GS} = 0$, $R_G = 1$ MΩ, f = 1 kHz		0.3	2	dB
V_n	Equivalent Input Noise Voltage	$V_{DS} = -15$ V, $V_{GS} = 0$, f = 1 kHz		35	100	$nV/\sqrt{Hz}$

†Trademark of Texas Instruments

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in *Silect* packages.

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TYPICAL CHARACTERISTICS

I_{GSS} vs T_A

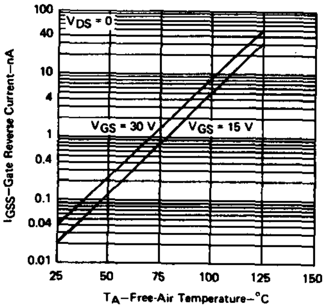


FIGURE 1

I_D vs V_{GS}

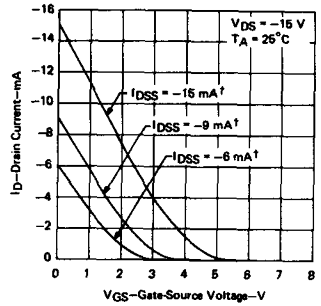


FIGURE 2

I_D vs V_{GS}

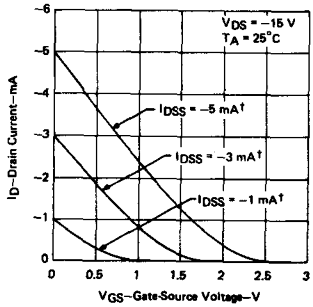


FIGURE 3

Correlation of

$|y_{fs}|$ and I_{DSS} with $V_{GS(100\ \mu A)}$

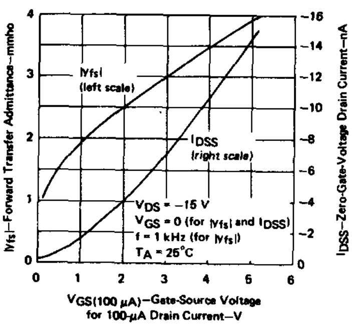


FIGURE 4

Normalized I_D

vs

Normalized V_{GS}

(Devices Having I_{DSS} Greater than 3 mA)

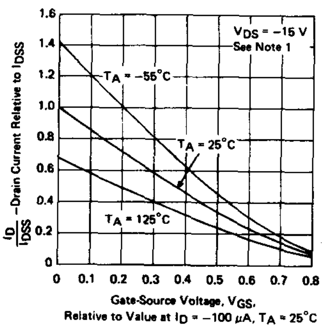


FIGURE 5

Normalized $|y_{fs}|$

vs

Normalized V_{GS}

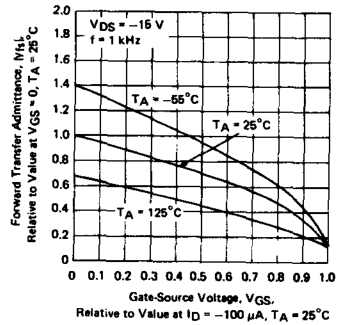


FIGURE 6

Correlation of

$r_{ds(on)}$ with $V_{GS(100\ \mu A)}$

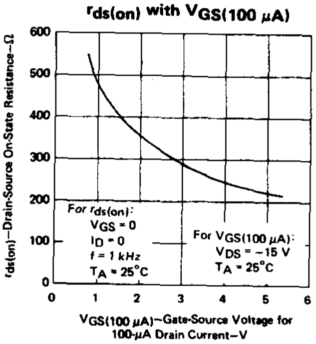


FIGURE 7

Normalized r_{ds}

vs

Normalized V_{GS}

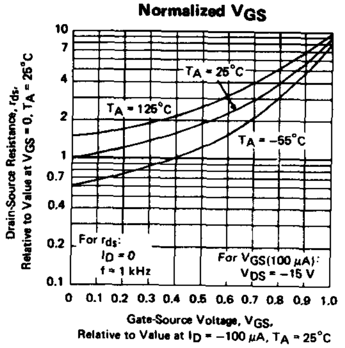


FIGURE 8

$|y_{os}|$ vs I_D

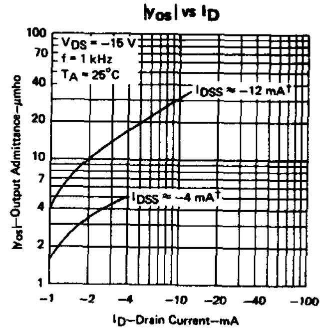


FIGURE 9

†Data is for devices having the indicated value of I_{DSS} at $V_{DS} = -15$ V, $V_{GS} = 0$, $T_A = 25°C$.
NOTE 1: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq$ 2%.

TYPICAL CHARACTERISTICS

C_{iss}, C_{rss} vs V_{GS}

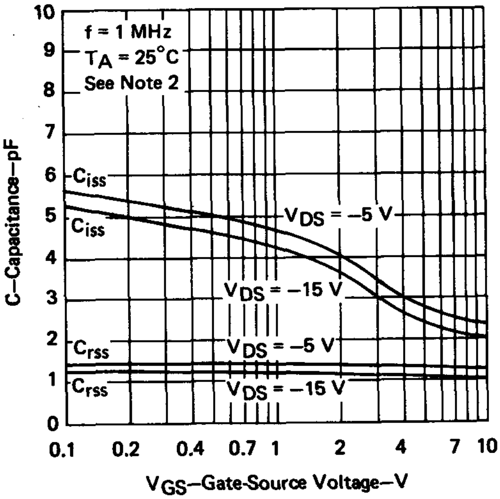


FIGURE 10

F vs f

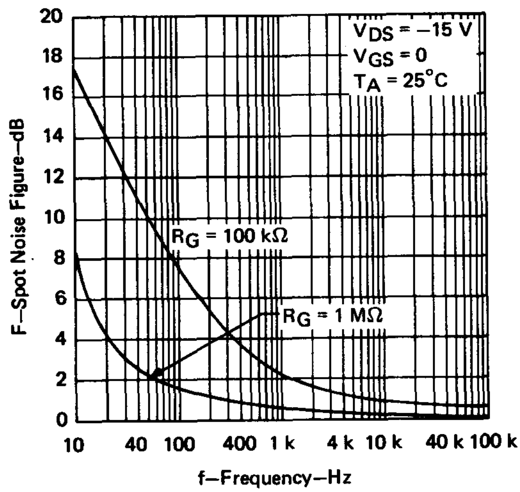


FIGURE 11

V_n vs f

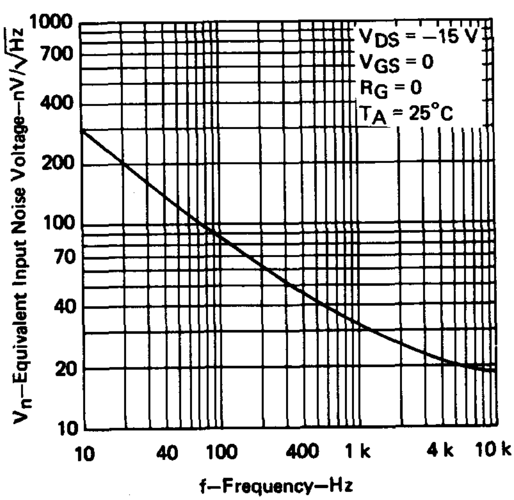


FIGURE 12

V_n vs I_D

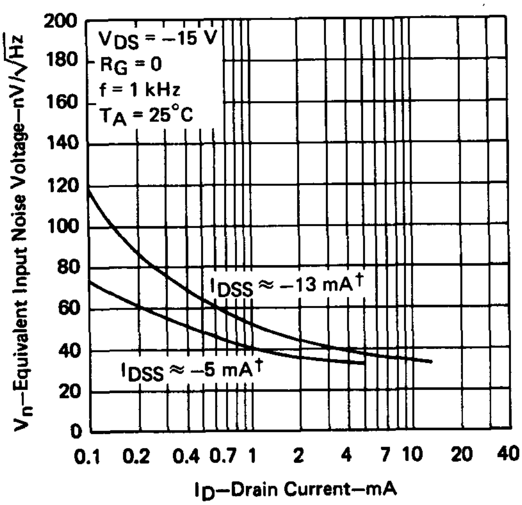
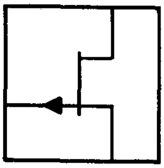


FIGURE 13

†Data is for devices having the indicated value of I_{DSS} at V_{DS} = −15 V, V_{GS} = 0, T_A = 25°C.
NOTE 2: Capacitance measurements were made using chips mounted in *Silect* packages.

CHIP TYPE JP72
P-CHANNEL SILICON JUNCTION FIELD-EFFECT TRANSISTORS

- JP72 is a 19 X 19-mil, epitaxial, planar, expanded-contact chip
- Available in TO-72 packages
- For use in commutator and chopper circuits



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES			UNIT
					LOW	TYP	HIGH	
$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 1\ \mu A$,	$V_{DS} = 0$		25♦	35		V
I_{GSS}	Gate Reverse Current	$V_{GS} = 25$ V,	$V_{DS} = 0$			<0.1		nA
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = -10$ V,	$V_{GS} = 10$ V			−<0.2	−1.5	nA
V_{GS}	Gate-Source Voltage	$V_{DS} = -10$ V,	$I_D = -1\ \mu A$		1	2.5	9.5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -10$ V,	$V_{GS} = 0$,	See Note 1	−2	−14		mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 0$,	$I_D = 0$,	f = 1 kHz		50	300	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -10$ V See Note 2	$V_{GS} = 0$,	f = 1 kHz,	4		12	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -10$ V, See Notes 2 and 3	$V_{GS} = 0$,	f = 1 MHz,		12	16	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, See Note 3	$V_{GS} = 10$ V,	f = 1 MHz,		2.5	5	pF

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

2. To obtain reproducible results, this parameter was measured with bias conditions applied for less than five seconds.

3. Capacitance measurements were made using chips mounted in TO-72 packages.

TYPICAL CHARACTERISTICS

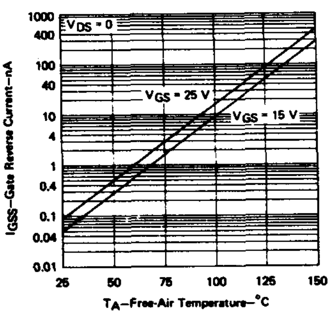


FIGURE 1

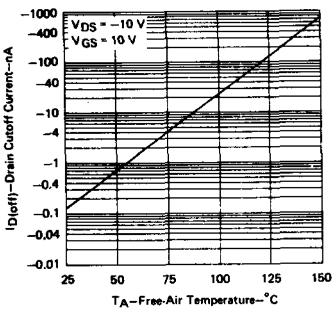


FIGURE 2

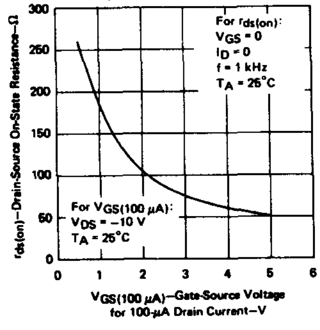


FIGURE 3

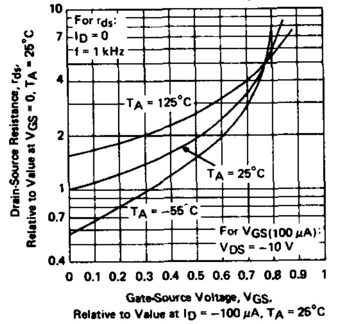


FIGURE 4

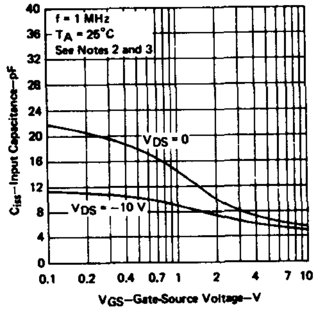


FIGURE 5

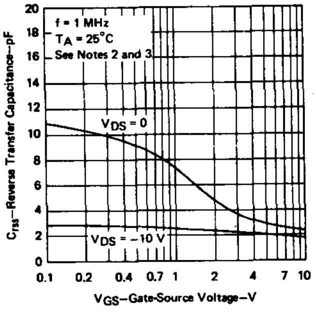
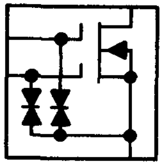


FIGURE 6

NOTES: 2. To obtain reproducible results, these parameters were measured with bias conditions applied for less than five seconds.
3. Capacitance measurements were made using chips mounted in TO-72 packages.

CHIP TYPE MN81
N-CHANNEL DUAL-GATE DEPLETION-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTORS



- **MN81 is a 19 X 19-mil, epitaxial, planar, expanded-contact chip which has integrated back-to-back diodes between the gates and the source and substrate**
- **Available in TO-72 packages**
- **For use in VHF amplifier and mixer circuits requiring low noise, low feedback capacitance, and very high gain**

electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES			UNIT
			LOW	TYP	HIGH	
$V_{(BR)DS}$	Drain-Source Breakdown Voltage	$I_D = 10\ \mu A$, $V_{G1S} = V_{G2S} = -5\ V$	25♦	28		V
$V_{(BR)G1SSF}$	Gate-One—Source Forward Breakdown Voltage	$I_{G1} = 10\ mA$, $V_{G2S} = V_{DS} = 0$, See Note 1	6♦	12	30	V
$V_{(BR)G1SSR}$	Gate-One—Source Reverse Breakdown Voltage	$I_{G1} = -10\ mA$, $V_{G2S} = V_{DS} = 0$, See Note 1	−6♦	−12	−30	V
$V_{(BR)G2SSF}$	Gate-Two—Source Forward Breakdown Voltage	$I_{G2} = 10\ mA$, $V_{G1S} = V_{DS} = 0$, See Note 1	6♦	12	30	V
$V_{(BR)G2SSR}$	Gate-Two—Source Reverse Breakdown Voltage	$I_{G2} = -10\ mA$, $V_{G1S} = V_{DS} = 0$, See Note 1	−6♦	−12	−30	V
I_{G1SSF}	Gate-One-Terminal Forward Current	$V_{G1S} = 5\ V$, $V_{G2} = V_{DS} = 0$		<0.01	10	nA
I_{G1SSR}	Gate-One-Terminal Reverse Current	$V_{G1S} = -5\ V$, $V_{G2} = V_{DS} = 0$		−<0.01	−10	nA
I_{G2SSF}	Gate-Two-Terminal Forward Current	$V_{G2S} = 5\ V$, $V_{G1S} = V_{DS} = 0$		<0.01	10	nA
I_{G2SSR}	Gate-Two-Terminal Reverse Current	$V_{G2S} = -5\ V$, $V_{G1S} = V_{DS} = 0$		−<0.01	−10	nA
I_{DS}	Zero-Gate-One-Voltage Drain Current	$V_{DS} = 15\ V$, $V_{G1S} = 0$, $V_{G2S} = 4\ V$, See Note 2	3	10	30	mA
$V_{G1S(off)}$	Gate-One—Source Cutoff Voltage	$V_{DS} = 15\ V$, $V_{G2S} = 4\ V$, $I_D = 20\ \mu A$	−0.5	−1.8	−4	V
$V_{G2S(off)}$	Gate-Two—Source Cutoff Voltage	$V_{DS} = 15\ V$, $V_{G1S} = 0$, $I_D = 20\ \mu A$	−0.2	−1.4	−4	V
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = 15\ V$, $V_{G1S} = 0$, $V_{G2S} = 4\ V$, $f = 1\ kHz$, See Note 3	7	15	22	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 15\ V$, $V_{G1S} = 0$, $V_{G2S} = 4\ V$, $f = 1\ MHz$, See Notes 3 and 4		5		pF
C_{oss}	Common-Source Short-Circuit Output Capacitance	$V_{DS} = 15\ V$, $V_{G1S} = 0$, $V_{G2S} = 4\ V$, $f = 1\ MHz$, See Notes 3 and 4		2		pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 15\ V$, $V_{G2S} = 4\ V$, $I_D = 10\ mA$, $f = 1\ MHz$, See Note 4	0.005	<0.1	0.03	pF

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. *To ensure that the protective diodes are functioning properly, this voltage is measured while the device is conducting rated forward gate current.*
2. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
3. To avoid overheating the transistor, these parameters must be measured with bias conditions applied for less than five seconds.
4. Capacitance measurements were made using chips mounted in TO-72 packages.

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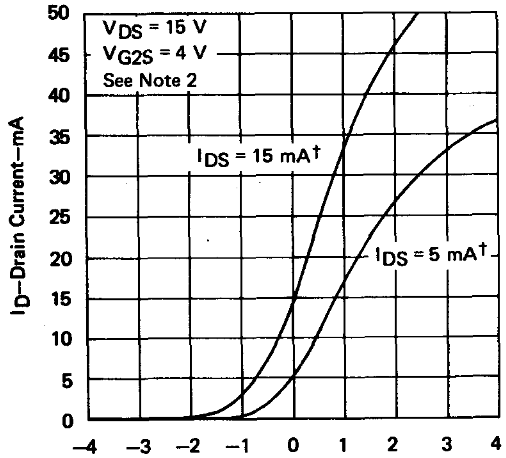
TYPICAL CHARACTERISTICS AT $T_A = 25°C$

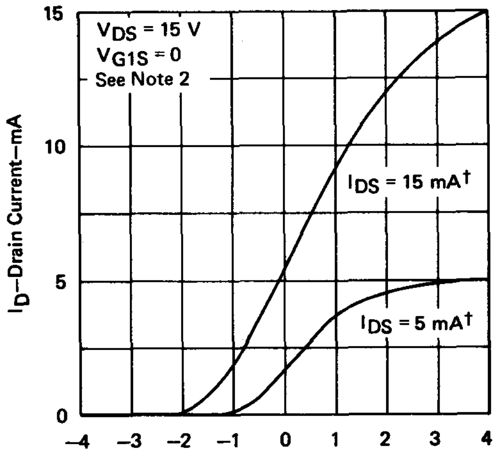
I_D vs V_{G1S}



V_{G1S}—Gate-One—Source Voltage—V

FIGURE 1

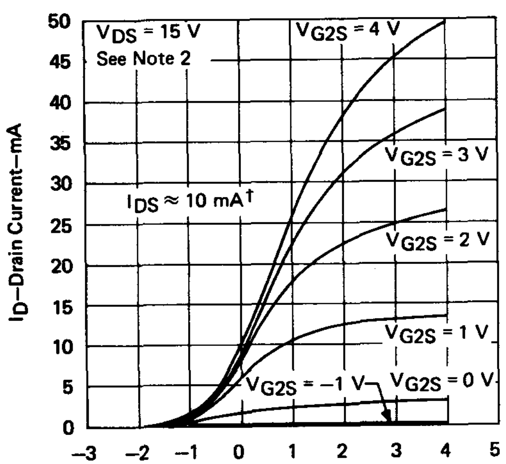
I_D vs V_{G2S}



V_{G2S}—Gate-Two—Source Voltage—V

FIGURE 2

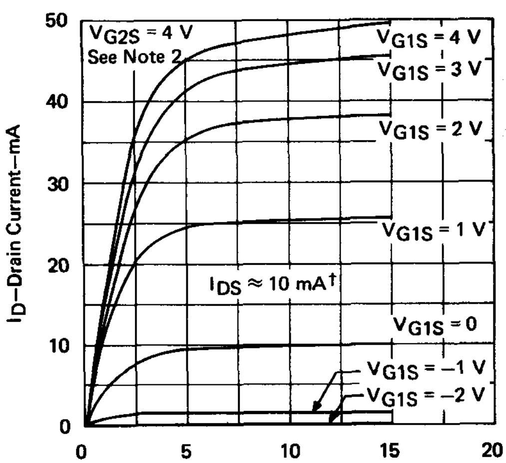
I_D vs V_{G1S}



V_{G1S}—Gate-One—Source Voltage—V

FIGURE 3

I_D vs V_{DS}



V_{DS}—Drain-Source Voltage—V

FIGURE 4

†Data is for devices having the indicated value of I_{DS} at $V_{DS} = 15$ V, $V_{G1S} = 0$, $V_{G2S} = 4$ V.
NOTE 2: This parameter was measured using pulse techniques. $t_w = 300$ μs, duty cycle $\leq 2\%$.

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TYPICAL CHARACTERISTICS AT $T_A = 25°C$

$|y_{fs}|$ vs V_{G1S}

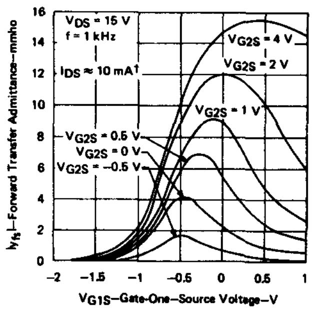

FIGURE 5

$|y_{fs}|$ vs V_{G2S}

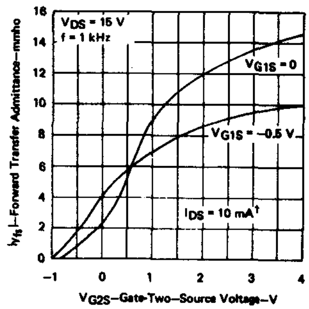

FIGURE 6

g_{fs} vs V_{G2S}

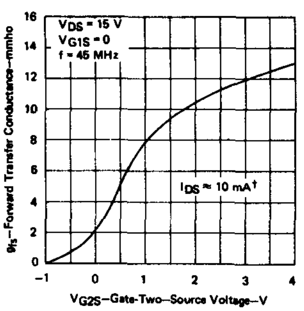

FIGURE 7

b_{fs} vs V_{G2S}

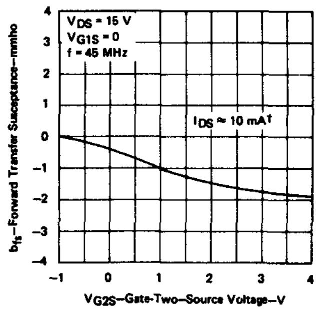

FIGURE 8

g_{os} vs V_{G2S}

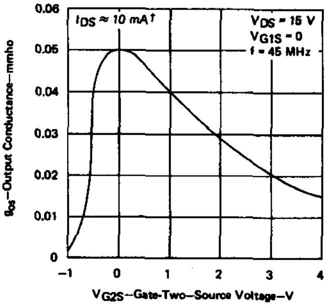

FIGURE 9

g_{os} vs V_{DS}

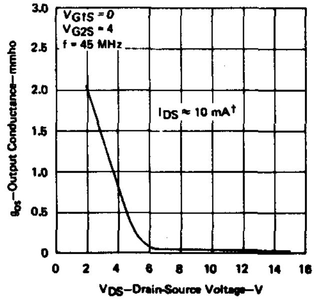

FIGURE 10

†Data is for devices having the indicated value of I_{DS} at $V_{DS} = 15$ V, $V_{G1S} = 0$, $V_{G2S} = 4$ V.

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TYPICAL CHARACTERISTICS AT $T_A = 25°C$

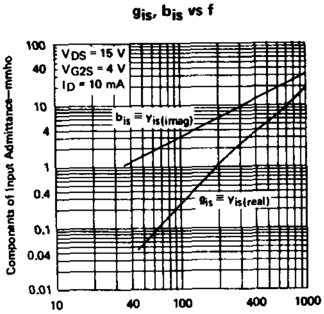

FIGURE 11

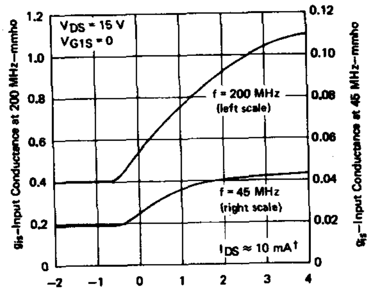

FIGURE 12

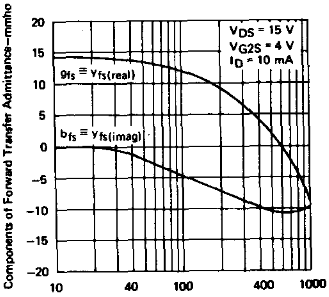

FIGURE 13

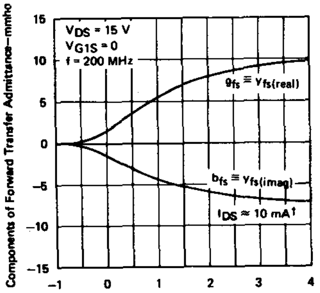

FIGURE 14

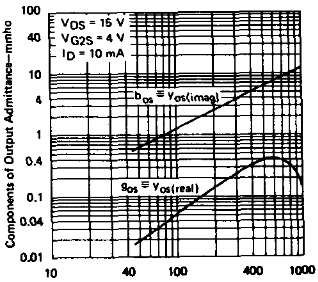

FIGURE 15

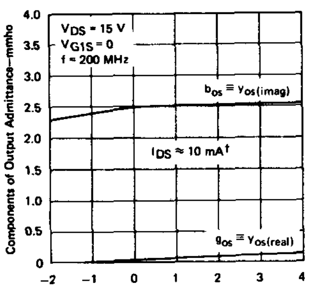

FIGURE 16

†Data is for devices having the indicated value of I_{DS} at V_{DS} = 15 V, V_{G1S} = 0, V_{G2S} = 4 V.

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

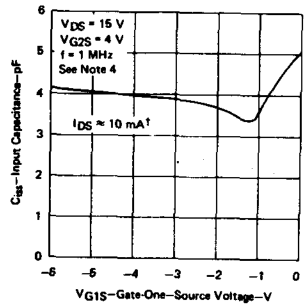

FIGURE 17

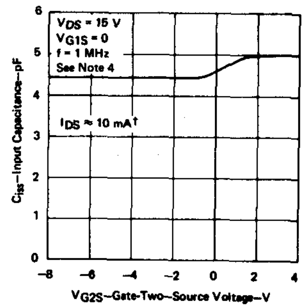

FIGURE 18

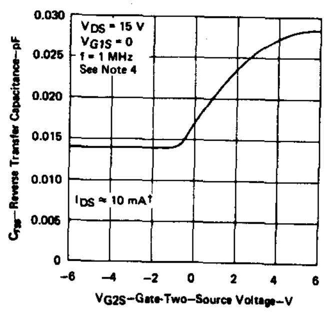

FIGURE 19

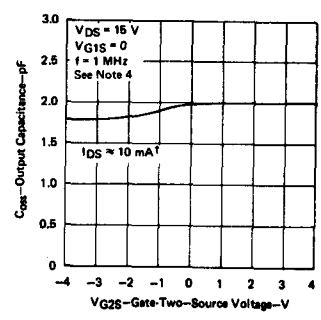

FIGURE 20

†Data is for devices having the indicated value of I_{DS} at V_{DS} = 15 V, V_{G1S} = 0, V_{G2S} = 4 V.
NOTE 4: Capacitance measurements were made using chips mounted in TO-72 packages.

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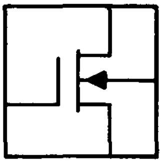
- **MN82 is a 19 X 19-mil, epitaxial, planar, expanded-contact MOS silicon chip**
- **Available in TO-72 packages**
- **For use in VHF amplifier circuits**



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES			UNIT
					LOW	TYP	HIGH	
$V_{(BR)DSV}$	Drain-Source Breakdown Voltage	I_D = 10 μA,	V_{GS} = −8 V		20◆	28		V
I_{GSSF}	Forward Gate-Terminal Current	V_{GS} = 8 V,	V_{DS} = 0			<1		pA
I_{GSSR}	Reverse Gate-Terminal Current	V_{GS} = −8 V,	V_{DS} = 0			−<1	−50	pA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	V_{DS} = 15 V,	I_D = 50 μA		−0.8	−1.5	−8	V
I_{DSS}	Zero-Gate-Voltage Drain Current	V_{DS} = 15 V,	V_{GS} = 0,	See Note 1	5	10	30	mA
$\|y_{fs}\|$	Small-Signal Common-Source Forward Transfer Admittance	V_{DS} = 15 V,	I_D = 5 mA,	f = 1 kHz	5	10	12	mmho
$\|y_{os}\|$	Small-Signal Common-Source Output Admittance					0.25		mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	V_{DS} = 15 V, See Note 2	I_D = 5 mA,	f = 1 MHz,		4		pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance					0.3	0.35	pF
C_{oss}	Common-Source Short-Circuit Output Capacitance					1.6		pF
g_{is}	Small-Signal Common-Source Input Conductance	V_{DS} = 15 V,	I_D = 5 mA,	f = 200 MHz		0.2		mmho
b_{is}	Small-Signal Common-Source Input Susceptance					4.5		
g_{fs}	Small-Signal Common-Source Forward Transfer Conductance					10		mmho
b_{fs}	Small-Signal Common-Source Forward Transfer Susceptance					−2		
g_{rs}	Small-Signal Common-Source Reverse Transfer Conductance					0.05		mmho
b_{rs}	Small-Signal Common-Source Reverse Transfer Susceptance					−0.4		
g_{os}	Small-Signal Common-Source Output Conductance					0.25		mmho
b_{os}	Small-Signal Common-Source Output Susceptance					2		
F	Spot Noise Figure	V_{DS} = 15 V,	I_D = 5 mA,	f = 200 MHz			5	dB

◆This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

CAUTION: The measurement of $V_{(BR)DSV}$ may be destructive.

NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-72 packages.

TYPICAL CHARACTERISTICS

I_{GSSF}, I_{GSSR} vs T_A

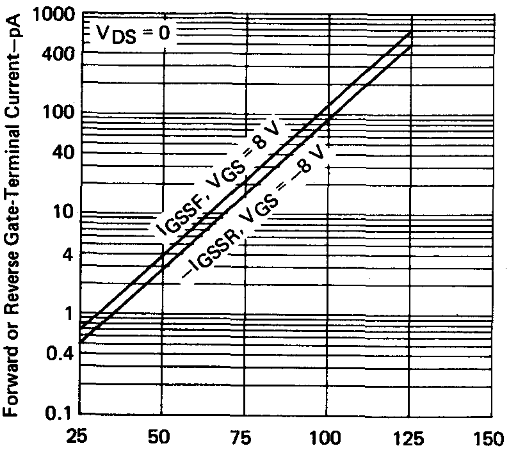


FIGURE 1

I_D vs V_{GS}

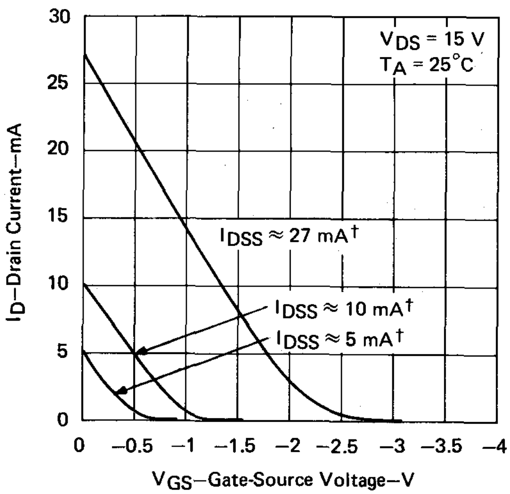


FIGURE 2

$|y_{fs}|$ vs I_D

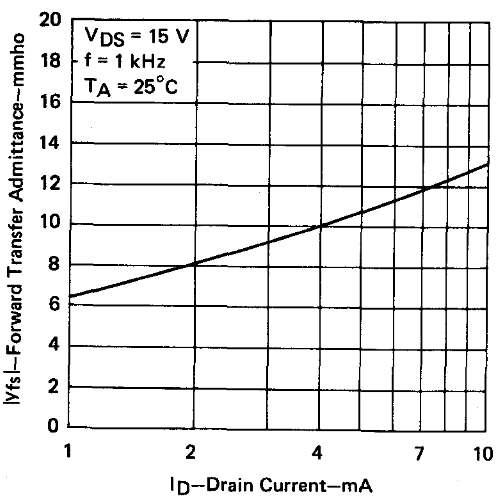


FIGURE 3

$|y_{os}|$ vs I_D

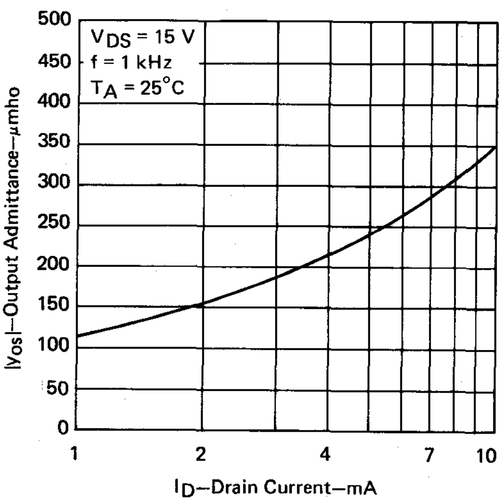


FIGURE 4

†Data is for devices having the indicated value of I_{DSS} at V_{DS} = 15 V, V_{GS} = 0, and T_A = 25°C.

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TYPICAL CHARACTERISTICS

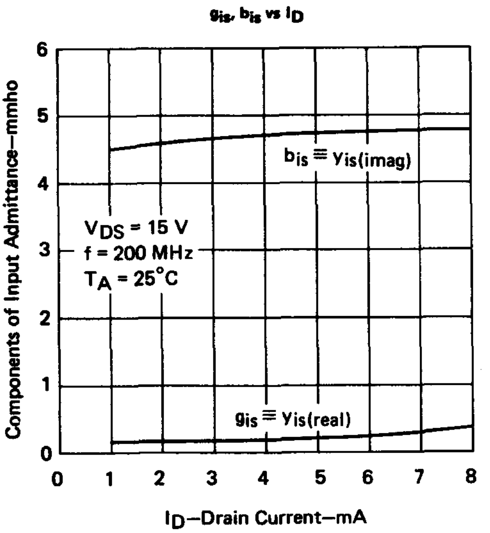

FIGURE 5

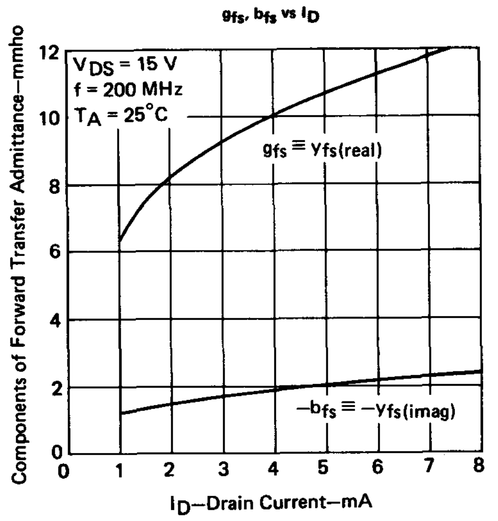

FIGURE 6

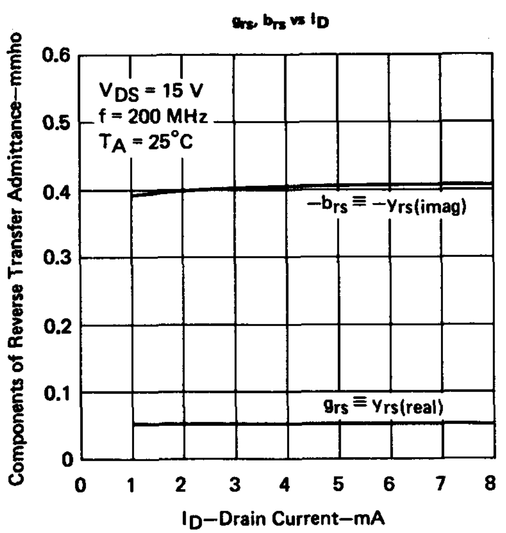

FIGURE 7

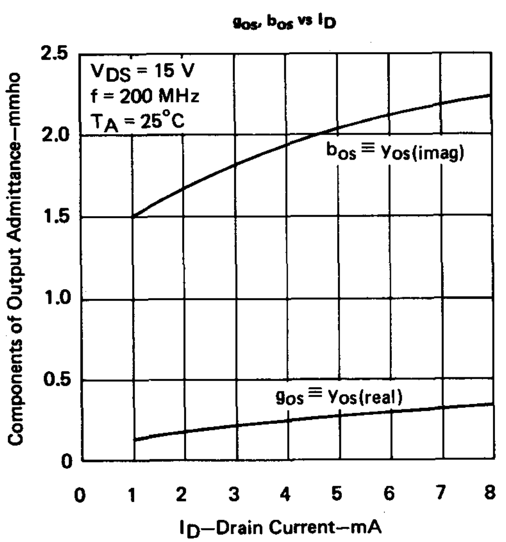

FIGURE 8

CHIP TYPE MN82
N-CHANNEL DEPLETION-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

TYPICAL CHARACTERISTICS

g_{is}, b_{is} vs f

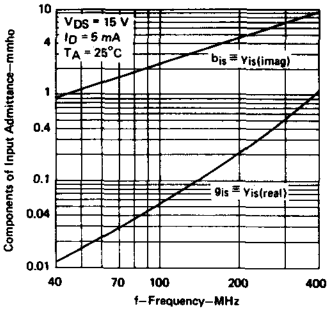

FIGURE 9

g_{fs}, b_{fs} vs f

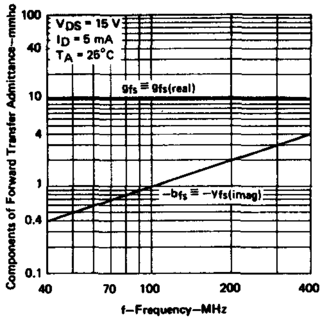

FIGURE 10

g_{rs}, b_{rs} vs f

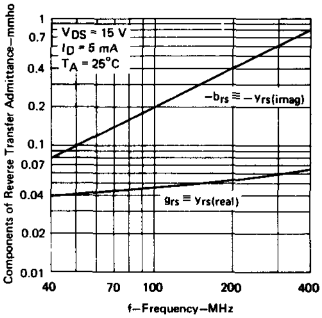

FIGURE 11

g_{os}, b_{os} vs f

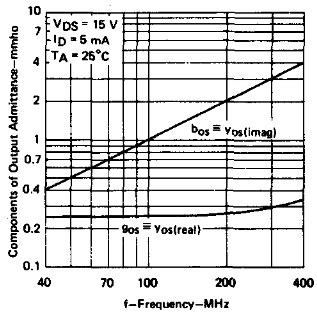

FIGURE 12

C_{iss} vs I_D

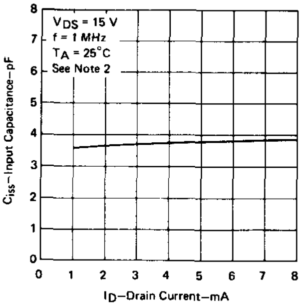

FIGURE 13

C_{rss} vs I_D

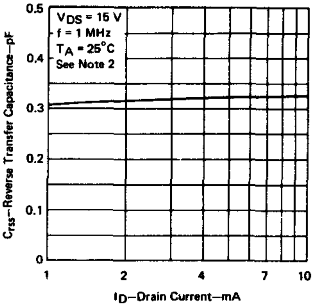

FIGURE 14

C_{oss} vs I_D

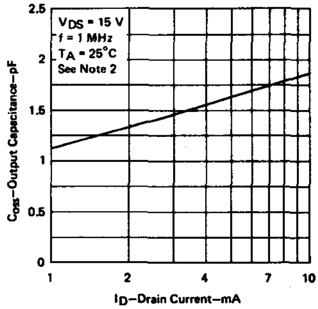

FIGURE 15

NOTE 2: Capacitance measurements were made using chips mounted in TO-72 packages.

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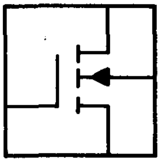
- **MN83 is a 21 X 21-mil, epitaxial, planar, expanded-contact MOS silicon chip**
- **Available in TO-72 packages**
- **For use in switching and chopper circuits**



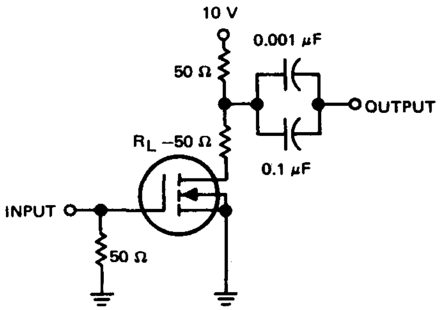
electrical and operating characteristics at 25°C free-air temperature

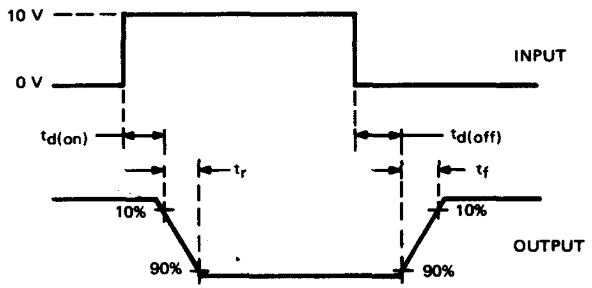
PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 10 μA,	V_{GS} = 0		25♦	40		V
I_{GSSF}	Forward Gate-Terminal Current	V_{GS} = 35 V,	V_{DS} = 0			<1	10	pA
I_{GSSR}	Reverse Gate-Terminal Current	V_{GS} = −35 V,	V_{DS} = 0			−<1	−10	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	V_{DS} = 10 V,	V_{GS} = 0			<1	10	nA
$V_{GS(th)}$	Gate-Source Threshold Voltage	V_{DS} = 10 V,	I_D = 10 μA		0.5	1	3	V
$I_{D(on)}$	On-State Drain Current	V_{DS} = 10 V,	V_{GS} = 10 V,	See Note 1	10	150	400	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	V_{GS} = 10 V,	I_D = 0,	f = 1 kHz		15	200	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	V_{DS} = 10 V, See Note 2	V_{GS} = 0,	f = 1 MHz,		4.5	6	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capaciatnce	V_{DS} = 0, See Note 2	V_{GS} = 0,	f = 1 MHz,		1.1	1.5	pF
$t_{d(on)}$	Turn-On Delay Time					1		ns
t_r	Rise Time	V_{DD} = 10 V,	$I_{D(on)}$ ≈ 10 mA,	R_L = 800 Ω,		2		ns
$t_{d(off)}$	Turn-Off Delay Time	$V_{GS(on)}$ = 10 V,	$V_{GS(off)}$ = 0,	Figure 1 Circuit		3		ns
t_f	Fall Time					12		ns

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.
CAUTION: The measurement of $V_{(BR)DSS}$ may be destructive.
NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in TO-72 packages.

CHIP TYPE MN83
N-CHANNEL ENHANCEMENT-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

PARAMETER MEASUREMENT INFORMATION





TEST CIRCUIT **VOLTAGE WAVEFORMS**

NOTES: a. The input waveform is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, duty cycle $\leq 1\%$, $t_r \leq 0.33$ ns, $t_f \leq 0.33$ ns, $t_w \approx 100$ ns.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 0.4$ ns, $R_{in} = 50\ \Omega$, $C_{in} \leq 2$ pF.

FIGURE 1

TYPICAL CHARACTERISTICS

I_{DSS} vs T_A

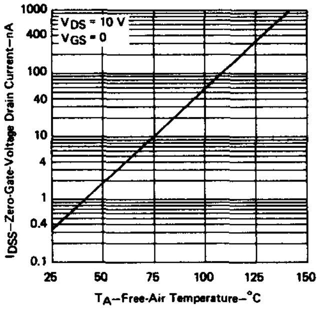


FIGURE 2

I_D vs V_{GS}

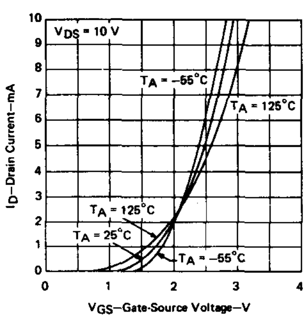


FIGURE 3

I_D vs V_{GS}

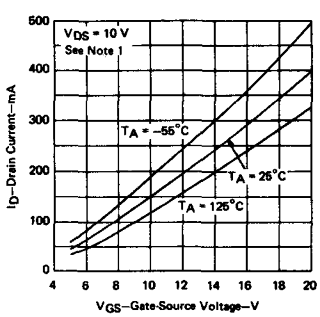


FIGURE 4

NOTE 1: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

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TYPICAL CHARACTERISTICS

$r_{ds(on)}$ vs V_{GS}

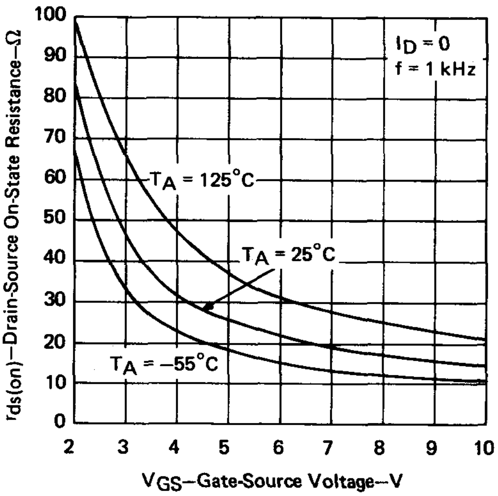


FIGURE 5

$t_{d(on)}$, t_r, $t_{d(off)}$, t_f vs R_L

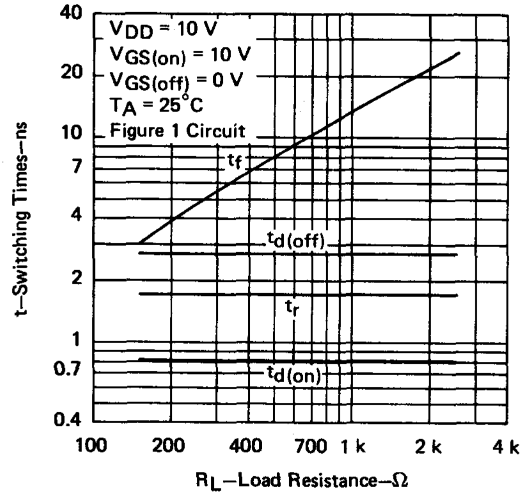


FIGURE 6

5

C_{iss} vs V_{GS}

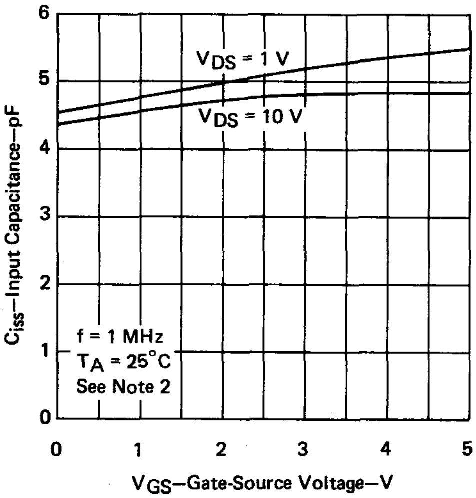


FIGURE 7

C_{rss} vs V_{GS}

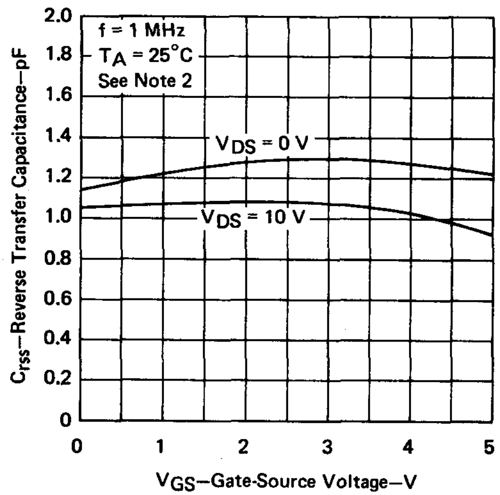
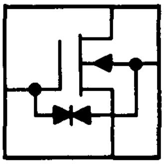


FIGURE 8

NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in TO-72 packages.

CHIP TYPE MN84
N-CHANNEL DEPLETION-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

- **MN84 is a 21 X 21-mil, epitaxial, planar, expanded-contact MOS silicon chip which has integrated back-to-back diodes between the gate and the substrate**
- **Available in TO-72 packages**
- **For low-power switching and chopper circuits**



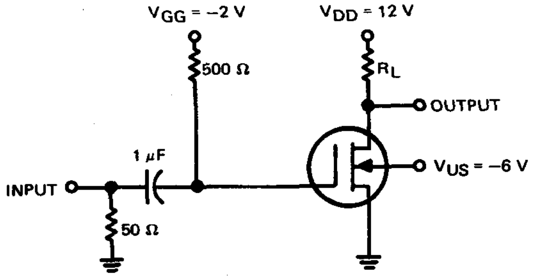
electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)GSSF}$	Forward Gate-Source Breakdown Voltage	$I_G = 1$ mA, $V_{DS} = 0$, $V_{US} = 0$, See Note 1	7♦	10		V
$V_{(BR)GSSR}$	Reverse Gate-Source Breakdown Voltage	$I_G = -1$ mA, $V_{DS} = 0$, $V_{US} = 0$, See Note 1	−7♦	−35		V
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = 7$ V, $V_{DS} = 0$, $V_{US} = 0$		<0.1	10	nA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = -7$ V, $V_{DS} = 0$, $V_{US} = 0$		−<0.1	−10	nA
$I_{S(off)}$	Source Cutoff Current	$V_{SD} = 12$ V, $V_{GD} = -6$ V, $V_{UD} = 0$		<0.1	1000	nA
		$V_{SD} = 12$ V, $V_{GD} = -6$ V, $V_{UD} = -6$ V		<0.1	1000	
$I_{D(off)}$	Drain Cutoff Current	$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = 0$		<0.1	100	nA
		$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = -6$ V		<0.1	100	
I_{USS}	Substrate Reverse Current	$V_{US} = -20$ V, $V_{DS} = 0$, $V_{GS} = 0$		−<0.1	−10	nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 12$ V, $I_D = 10$ µA, $V_{US} = 0$	−0.1	−0.75	−1.5	V
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = 12$ V, $V_{GS} = 0$, $V_{US} = 0$	1	5	12	mA
$I_{D(on)}$	On-State Drain Current	$V_{DS} = 3$ V, $V_{GS} = 6$ V, $V_{US} = -6$ V, See Note 2	50	100		mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = 6$ V, $I_D = 0$, $V_{US} = 0$, f = 1 kHz		18	70	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = 0$, f = 1 MHz, See Note 3		5.5	7	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = -6$ V, $V_{US} = 0$, f = 1 MHz, See Note 3		1.4	2	pF
C_{ds}	Drain-Source Capacitance	$V_{DS} = 12$ V, $V_{GS} = -6$ V, $V_{US} = 0$, f = 1 MHz, See Notes 3 and 4		3.5	5	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = 12$ V, $I_{D(on)} \approx 55$ mA, $R_L = 200\ \Omega$, $V_{GS(on)} \approx 6$ V, $V_{GS(off)} \approx -2$ V, $V_{US} = -6$ V, Figure 1 Circuit		1.4		ns
t_r	Rise Time			0.7		
$t_{d(off)}$	Turn-Off Delay Time			2.5		
t_f	Fall Time			4		

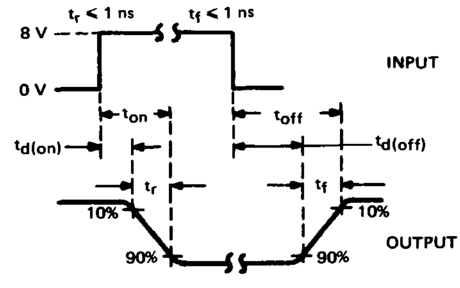
♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

NOTES:
1. Both gate breakdown voltages are measured while the device is conducting rated gate current. This ensures that the gate-voltage-limiting network is functioning properly.
2. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
3. Capacitance measurements were made using chips mounted in TO-72 packages.
4. C_{ds} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The gate and case are connected to the guard terminal of the bridge.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$; $t_w \approx 200$ ns, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

I_{GSSF} vs T_A

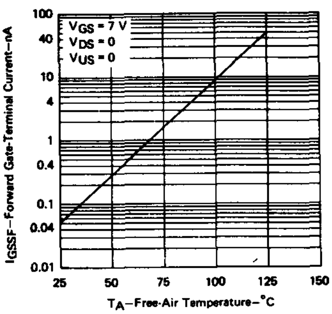


FIGURE 2

$I_{S(off)}$ vs T_A

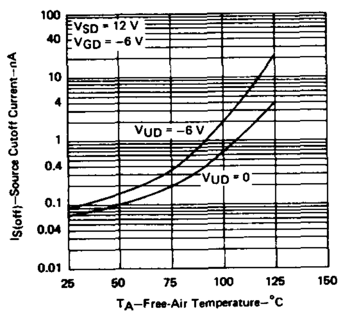


FIGURE 3

$I_{D(off)}$ vs T_A

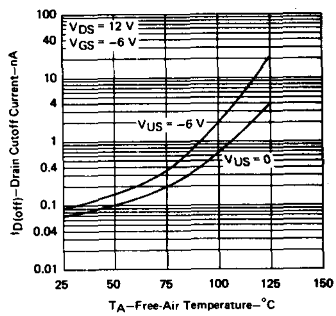


FIGURE 4

I_{USS} vs T_A

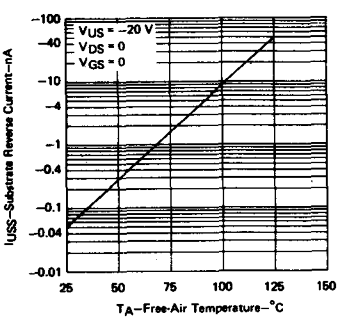


FIGURE 5

$V_{GS(off)}$ vs T_A

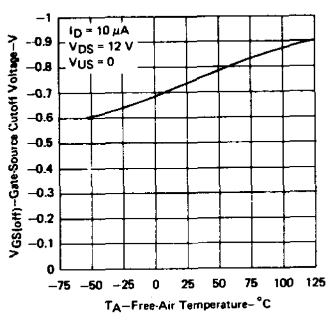


FIGURE 6

I_{DSS} vs T_A

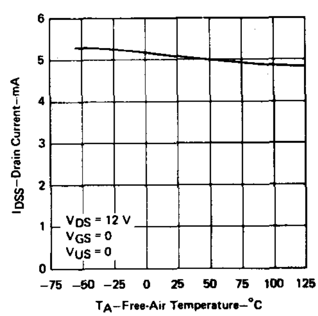


FIGURE 7

5

TYPICAL CHARACTERISTICS

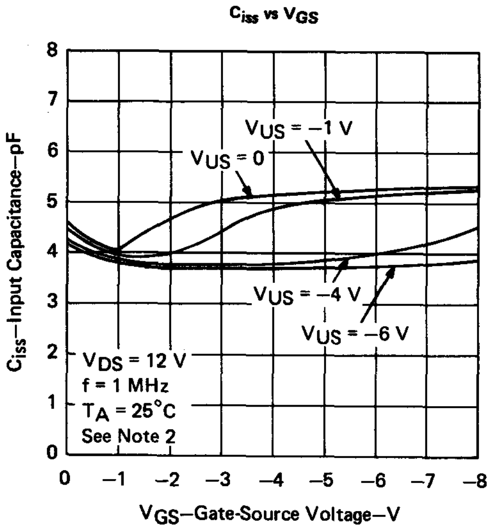


FIGURE 8

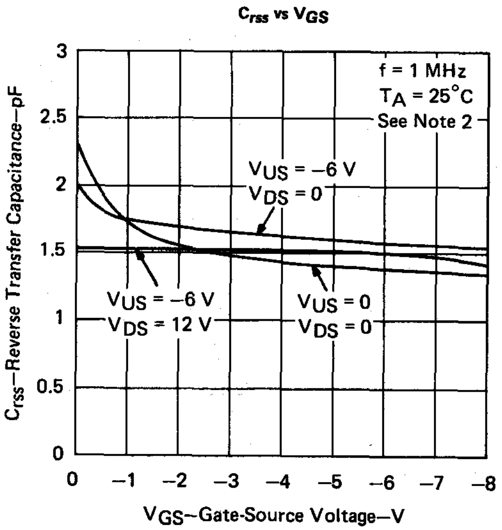


FIGURE 9

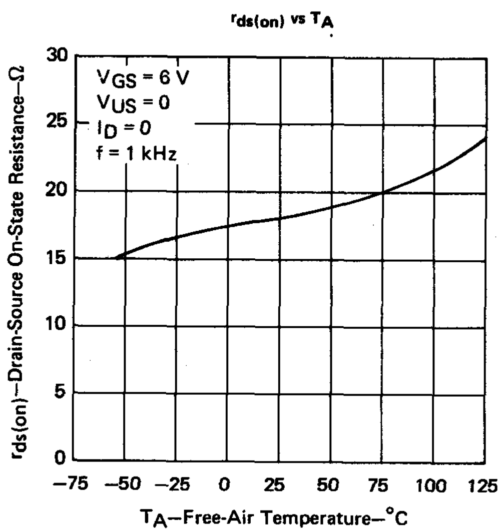


FIGURE 10

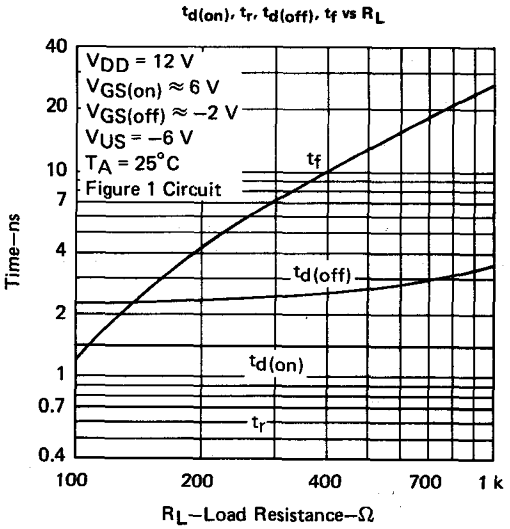


FIGURE 11

NOTE 2: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ⩽ 2%.

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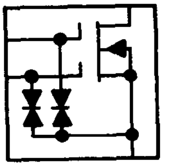
N-CHANNEL DUAL-GATE DEPLETION-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTORS

- MN85 is a 26 X 26-mil, epitaxial, planar, expanded-contact MOS silicon chip which has integrated back-to-back diodes between the gates and the source and substrate
- Available in TO-72 packages
- For use in VHF amplifier and mixer circuits requiring low noise, low feedback capacitance, and very high gain



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES			UNIT
			LOW	TYP	HIGH	
$V_{(BR)DS}$	Drain-Source Breakdown Voltage	I_D = 10 μA, $V_{G1S} = V_{G2S}$ = −4 V, t = 5 s	27♦	40		V
$V_{(BR)DS}$	Instantaneous Drain-Source Breakdown Voltage	I_D = 10 μA, $V_{G1S} = V_{G2S}$ = −4 V	25♦	32	40	V
$V_{(BR)G1SSF}$	Gate-One—Source Forward Breakdown Voltage	I_{G1} = 10 mA, $V_{G2S} = V_{DS}$ = 0, See Note 1	6♦	12	30	V
$V_{(BR)G1SSR}$	Gate-One—Source Reverse Breakdown Voltage	I_{G1} = −10 mA, $V_{G2S} = V_{DS}$ = 0, See Note 1	−6♦	−12	−30	V
$V_{(BR)G2SSF}$	Gate-Two—Source Forward Breakdown Voltage	I_{G2} = 10 mA, $V_{G1S} = V_{DS}$ = 0, See Note 1	6♦	12	30	V
$V_{(BR)G2SSR}$	Gate-Two—Source Reverse Breakdown Voltage	I_{G2} = −10 mA, $V_{G1S} = V_{DS}$ = 0, See Note 1	−6♦	−12	−30	V
I_{G1SSF}	Gate-One-Terminal Forward Current	V_{G1S} = 5 V, $V_{G2} = V_{DS}$ = 0,		<0.01	10	nA
I_{G1SSR}	Gate-One-Terminal Reverse Current	V_{G1S} = −5 V, $V_{G2} = V_{DS}$ = 0		−<0.01	−10	nA
I_{G2SSF}	Gate-Two-Terminal Forward Current	V_{G2S} = 5 V, $V_{G1S} = V_{DS}$ = 0		<0.01	10	nA
I_{G2SSR}	Gate-Two-Terminal Reverse Current	V_{G2S} = −5 V, $V_{G1S} = V_{DS}$ = 0		−<0.01	−10	nA
I_{DS}	Zero-Gate-One-Voltage Drain Current	V_{DS} = 15 V, V_{G1S} = 0, V_{G2S} = 4 V, See Note 2	6	15	40	mA
$V_{G1S(off)}$	Gate-One—Source Cutoff Voltage	V_{DS} = 15 V, V_{G2S} = 4 V, I_D = 20 μA	−0.5	−1.3	−5.5	V
$V_{G2S(off)}$	Gate-Two—Source Cutoff Voltage	V_{DS} = 15 V, V_{G1S} = 0, I_D = 20 μA	−0.2	−1.0	−4	V
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	V_{DS} = 15 V, V_{G1S} = 0, V_{G2S} = 4 V, f = 1 kHz, See Note 3	15	27	40	mmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	V_{DS} = 15 V, V_{G2S} = 4 V, I_D = 10 mA, f = 1 MHz, See Note 4		6		pF
C_{oss}	Common-Source Short-Circuit Output Capacitance	V_{DS} = 15 V, V_{G2S} = 4 V, I_D = 10 mA, f = 1 MHz, See Note 4		2.5		pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	V_{DS} = 15 V, V_{G2S} = 4 V, I_D = 1 mA, f = 1 MHz, See Note 4	0.005	<0.03	0.05	pF

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES:
1. To ensure that the protective diodes are functioning properly, this voltage is measured while the device is conducting rated forward gate current.
2. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
3. To avoid overheating the transistor, this parameter must be measured with bias conditions applied for less than five seconds.
4. Capacitance measurements were made using chips mounted in TO-72 packages.

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TYPICAL CHARACTERISTICS AT T_A = 25°C

I_D vs V_{G1S}

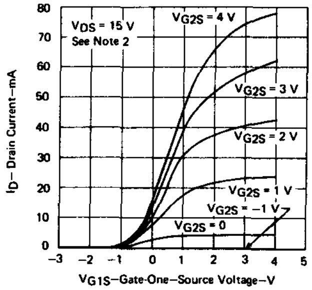


FIGURE 1

I_D vs V_{G1S}

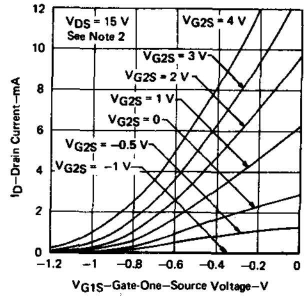


FIGURE 2

I_D vs V_{G2S}

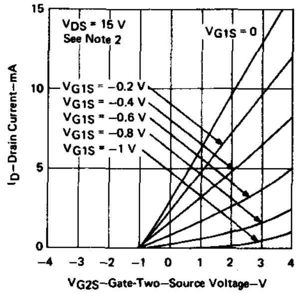


FIGURE 3

I_D vs V_{DS}

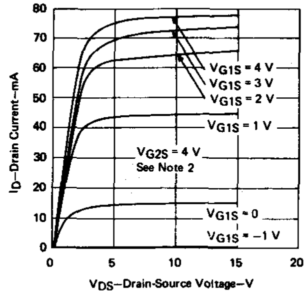


FIGURE 4

$|y_{fs}|$ vs V_{G1S}

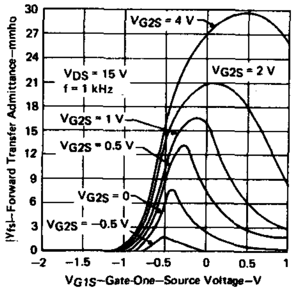


FIGURE 5

$|y_{fs}|$ vs V_{G2S}

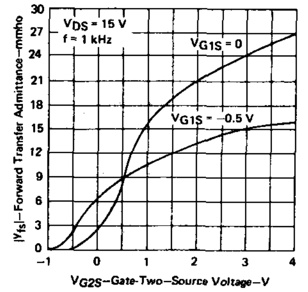


FIGURE 6

NOTE 2: This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

C_{iss} vs V_{G1S}

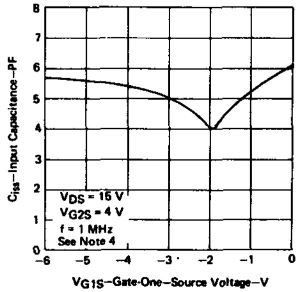


FIGURE 7

C_{iss}, C_{oss} vs V_{G2S}

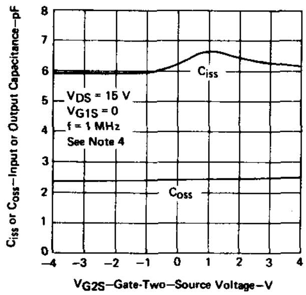


FIGURE 8

g_{is}, b_{is} vs f

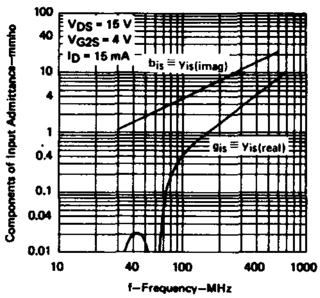


FIGURE 9

g_{fs}, b_{fs} vs f

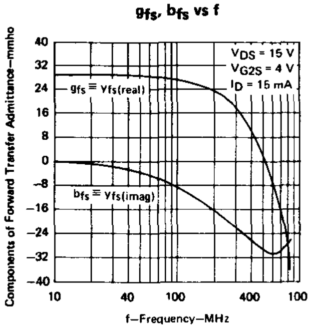


FIGURE 10

g_{rs}, b_{rs} vs f

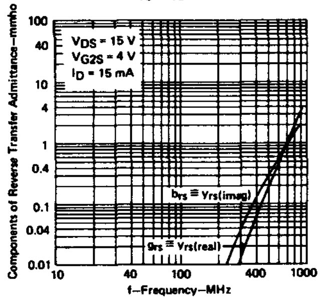


FIGURE 11

g_{os}, b_{os} vs f

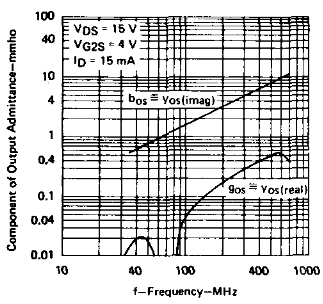


FIGURE 12

NOTE 4: Capacitance measurements were made using chips mounted in TO-72 packages.

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

g_{os} vs V_{DS}

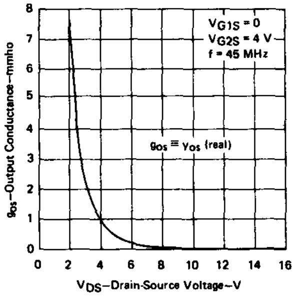


FIGURE 13

g_{is}, b_{is} vs V_{G2S}

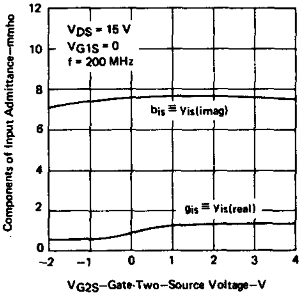


FIGURE 14

g_{os} vs V_{G2S}

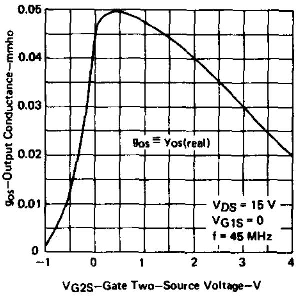


FIGURE 15

g_{os}, b_{os} vs V_{G2S}

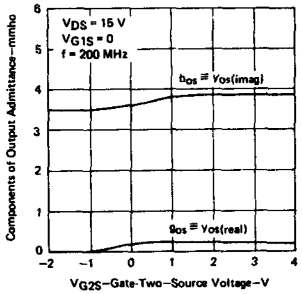


FIGURE 16

g_{fs}, b_{fs} vs V_{G2S}

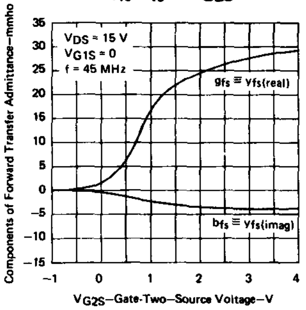


FIGURE 17

g_{fs}, b_{fs} vs V_{G2S}

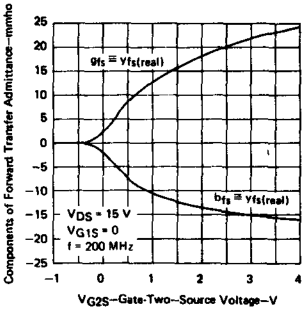
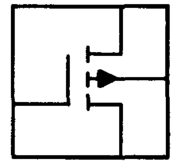


FIGURE 18

CHIP TYPE MP91
P-CHANNEL ENHANCEMENT-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

- **MP91 is a 20 X 20-mil, epitaxial, planar, expanded-contact MOS silicon chip**
- **Available in TO-72 packages**
- **For use in switching and chopper circuits**



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS†			OBSERVED VALUES			UNIT
					LOW	TYP	HIGH	
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	$I_D = -10\ \mu A$,	$V_{GS} = 0$		−40♦	−60		V
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -40$ V,	$V_{DS} = 0$			−<1	−10	pA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 40$ V,	$V_{DS} = 0$			<1	10	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V,	$V_{GS} = 0$			−0.1	−0.5	nA
I_{SDS}	Zero-Gate-Voltage Source Current	$V_{SD} = -20$ V,	$V_{GD} = 0$,	$V_{UD} = 0$		−0.1	−0.4	nA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V,	$I_D = -10\ \mu A$		−1.5	−3.5	−5	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V,	$V_{GS} = -10$ V,	See Note 1	−5	−20	−30	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = -10$ V,	$I_D = 0$,	f = 1 kHz		275	450	Ω
		$V_{GS} = -20$ V,	$I_D = 0$,	f = 1 kHz		150	250	
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V,	$I_D = -10$ mA,	f = 1 kHz	1	3.2	5	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance					150	300	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, See Note 2	$V_{GS} = 0$,	f = 1 MHz,		2.5	5	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, See Note 2	$V_{GS} = 0$,	f = 1 MHz,		0.3	0.5	pF
C_{oss}	Common-Source Short-Circuit Output Capacitance	$V_{DS} = -15$ V, See Note 2	$V_{GS} = 0$,	f = 1 MHz,		1.6	2.5	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = -15$ V, $V_{GS(on)} \approx -10$ V, Figure 1 Circuit	$I_{D(on)} \approx -10$ mA, $V_{GS(off)} = 0$,	$R_L = 1.4$ kΩ, $R_G = 1.4$ kΩ,		8		ns
t_r	Rise Time					19		
$t_{d(off)}$	Turn-Off Delay Time					6		
t_f	Fall Time					28		
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = -15$ V, $V_{GS(on)} \approx -10$ V, Figure 2 Circuit	$I_{D(on)} \approx -2$ mA, $V_{GS(off)} = 0$,	$R_L = 8.2$ kΩ, $R_G = 4.5$ kΩ,		12		ns
t_r	Rise Time					12		
$t_{d(off)}$	Turn-Off Delay Time					10		
t_f	Fall Time					35		

†All measurements, except I_{SDS}, are made with the case and substrate connected to the source.

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

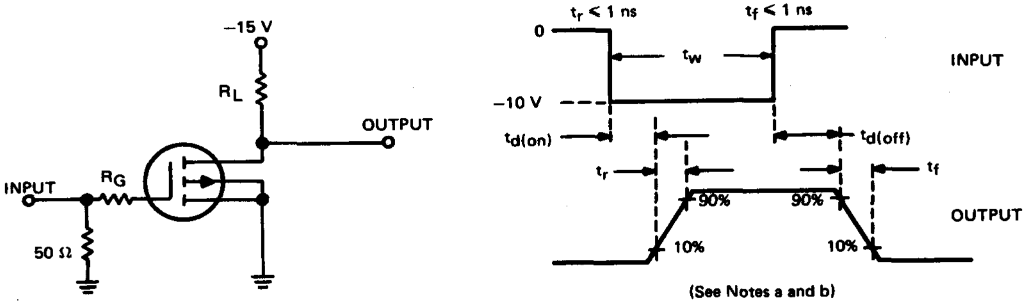
CAUTION: The measurement of $V_{(BR)DSS}$ may be destructive.

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-72 packages.

5

PARAMETER MEASUREMENT INFORMATION

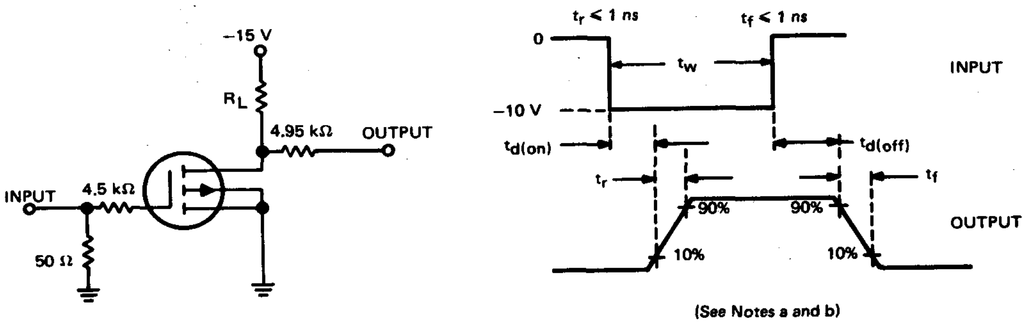


TEST CIRCUITS

(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, t_w ≈ 100 ns, duty cycle ≤ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ≤ 1 ns, R_{in} ≥ 100 kΩ, C_{in} ≤ 2 pF.

FIGURE 1—SWITCHING TIMES



TEST CIRCUITS

(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, t_w ≈ 100 ns, duty cycle ≤ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: t_r ≤ 1 ns, Z_{in} ≈ 50 Ω.

FIGURE 2—SWITCHING TIMES

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TYPICAL CHARACTERISTICS

I_{DSS} vs T_A

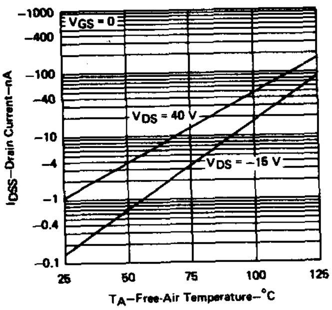


FIGURE 3

$V_{GS(th)}$ vs T_A

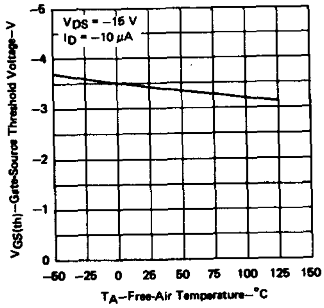


FIGURE 4

$r_{ds(on)}$ vs T_A

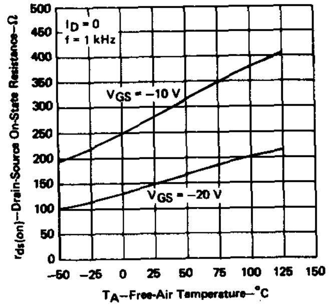


FIGURE 5

C_{iss} vs V_{GS}

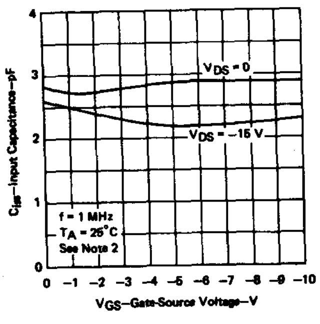


FIGURE 6

C_{rss} vs V_{GS}

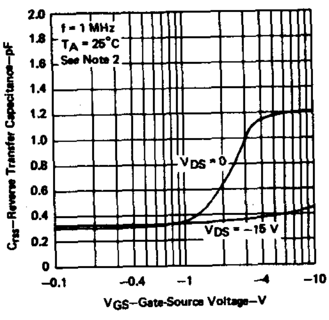


FIGURE 7

C_{oss} vs V_{GS}

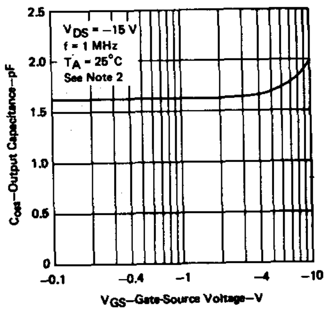


FIGURE 8

$t_{d(on)}$, t_r, $t_{d(off)}$, t_f vs R_G

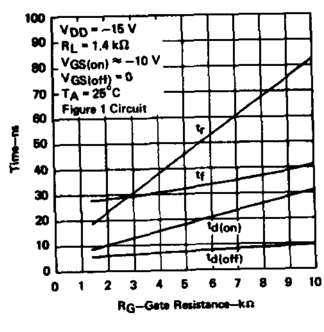


FIGURE 9

$t_{d(on)}$, t_r, $t_{d(off)}$, t_f vs R_L

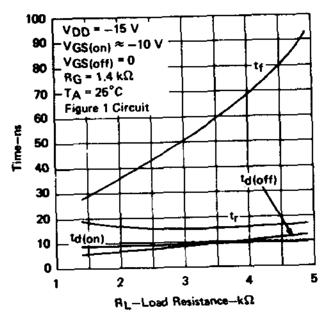


FIGURE 10

$t_{d(on)}$, t_r, $t_{d(off)}$, t_f vs R_L

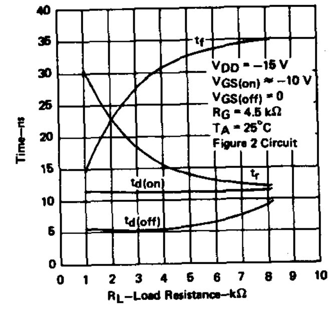
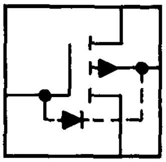


FIGURE 11

NOTE 2: Capacitance measurements were made using chips mounted in TO-72 packages.

CHIP TYPE MP92
P-CHANNEL ENHANCEMENT-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

- **MP92 is a 25 X 25-mil, epitaxial, planar, expanded-contact MOS silicon chip available with or without gate-protection diodes**
- **Available in TO-72 packages**
- **For use in chopper, multiplexer, and commutator circuits**



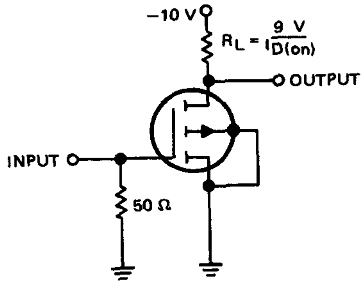
electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS†	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)GSSF}$■	Gate-Source Forward Breakdown Voltage	$I_G = -100\ \mu A$, $V_{DS} = 0$, See Note 1	−25♦	−50		V
I_{GSSF}■	Gate Terminal Forward Current	$V_{GS} = -25$ V, $V_{DS} = 0$		−30	−100	pA
I_{GSSF}●	Gate Terminal Forward Current	$V_{GS} = -25$ V, $V_{DS} = 0$		−1	−10	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -15$ V, $V_{GS} = 0$		−<0.1	−10	nA
I_{SDS}	Zero-Gate-Voltage Source Current	$V_{SD} = -15$ V, $V_{GD} = 0$, $V_{UD} = 0$		−<0.1		nA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10\ \mu A$	−1.5	−3	−5	V
V_{GS}	Gate-Source Voltage	$V_{DS} = -15$ V, $I_D = -8$ mA	−4.5	−6	−8	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -15$ V, See Note 2	−40	−60	−120	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = -5$ V, $I_D = 0$, f = 1 kHz		250		Ω
		$V_{GS} = -10$ V, $I_D = 0$, f = 1 kHz		100		
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $I_D = -8$ mA, f = 1 kHz	3.5	4.2	6.5	mmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance	$V_{DS} = -15$ V, $I_D = -8$ mA, f = 1 kHz		80	250	μmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $I_D = -8$ mA, f = 1 MHz, See Note 3		8	10	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = -15$ V, $I_D = -8$ mA, f = 1 MHz, See Note 3		2	4	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = -10$ V, $I_{D(on)} = -10$ mA, $V_{GS(on)} = -15$ V, $V_{GS(off)} = 0$, See Figure 1		6		ns
t_r	Rise Time			5		
$t_{d(off)}$	Turn-Off Delay Time			8		
t_f	Fall Time			16		

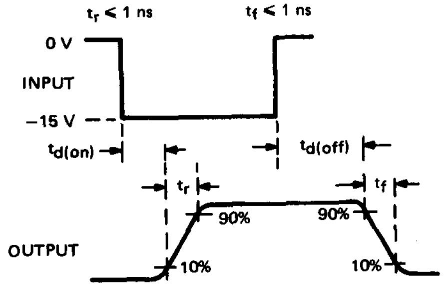
†All measurements except I_{SDS} are made with the case and substrate connected to the source.
♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.
■These parameters apply only for chips having protective diodes.
●This parameter applies only for chips not having protective diodes.

NOTES: 1. To ensure that the protective diode is functioning properly, this voltage is measured while the device is conducting rated forward gate current.
2. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
3. Capacitance measurements were made using chips mounted in TO-72 packages.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES. a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_w = 200$ ns, duty cycle $\le 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \le 1$ ns, $R_{in} \ge 100\ k\Omega$, $C_{in} \le 7$ pF.

FIGURE 1–SWITCHING TIMES

TYPICAL CHARACTERISTICS†

I_{GSSF} vs T_A
(Devices with Protective Diodes)

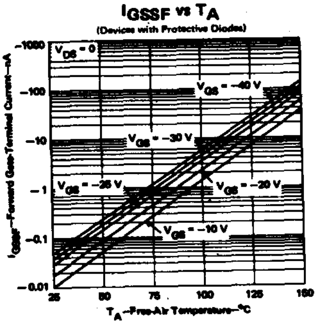


FIGURE 2

I_{DSS}, I_{SDS} vs T_A

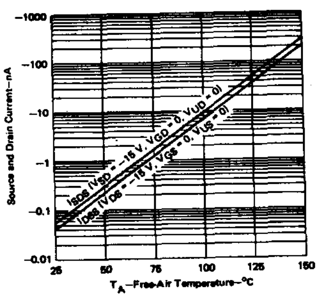


FIGURE 3

I_D vs V_{DS}

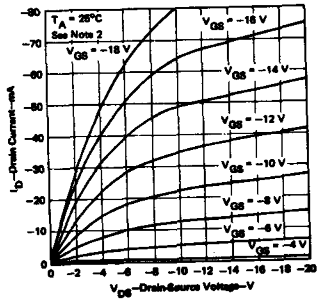


FIGURE 4

I_D vs V_{GS}

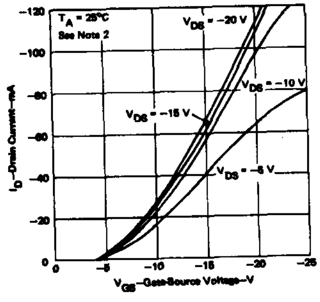


FIGURE 5

†All measurements except I_{SDS} were made with the case and substrate connected to the source.
NOTE 2: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\le 2\%$.

TYPICAL CHARACTERISTICS†

$|y_{fs}|$ vs I_D

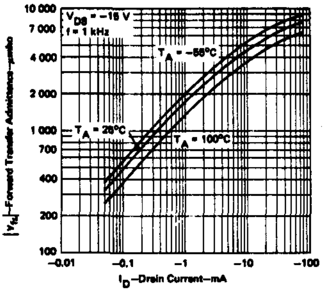


FIGURE 6

$|y_{os}|$ vs I_D

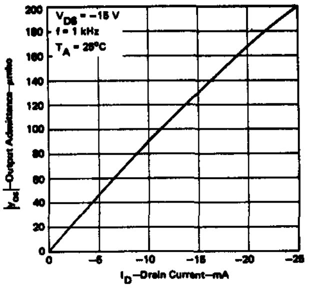


FIGURE 7

C_{iss} vs V_{GS}

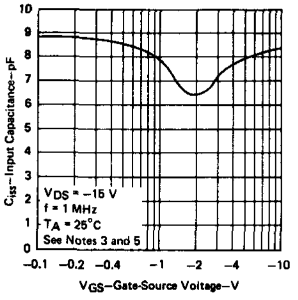


FIGURE 8

C_{rss} vs V_{GS}

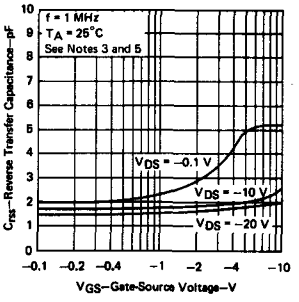


FIGURE 9

$r_{ds(on)}$ vs T_A

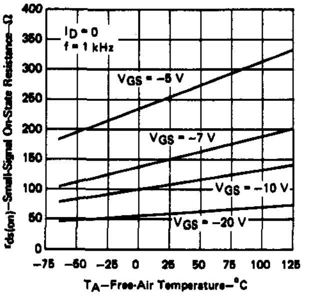


FIGURE 10

$t_{d(on)}$, t_r, $t_{d(off)}$, t_f vs $I_{D(on)}$

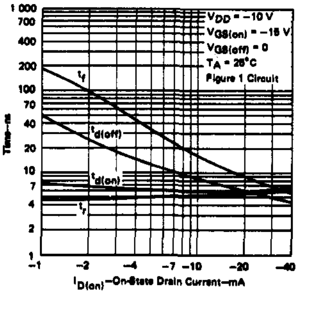


FIGURE 11

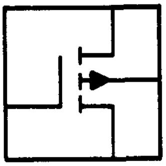
†All measurements except I_{SDS} were made with the case and substrate connected to the source.

NOTES: 3. Capacitance measurements were made using chips mounted in TO-72 packages.

5. To avoid overheating the transistor, these parameters were measured with bias conditions applied for less than five seconds.

CHIP TYPE MP93
P-CHANNEL ENHANCEMENT-TYPE
INSULATED-GATE FIELD-EFFECT TRANSISTORS

- **MP93 is a 17 X 20-mil, epitaxial, planar, expanded-contact MOS silicon chip**
- **Available in TO-72 packages**
- **For use in series- and shunt-chopper, multiplexer, and commutator circuits**

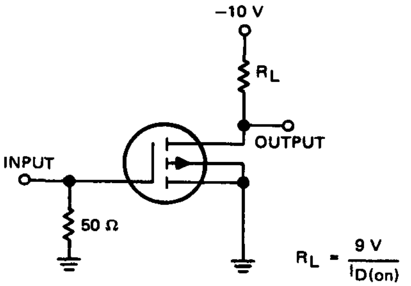


electrical and operating characteristics at 25°C free-air temperature

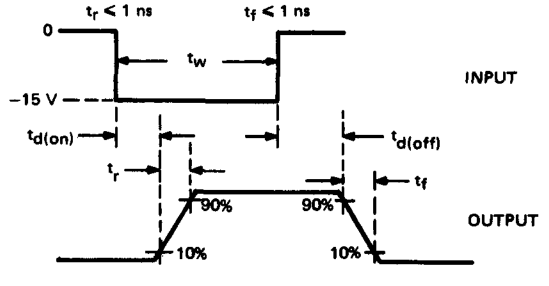
PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
I_{GSSF}	Forward Gate-Terminal Current	$V_{GS} = -30$ V, $V_{DS} = 0$		−<1	−2.5	pA
I_{GSSR}	Reverse Gate-Terminal Current	$V_{GS} = 30$ V, $V_{DS} = 0$		<1	2.5	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -30$ V, $V_{GS} = 0$		−<1	−5	nA
I_{SDS}	Zero-Gate-Voltage Source Current	$V_{SD} = -30$ V, $V_{GD} = V_{UD} = 0$		−<1	−5	nA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15$ V, $I_D = -10\ \mu A$	−2	−4.5	−6	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15$ V, $V_{GS} = -15$ V, See Note 1	−3	−9.5	−12	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = -15$ V, $I_D = 0$, f = 1 kHz		500	1000	Ω
$\lvert y_{fs} \rvert$	Small-Signal Common-Source Forward Transfer Admittance	$V_{DS} = -15$ V, $V_{GS} = -15$ V, f = 1 kHz, See Note 2	400	1750		µmho
$\lvert y_{os} \rvert$	Small-Signal Common-Source Output Admittance				200	µmho
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -15$ V, $V_{GS} = -15$ V, f = 1 MHz, See Notes 2 and 3		2.5	4	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0$, $V_{GS} = 0$, f = 1 MHz, See Note 3		0.4	0.7	pF
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = -10$ V, $I_{D(on)} = -1$ mA, $R_L = 9$ kΩ, $V_{GS(on)} = -15$ V, $V_{GS(off)} = 0$, See Figure 1		10	30	ns
t_r	Rise Time			13	50	
$t_{d(off)}$	Turn-Off Delay Time			25	75	
t_f	Fall Time			80	100	

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. To avoid overheating the transistor, this parameter must be measured with bias conditions applied for less than five seconds.
3. Capacitance measurements were made using chips mounted in TO-72 packages.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$; $t_w = 200$ ns, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

I_D vs V_{GS}

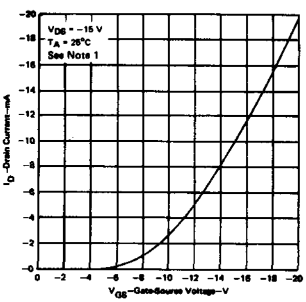


FIGURE 2

$|y_{fs}|$ vs I_D

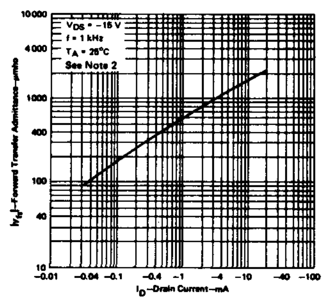


FIGURE 3

$r_{ds(on)}$ vs V_{GS}

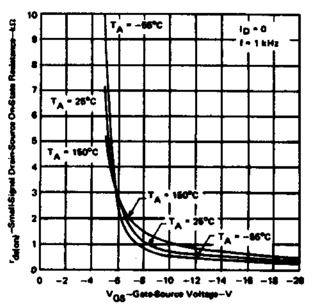


FIGURE 4

C_{iss} vs V_{GS}

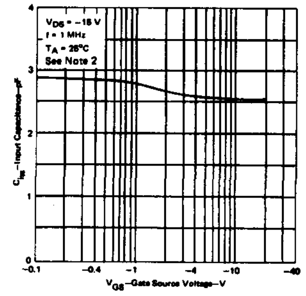


FIGURE 5

C_{rss} vs V_{DS}

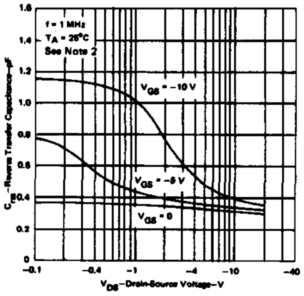


FIGURE 6

$t_{d(on)}$, t_r, $t_{d(off)}$, t_f vs $I_{D(on)}$

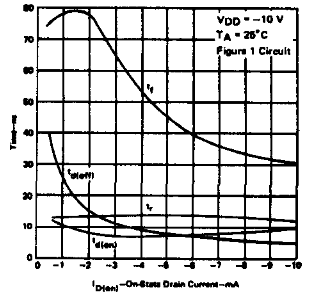


FIGURE 7

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
2. To avoid overheating the transistor, this parameter must be measured with bias conditions applied for less than five seconds.
3. Capacitance measurements were made using chips mounted in TO-72 packages.

TEXAS INSTRUMENTS
INCORPORATED
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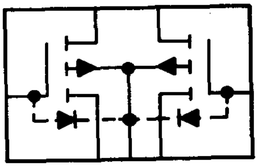
CHIP TYPE MP94
DUAL P-CHANNEL ENHANCEMENT-TYPE INSULATED-GATE FIELD-EFFECT TRANSISTORS

- MP94 is a 26 X 38-mil, epitaxial, planar, expanded-contact, MOS silicon chip containing two transistors available with or without gate-protection diodes
- Available in TO-76 packages
- For use in switching and chopper circuits



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS†		OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)GSSF}$■	Gate-Source Forward Breakdown Voltage	$I_G = -100\ \mu A$, $V_{DS} = 0$, See Note 1		−30♦	−40		V
I_{GSSF}■	Gate-Terminal Forward Current	$V_{GS} = -15\ V$, $V_{DS} = 0$			−0.3	−1	nA
I_{GSSF}●	Gate-Terminal Forward Current	$V_{GS} = -25\ V$, $V_{DS} = 0$			−1	−4	pA
I_{GSSR}●	Gate-Terminal Reverse Current	$V_{GS} = 25\ V$, $V_{DS} = 0$			1	4	pA
I_{DSS}	Zero-Gate-Voltage Drain Current	$V_{DS} = -20\ V$, $V_{GS} = 0$			−<1	−10	nA
I_{SDS}	Zero-Gate-Voltage Source Current	$V_{SD} = -20\ V$, $V_{GD} = 0$			−<1	−10	nA
$V_{GS(th)}$	Gate-Source Threshold Voltage	$V_{DS} = -15\ V$, $I_D = -10\ \mu A$		−2.5	−3.3	−6	V
$I_{D(on)}$	On-State Drain Current	$V_{DS} = -15\ V$, $V_{GS} = -15\ V$, See Note 2		−1.5	−15	−50	mA
$r_{ds(on)}$	Small-Signal Drain-Source On-State Resistance	$V_{GS} = -15\ V$, $I_D = 0$,	f = 1 kHz		290	400	Ω
C_{iss}	Common-Source Short-Circuit Input Capacitance	$V_{DS} = -20\ V$, $V_{GS} = 0$	f = 1 MHz, See Notes 3 and 4		3	4	pF
C_{rss}	Common-Source Short-Circuit Reverse Transfer Capacitance	$V_{DS} = 0\ V$, $V_{GS} = 0$			1.2	2.5	pF
		$V_{DS} = -20\ V$, $V_{GS} = 0$			0.4		
C_{ds}	Drain-Source Capacitance	$V_{DS} = -20\ V$, $V_{GS} = 0$			1	3	pF

†For all measurements except C_{ds}, the drain, source, and gate leads of the transistor not under test and the common substrate are grounded. For testing I_{SDS}, ground is the drain of the transistor under test, but for all other measurements, it is the source.

♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.

■These parameters apply only for chips having protective diodes.

●These parameters apply only for chips not having protective diodes.

NOTES:
1. To ensure that the protective diode is functioning properly, this voltage is measured while the device is conducting rated forward gate current.
2. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
3. Capacitance measurements were made using chips mounted in TO-76 packages.
4. C_{ds} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The case and all terminals of both transistors except the drain and source of the transistor under test are connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

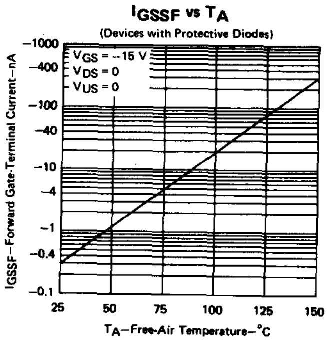


FIGURE 1

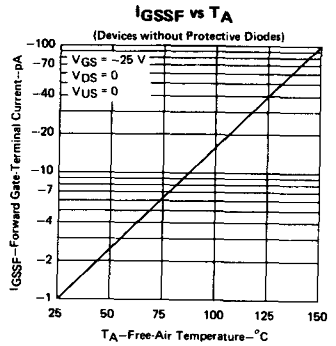


FIGURE 2

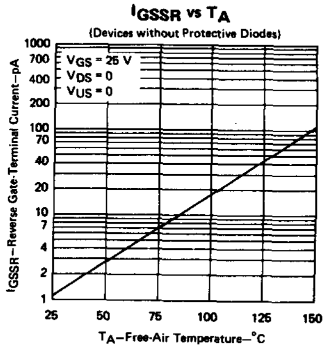


FIGURE 3

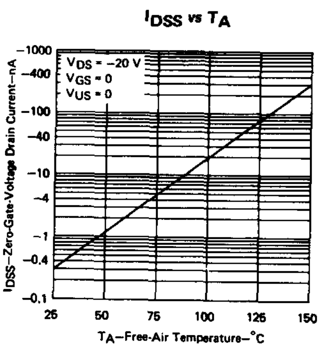


FIGURE 4

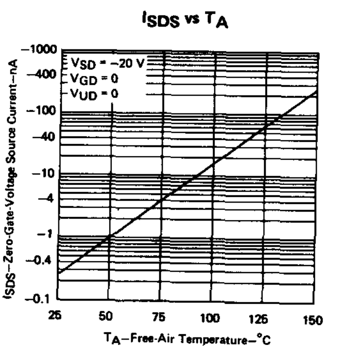


FIGURE 5

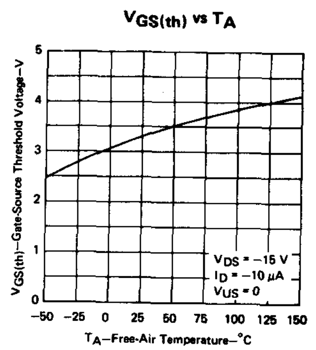


FIGURE 6

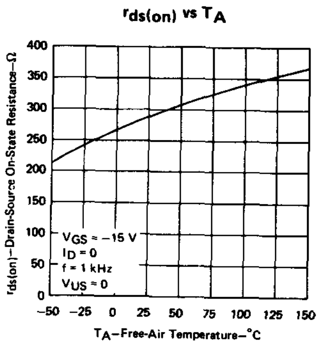


FIGURE 7

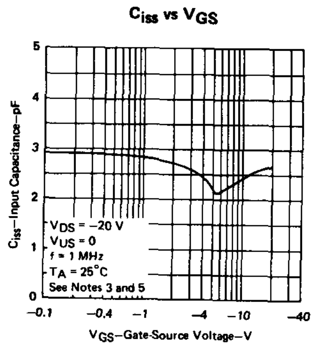


FIGURE 8

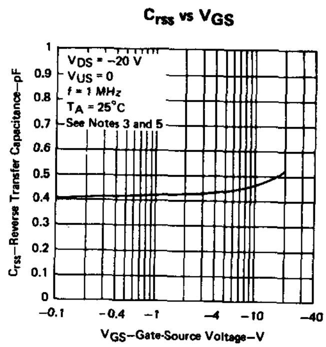


FIGURE 9

NOTES: 3. Capacitance measurements were made using chips mounted in TO-76 packages.
5. To avoid overheating the transistor, these parameters were measured with bias conditions applied for less than five seconds.

TEXAS INSTRUMENTS
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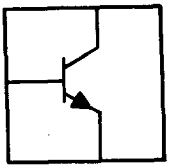
- N11 is a 16 X 16-mil, melt-grown (non-epitaxial), planar, direct-contact chip
- Available in TO-18, TO-71, and a short-can version of TO-78 packages
- For use in low-level, low-noise, high-gain amplifier circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	100◆	150		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$, See Note 1	55◆	75		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	7◆	10		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 45\ V$, $I_E = 0$		<1	10	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5\ V$, $I_C = 0$		<1	10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 1\ \mu A$	20	180		
		$V_{CE} = 5\ V$, $I_C = 10\ \mu A$	40	220	600	
		$V_{CE} = 5\ V$, $I_C = 100\ \mu A$	75	250		
		$V_{CE} = 5\ V$, $I_C = 1\ mA$	175	300		
		$V_{CE} = 5\ V$, $I_C = 10\ mA$, See Note 1	170	290	800	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5\ V$, $I_C = 100\ \mu A$		0.6	0.75	V
		$V_{CE} = 5\ V$, $I_C = 1\ mA$		0.65	0.95	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 100\ \mu A$, $I_C = 1\ mA$		0.1	0.35	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5\ V$, $I_C = 1\ mA$, $f = 1\ kHz$	1.5	9	24	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		80	320	900	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			2×10^{-4}	8×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance			12	40	µmho
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5\ V$, $I_C = 500\ \mu A$, $f = 30\ MHz$	1.5	3.3		
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5\ V$, $I_E = 0$, $f = 1\ MHz$, See Notes 2 and 3		3.5	6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$, $f = 1\ MHz$, See Notes 2 and 3		5	6	pF
C_{cb}	Collector-Base Capacitance	$V_{CB} = 5\ V$, $I_E = 0$, $f = 1\ MHz$, See Notes 2 and 3		2.5		pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 5\ V$, $I_C = 0$, $f = 1\ MHz$, See Notes 2 and 3		4.5		pF
$\overline{F}$	Average Noise Figure	$V_{CE} = 5\ V$, $I_C = 10\ \mu A$, $R_G = 10\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 4		0.5	4	dB
F	Spot Noise Figure	$V_{CE} = 5\ V$, $I_C = 10\ \mu A$, $R_G = 10\ k\Omega$, $f = 100\ Hz$		2	8	dB
		$V_{CE} = 5\ V$, $I_C = 10\ \mu A$, $R_G = 10\ k\Omega$, $f = 1\ kHz$		1	4	
		$V_{CE} = 5\ V$, $I_C = 10\ \mu A$, $R_G = 10\ k\Omega$, $f = 10\ kHz$		1	3	

Refer to notes on the following page.

CHIP TYPE N11
N-P-N SILICON TRANSISTORS

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

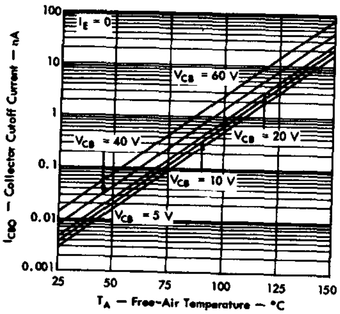


FIGURE 1

h_{FE} vs I_C

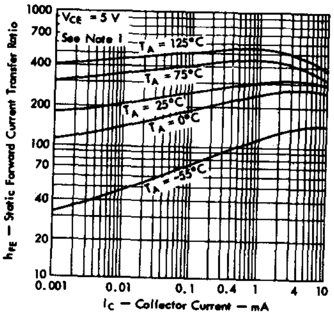


FIGURE 2

h_{FE} vs I_C

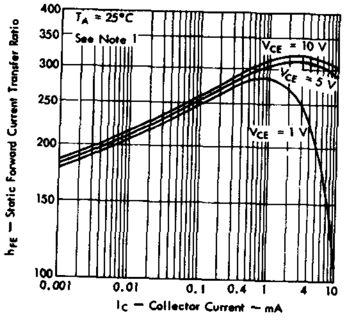


FIGURE 3

V_{BE} vs T_A

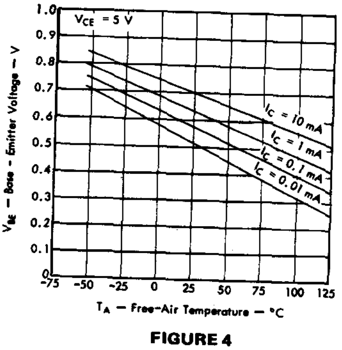


FIGURE 4

$V_{CE(sat)}$ vs T_A

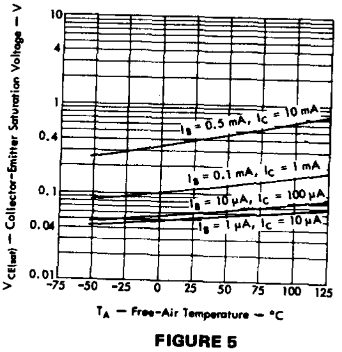


FIGURE 5

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES:
1. These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in TO-18 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.
4. Average Noise Figure was measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

TYPICAL CHARACTERISTICS

h_{ie} vs I_C

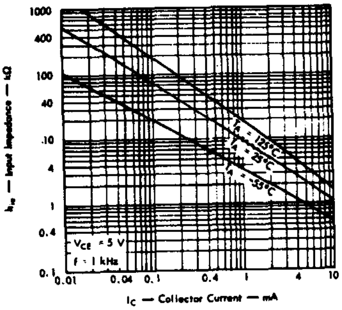


FIGURE 6

h_{fe} vs I_C

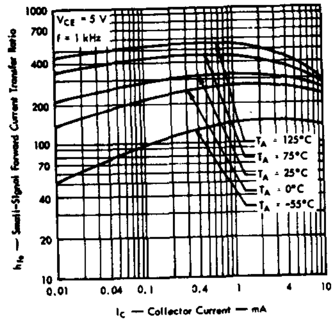


FIGURE 7

h_{re} vs I_C

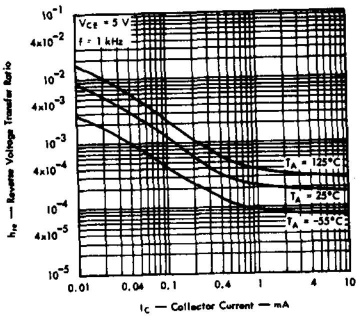


FIGURE 8

h_{oe} vs I_C

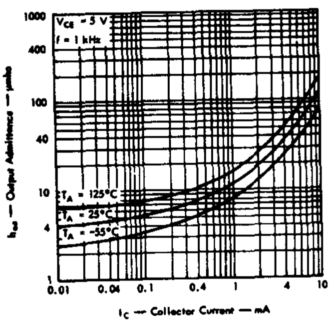


FIGURE 9

$|h_{fe}|$ vs I_C

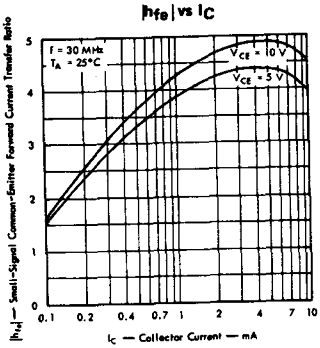


FIGURE 10

C_{obo}, C_{cb} vs V_{CB}

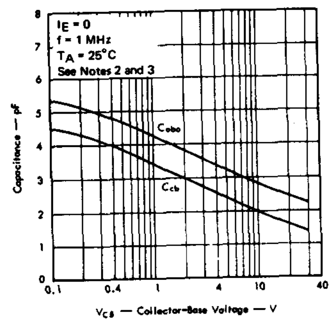


FIGURE 11

C_{ibo}, C_{eb} vs V_{EB}

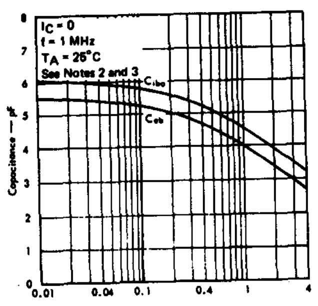


FIGURE 12

$\overline{F}$ vs R_G

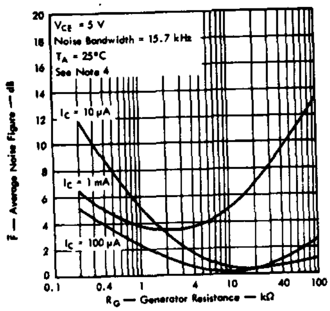


FIGURE 13

F vs f

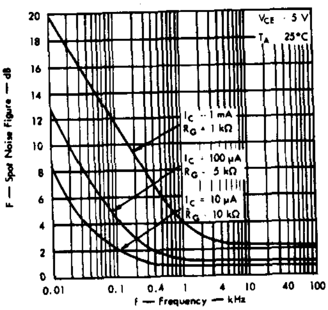
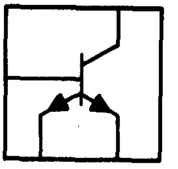


FIGURE 14

NOTES:
2. Capacitance measurements were made using chips mounted in TO-18 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.
4. Average Noise Figure was measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

CHIP TYPE N12
N-P-N SILICON TRANSISTORS

- N12 is a 21 X 21-mil, epitaxial, planar, direct-contact, double-emitter chip
- Available in TO-72 packages
- For use in low-level, high-speed chopper circuits requiring the very low offset voltage of double-emitter transistors



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_{E1} = I_{E2} = 0$	40♦	100		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$, See Note 1	18♦	24		V
$V_{(BR)E1E2}$	Emitter-Emitter Breakdown Voltage	$I_{E1} = \pm 1\ \mu A$, $V_{CB} = 0$, See Note 2	±12♦	±24		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ V, $I_{E1} = I_{E2} = 0$		<0.01	10	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$, See Note 1		<0.01	10	nA
$I_{E1E2(off)}$	Emitter Cutoff Current	$V_{E1E2} = \pm 15$ V, $V_{CB} = 0$, See Note 2		±<0.01	±10	nA
$\lvert V_{E1E2(ofs)} \rvert$	Emitter-Emitter Offset Voltage	$I_B = 1$ mA, $I_{E1} = I_{E2} = 0$		7	25	µV
$\lvert \Delta V_{E1E2(ofs)} \rvert \Delta I_B$	Offset Voltage Change with Base Current†	$I_{B(1)} = 1.5$ mA, $I_{B(2)} = 0.5$ mA, $I_{E1} = I_{E2} = 0$		5	75	µV
$\lvert \Delta V_{E1E2(ofs)} \rvert \Delta T_A$	Offset Voltage Change with Temperature†	$I_B = 1$ mA, $I_{E1} = I_{E2} = 0$, $T_{A(1)} = 100°C$, $T_{A(2)} = -25°C$		20	175	µV
V_{BC}	Base-Collector Voltage	$I_B = 1$ mA, $I_{E1} = I_{E2} = 0$		0.7		V
$r_{e1e2(on)}$	Small-Signal Emitter-Emitter On-State Resistance	$I_B = 1$ mA, $I_{E1} = I_{E2} = 0$, $I_e = 100\ \mu A$, f = 1 kHz		20	60	Ω
f_T	Transition Frequency	$V_{CE} = 5$ V, $I_C = 1$ mA, f = 20 MHz, See Note 1	30	60		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, $I_{E1} = I_{E2} = 0$, f = 1 MHz, See Note 3		4	10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 5$ V, $I_C = 0$, f = 1 MHz, See Notes 1 and 3		3	6	pF

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.
†Offset Voltage Change is defined as the magnitude of the algebraic difference between the offset voltages at two specified base currents or temperatures.

NOTES: 1. These values apply separately for each emitter with the other emitter open-circuited.
2. These parameters were measured with the collector short-circuited to the base but open-circuited with respect to the emitters. The values apply for both polarities of emitter-to-emitter voltage.
3. Capacitance measurements were made using chips mounted in TO-72 packages.

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TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

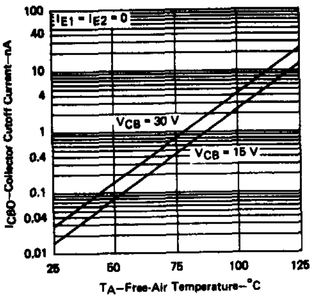


FIGURE 1

$I_{E1E2(off)}$ vs T_A

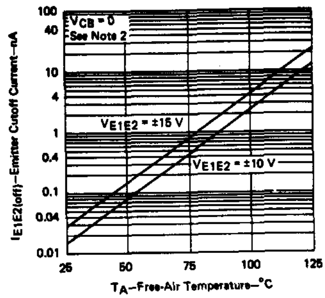


FIGURE 2

I_{E1} vs V_{E1E2}

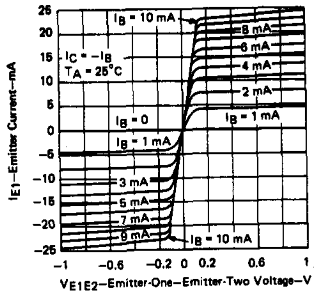


FIGURE 3

V_{BC} vs I_B

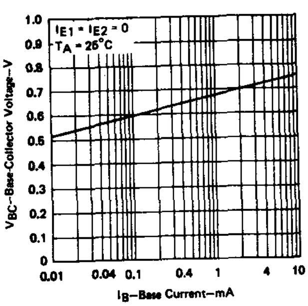


FIGURE 4

$V_{E1E2(ofs)}$ vs T_A

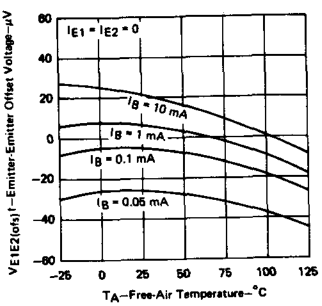


FIGURE 5

$V_{E1E2(ofs)}$ vs I_B

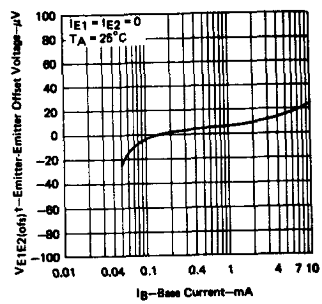


FIGURE 6

$r_{e1e2(on)}$ vs I_B

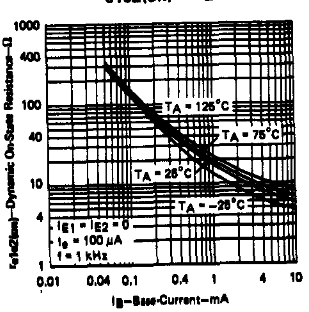


FIGURE 7

C_{obo} vs V_{CB}

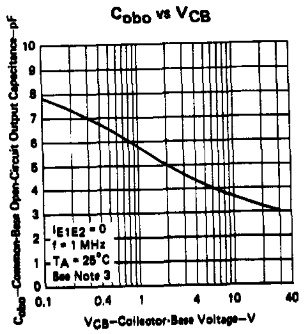


FIGURE 8

C_{ibo} vs V_{EB}

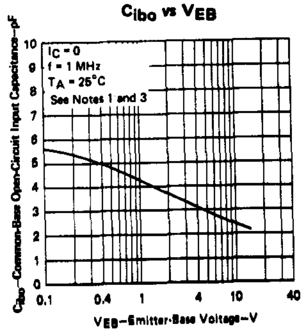


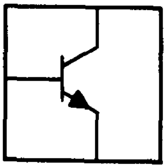
FIGURE 9

NOTES: 1. These values apply separately for each emitter with the other emitter open-circuited.
2. These parameters were measured with the collector short-circuited to the base but open-circuited with respect to the emitters. The values apply for both polarities of emitter-to-emitter voltage.
3. Capacitance measurements were made using chips mounted in TO-72 packages.

†The polarity of the offset voltage at $T_A = 25°C$ and $I_B = 1$ mA was arbitrarily assumed to be positive.

CHIP TYPE N13
N-P-N SILICON TRANSISTORS

- N13 is a 26 X 26-mil, epitaxial, planar, direct-contact chip
- Available in TO-18, TO-39, plastic dual-in-line quad, and *Silect*† packages
- For use as a high-speed, high-current, memory-core driver or in other medium-current (to 1.5 A) switching circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$		50♦	80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA,	$I_B = 0$,	See Note 1	30♦	50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$		6♦	7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40$ V,	$I_E = 0$			<0.2	1.7	µA
I_{CES}	Collector Cutoff Current	$V_{CE} = 50$ V,	$V_{BE} = 0$			<1	10	µA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V,	$I_C = 10$ mA	See Note 1	30	70		
		$V_{CE} = 1$ V,	$I_C = 100$ mA		35	85	150	
		$V_{CE} = 1$ V,	$I_C = 500$ mA		30	50		
		$V_{CE} = 5$ V,	$I_C = 1$ A		25	45		
		$V_{CE} = 5$ V,	$I_C = 1.5$ A		10	25		
V_{BE}	Base-Emitter Voltage	$I_B = 10$ mA,	$I_C = 100$ mA	See Note 1		0.75	0.9	V
		$I_B = 50$ mA,	$I_C = 500$ mA		0.8	0.90	1.1	
		$I_B = 100$ mA,	$I_C = 1$ A			1.05	1.5	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA,	$I_C = 10$ mA	See Note 1		0.20	0.3	V
		$I_B = 10$ mA,	$I_C = 100$ mA			0.18	0.3	
		$I_B = 50$ mA,	$I_C = 500$ mA			0.3	0.52	
		$I_B = 100$ mA,	$I_C = 1$ A			0.5	1.0	
f_T	Transition Frequency	$V_{CE} = 5$ V,	$I_C = 50$ mA,	f = 100 MHz	300	380		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, See Note 2	$I_E = 0$,	f = 1 MHz,		6	12	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, See Note 2	$I_C = 0$,	f = 1 MHz,		50	55	pF
t_d	Delay Time	$V_{CC} = 30$ V,	$I_C \approx 500$ mA,	2N3724 Data Sheet Circuit		6		ns
t_r	Rise Time	$I_{B(1)} \approx 50$ mA,	$V_{BE(off)} \approx -3.8$ V			13		
t_s	Storage Time	$V_{CC} = 30$ V,	$I_C \approx 500$ mA,			23		
t_f	Fall Time	$I_{B(1)} \approx 50$ mA,	$I_{B(2)} \approx -50$ mA			11		
t_d	Delay Time	$V_{CC} = 30$ V, $I_{B(2)} \approx -50$ mA,	$I_C \approx 500$ mA, $V_{BE(off)} \approx -4.1$ V,	$I_{B(1)} \approx 50$ mA, See Figure 1		6		ns
t_r	Rise Time					13		
t_s	Storage Time					23		
t_f	Fall Time					11		

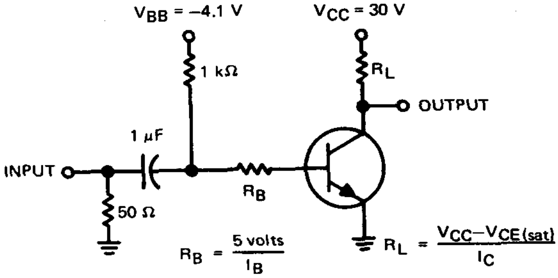
†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

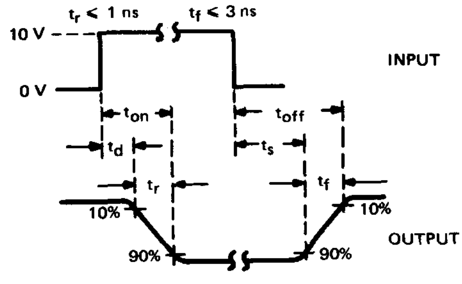
NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-39 packages.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_w \leq 200$ ns, duty cycle ≤ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

FIGURE 1–SWITCHING TIMES

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

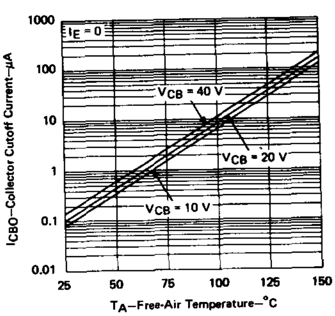


FIGURE 2

h_{FE} vs I_C

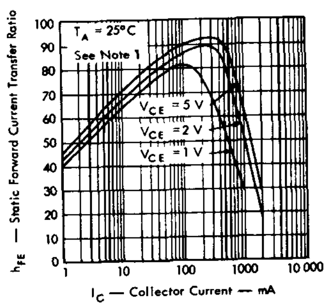


FIGURE 3

h_{FE} vs I_C

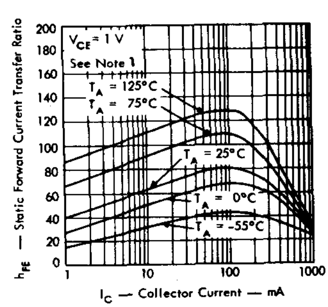


FIGURE 4

h_{FE} vs I_C

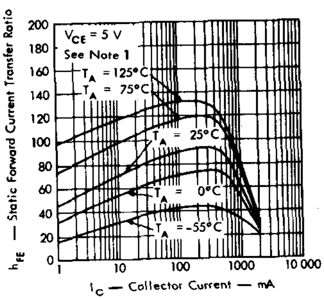


FIGURE 5

V_{BE} vs I_C

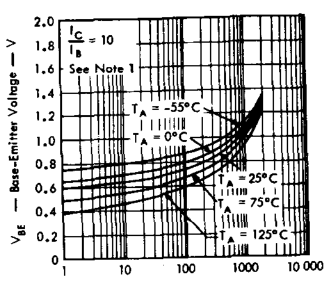


FIGURE 6

$V_{CE(sat)}$ vs I_C

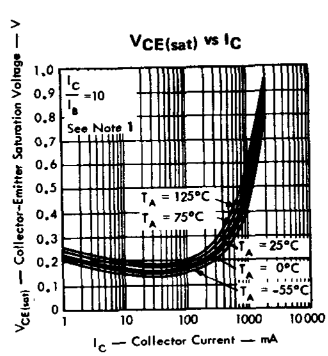


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

f_T vs I_C

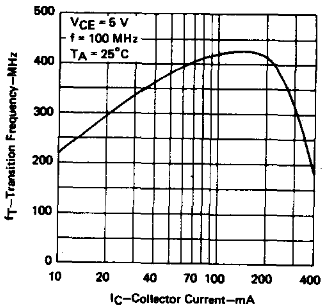


FIGURE 8

C_{obo} vs V_{CB}

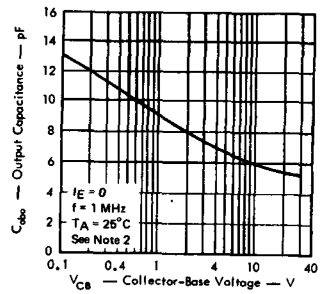


FIGURE 9

C_{ibo} vs V_{EB}

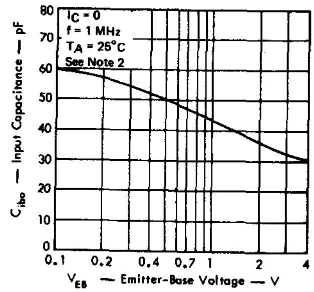


FIGURE 10

t_d, t_r, t_s, t_f vs I_C

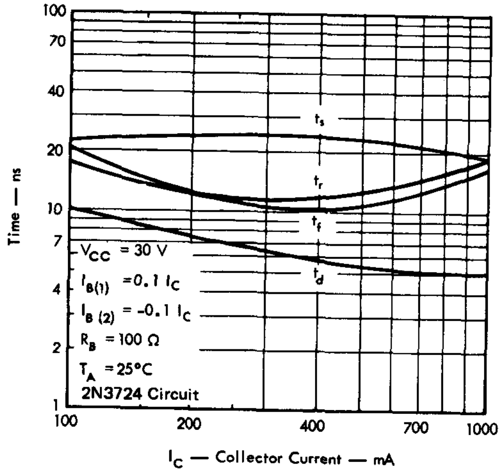


FIGURE 11

t_d, t_r, t_s, t_f vs T_A

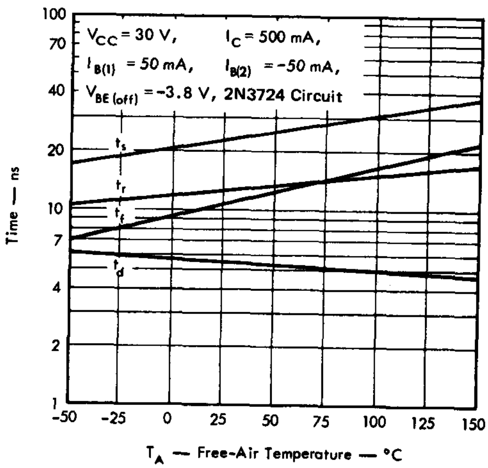


FIGURE 12

NOTE 2: Capacitance measurements were made using chips mounted in TO-39 packages.

TYPICAL CHARACTERISTICS

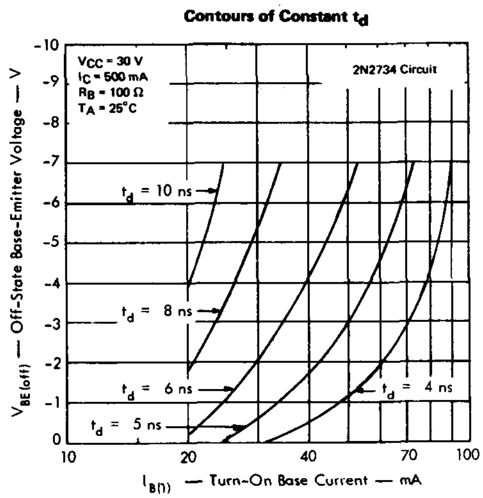


FIGURE 13

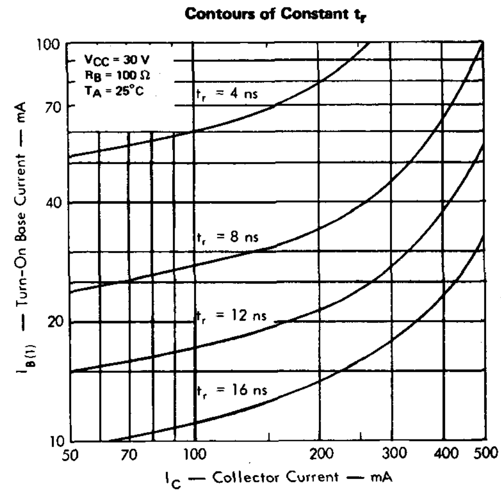


FIGURE 14

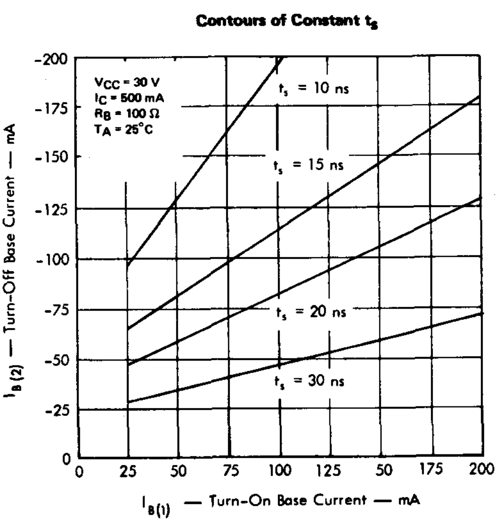


FIGURE 15

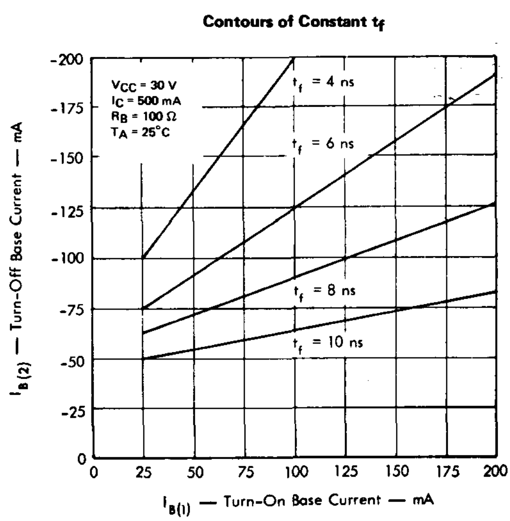
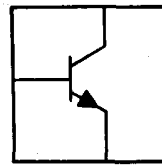


FIGURE 16

CHIP TYPE N14
N-P-N SILICON TRANSISTORS

- N14 is a 20 X 20-mil, epitaxial, planar, direct-contact chip
- Available in *Silect*† Packages
- For use in general purpose, saturated switching, and amplifier circuits



electrical and operating characteristics at 25°C free-air temperature

	PARAMETER	CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$		50♦	100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA,	$I_B = 0$,	See Note 1	30♦	50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$		5♦	7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ V,	$I_E = 0$			4	50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 1$ V,	$I_C = 100\ \mu A$		20	60		
		$V_{CE} = 1$ V,	$I_C = 1$ mA		35	110		
		$V_{CE} = 1$ V,	$I_C = 10$ mA	See Note 1	50	150	300	
		$V_{CE} = 1$ V,	$I_C = 50$ mA		30	110		
		$V_{CE} = 1$ V,	$I_C = 100$ mA		15	60		
V_{BE}	Base-Emitter Voltage	$I_B = 1$ mA,	$I_C = 10$ mA	See Note 1	0.6	0.75	0.9	V
		$I_B = 5$ mA,	$I_C = 50$ mA			0.85	0.95	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA,	$I_C = 10$ mA	See Note 1		0.10	0.25	V
		$I_B = 5$ mA,	$I_C = 50$ mA			0.15	0.4	
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ V,	$I_C = 1$ mA,	f = 1 kHz	1	3.7	10	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio				50	140	400	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio				0.1×10^{-4}	0.7×10^{-4}	8×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance				1	8	40	μmho
f_T	Transition Frequency	$V_{CE} = 20$ V,	$I_C = 10$ mA,	f = 100 MHz	250	800		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 5$ V, See Note 2	$I_E = 0$,	f = 1 MHz,		1.6	4	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, See Note 2	$I_C = 0$,	f = 1 MHz,		6.5	8	pF
$\overline{F}$	Average Noise Figure	$V_{CE} = 5$ V, Noise Bandwidth = 15.7 kHz,	$I_C = 100\ \mu A$,	$R_G = 1$ kΩ, See Note 3			6	dB
t_d	Delay Time	$V_{CC} = 3$ V,	$I_C \approx 10$ mA,	2N3903 Data Sheet Circuit		14		ns
t_r	Rise Time	$I_{B(1)} \approx 1$ mA,	$V_{BE(off)} \approx -0.5$ V			8		
t_s	Storage Time	$V_{CC} = 3$ V,	$I_C \approx 10$ mA,			22		
t_f	Fall Time	$I_{B(1)} \approx 1$ mA,	$I_{B(2)} \approx -1$ mA			10		
t_d	Delay Time	$V_{CC} = 30$ V, $I_{B(2)} \approx -1$ mA,	$I_C \approx 10$ mA, $V_{BE(off)} \approx -4.1$ V,	$I_{B(1)} \approx 1$ mA, See Figure 1		40		ns
t_r	Rise Time					8		
t_s	Storage Time					22		
t_f	Fall Time					10		

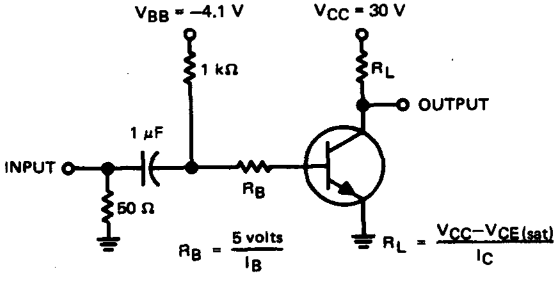
†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

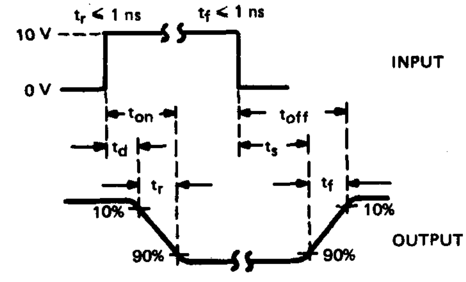
NOTES:
1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in *Silect* packages.
3. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

5

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)

VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$; for measuring t_d and t_r, $t_w \approx 200$ ns, duty cycle $\leq 2\%$; for measuring t_s and t_f, $t_w \approx 10\ \mu s$, duty cycle $\leq 2\%$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

$V_{(BR)CER}$ vs R_{BE}

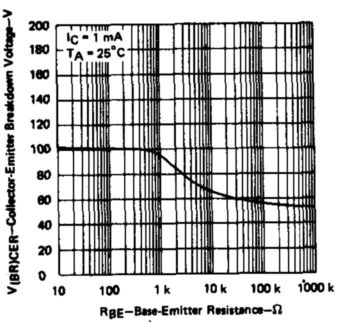


FIGURE 2

h_{FE} vs I_C

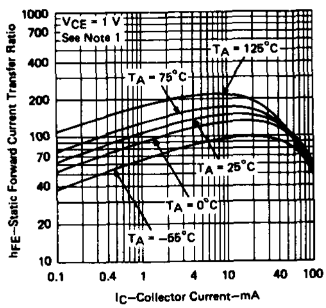


FIGURE 3

h_{FE} vs I_C

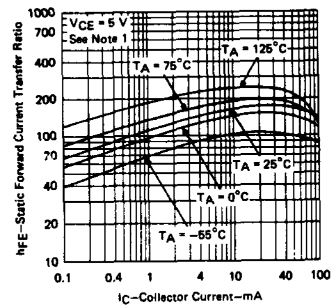


FIGURE 4

I_{CBO} vs T_A

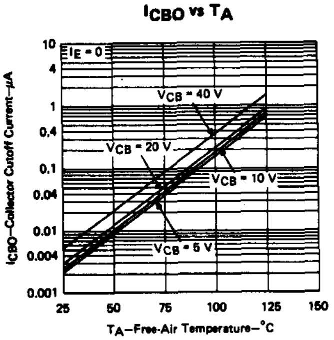


FIGURE 5

V_{BE} vs I_C

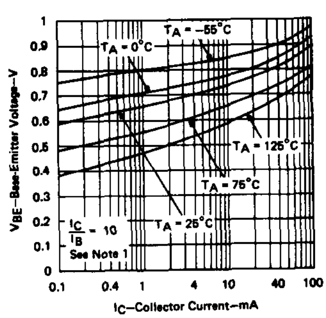


FIGURE 6

$V_{CE(sat)}$ vs I_C

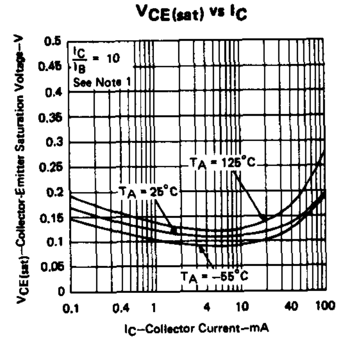


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

TYPICAL CHARACTERISTICS

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

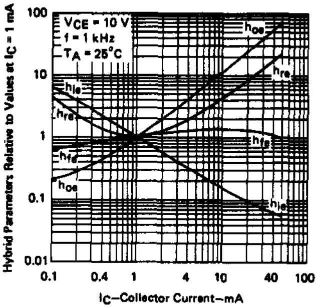


FIGURE 8

f_T vs I_C

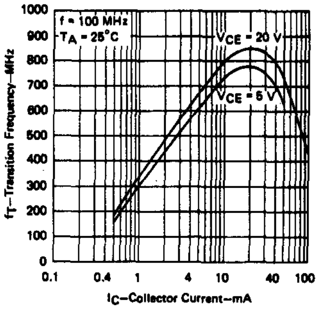


FIGURE 9

C_{cb}, C_{obo} vs V_{CE}

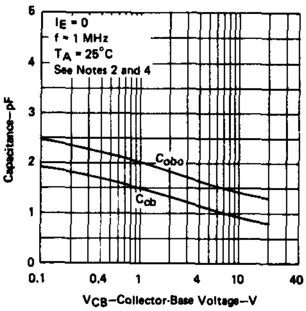


FIGURE 10

C_{ibo} vs V_{EB}

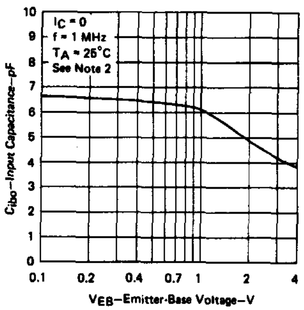


FIGURE 11

t_d vs I_C

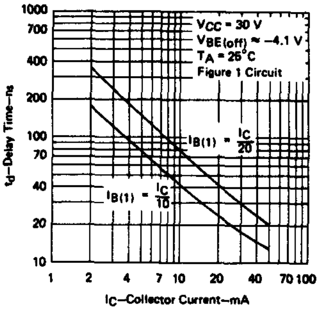


FIGURE 12

t_r vs I_C

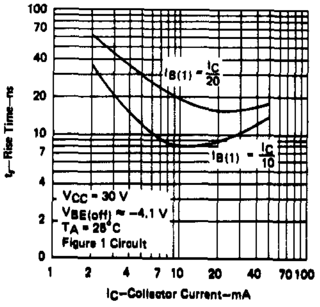


FIGURE 13

t_s vs I_C

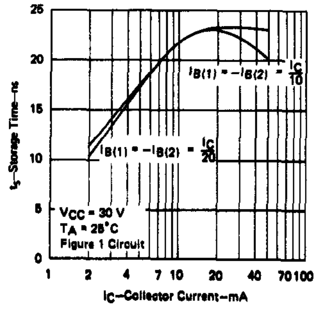


FIGURE 14

t_f vs I_C

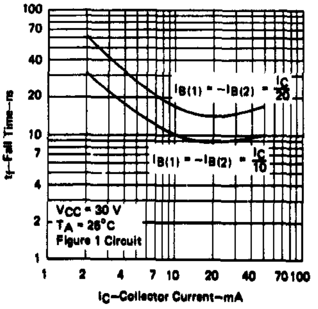


FIGURE 15

NOTES: 1. These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in *Silect* packages.
4. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge. C_{obo} measurement is made with the third terminal floating.

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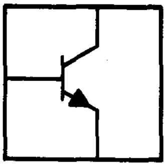
- **N15 is a 35 X 35-mil, epitaxial, planar, direct-contact chip**
- **Available in TO-39 and *Silect*† packages**
- **For use in high-voltage amplifier circuits, especially in certain critical TV applications**



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES			UNIT
			LOW	TYP	HIGH	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 μA, I_E = 0	250♦	350		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 30 mA, I_B = 0, See Note 1	250♦	350		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 100 μA, I_C = 0	7♦	10		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 100 V, I_E = 0		<1	50	nA
I_{EBO}	Emitter Cutoff Current	V_{EB} = 5 V, I_C = 0		<0.1	10	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 25 V, I_C = 5 mA, See Note 1	10	70		
		V_{CE} = 25 V, I_C = 30 mA, See Note 1	35	75	200	
		V_{CE} = 25 V, I_C = 100 mA, See Note 1	20	75		
V_{BE}	Base-Emitter Voltage	V_{CE} = 25 V, I_C = 30 mA, See Note 1		0.7	0.85	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 3 mA, I_C = 30 mA, See Note 1		0.12	1	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	V_{CE} = 25 V, I_C = 30 mA, f = 1 kHz		150		Ω
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	V_{CE} = 25 V, I_C = 30 mA, f = 1 kHz		75		
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	V_{CE} = 25 V, I_C = 30 mA, f = 1 kHz		2×10^{-4}		
h_{oe}	Small-Signal Common-Emitter Output Admittance	V_{CE} = 25 V, I_C = 30 mA, f = 1 kHz		30		μmho
f_T	Transition Frequency	V_{CE} = 25 V, I_C = 10 mA, f = 20 MHz	30	80		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz, See Notes 2 and 3		6		pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	V_{EB} = 0.5 V, I_C = 0, f = 1 MHz, See Notes 2 and 3		50		pF
C_{cb}	Collector-Base Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz, See Notes 2 and 3		5	10	pF
C_{eb}	Emitter-Base Capacitance	V_{EB} = 0.5 V, I_C = 0, f = 1 MHz, See Notes 2 and 3		50	75	pF

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-39 packages.

3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.

5

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

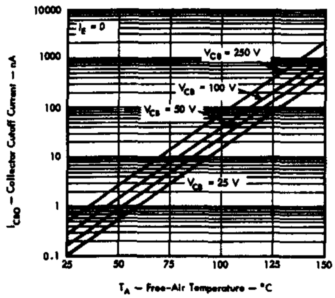


FIGURE 1

h_{FE} vs I_C

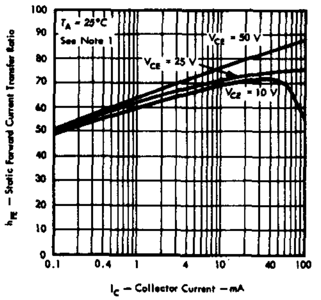


FIGURE 2

h_{FE} vs I_C

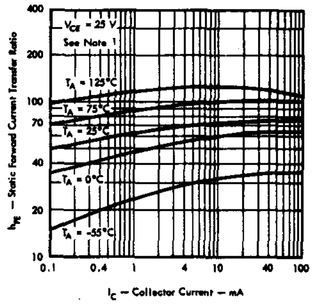


FIGURE 3

V_{BE} vs I_C

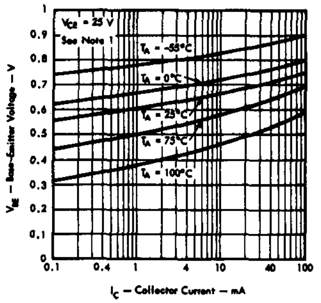


FIGURE 4

$V_{CE(sat)}$ vs I_C

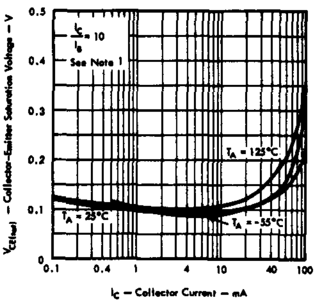


FIGURE 5

NOTE 1: This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

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TYPICAL CHARACTERISTICS

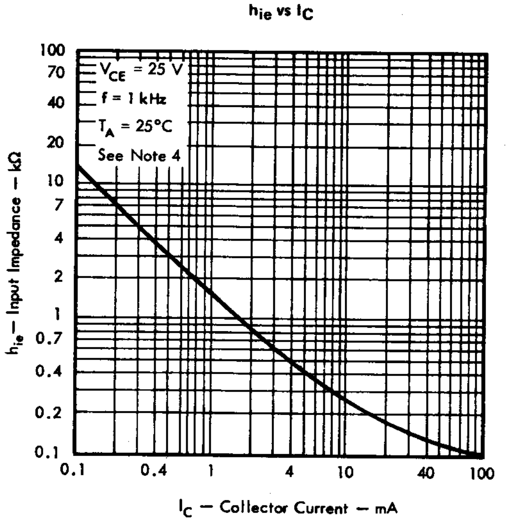


FIGURE 6

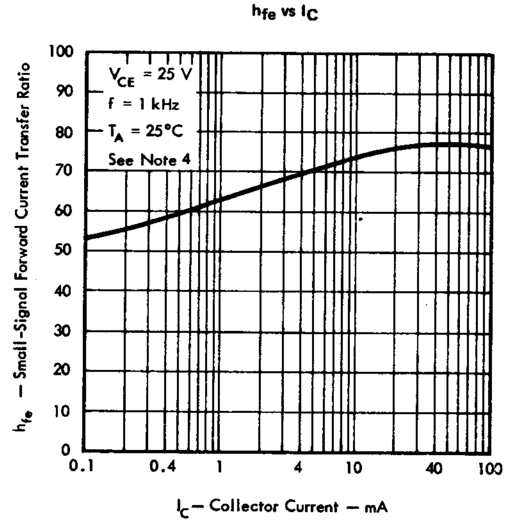


FIGURE 7

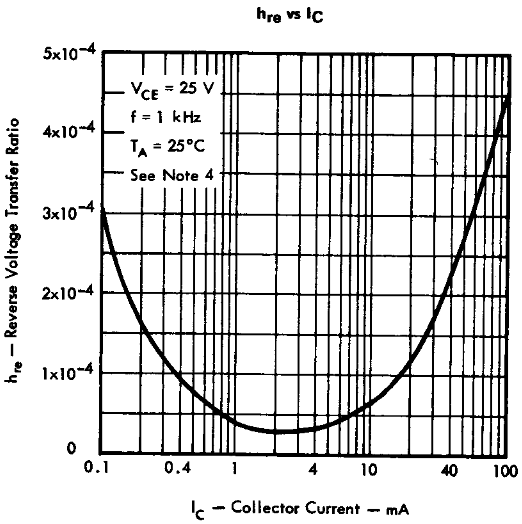


FIGURE 8

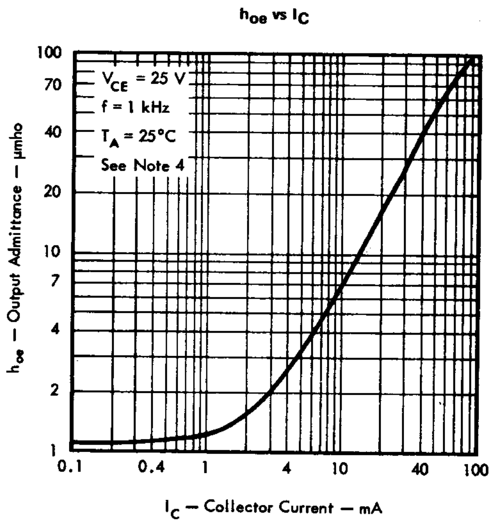


FIGURE 9

NOTE 4: To avoid overheating the transistor, this parameter was measured with bias conditions applied for less than five seconds.

TYPICAL CHARACTERISTICS

f_T vs I_C

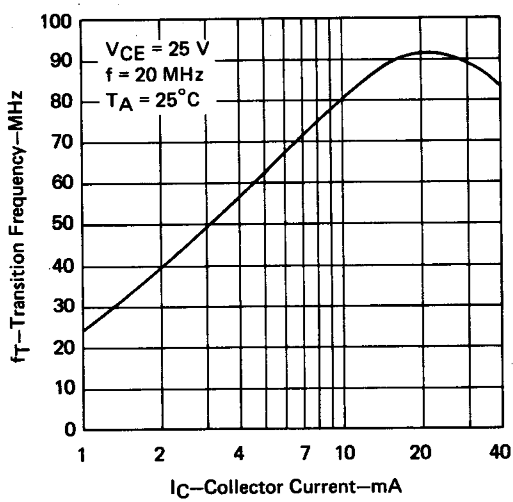


FIGURE 10

C_{cb}, C_{obo} vs V_{CB}

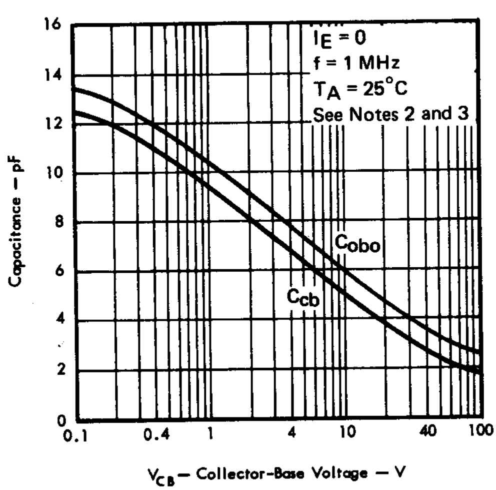


FIGURE 11

C_{eb}, C_{ibo} vs V_{EB}

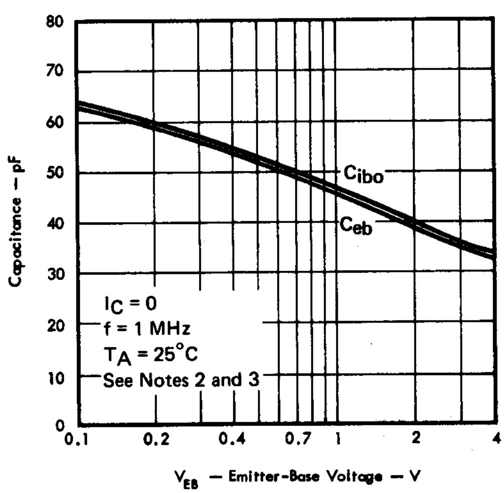
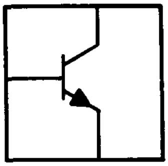


FIGURE 12

NOTES: 2. Capacitance measurements were made using chips mounted in TO-39 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.

CHIP TYPE N16
N-P-N SILICON TRANSISTORS

- **N16 is an 11 X 15-mil, epitaxial, planar, expanded-contact chip**
- **Available in TO-72 and *Silect*† packages**
- **For use in high-frequency (nearly to 1 GHz), low-noise amplifier circuits such as TV mixers and IF-amplifier stages**



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	30♦	60		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 2$ mA, $I_B = 0$, See Note 1	18♦	50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	4♦	5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 15$ V, $I_E = 0$		<0.1	100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 2$ mA	30	70	150	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 2$ mA		0.75		V
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 2$ mA, f = 100 MHz	5	9		
$\lvert y_{ie} \rvert$	Small-Signal Common-Emitter Input Admittance	$V_{CE} = 12$ V, $I_C = 2$ mA, f = 45 MHz		3		mmho
$\lvert y_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 12$ V, $I_C = 2$ mA, f = 45 MHz		70		mmho
$\lvert y_{oe} \rvert$	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 12$ V, $I_C = 2$ mA, f = 45 MHz		0.3		mmho
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		0.45	0.65	pF
r_{iep}	Parallel-Equivalent Common-Emitter Short-Circuit Input Resistance	$V_{CE} = 10$ V, $I_C = 2$ mA, f = 10 MHz		0.9		kΩ
r_{oep}	Parallel-Equivalent Common-Emitter Short-Circuit Output Resistance	$V_{CE} = 10$ V, $I_C = 2$ mA, f = 10 MHz		60		kΩ
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 10$ V, $I_E = -2$ mA, f = 79.8 MHz, See Note 2		14	20	ps
F	Spot Noise Figure	$V_{CE} = 10$ V, $I_C = 2$ mA, $R_G = 50\ \Omega$, f = 200 MHz		3	5	dB

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance and $r_b'C_c$ measurements were made using chips mounted in *Silect* packages.

3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

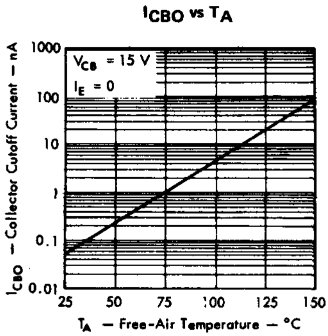


FIGURE 1

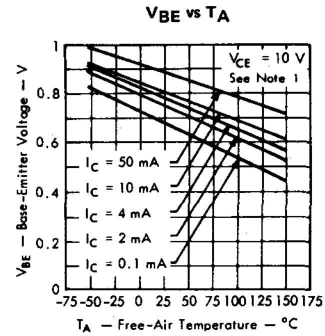


FIGURE 2

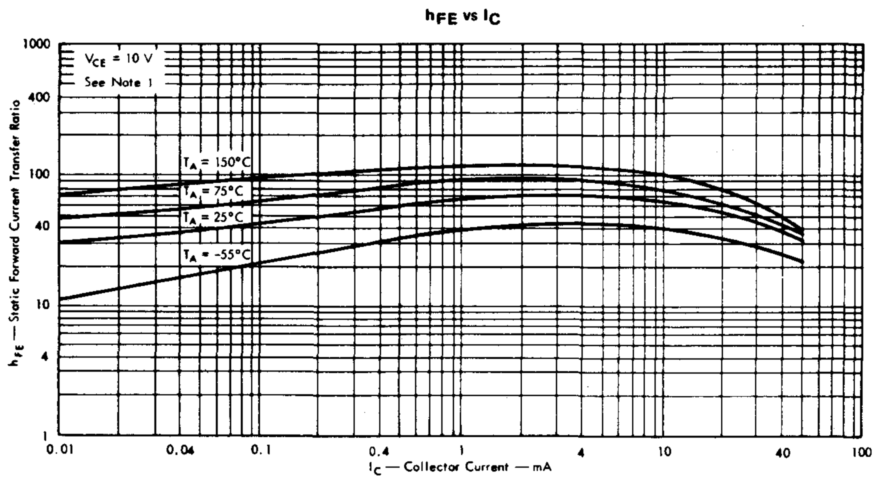


FIGURE 3

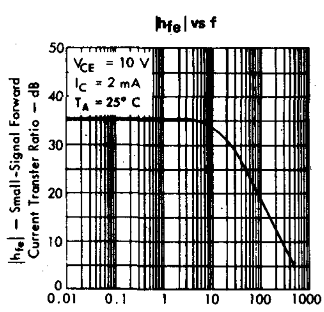


FIGURE 4

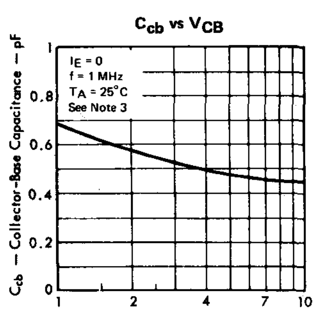


FIGURE 5

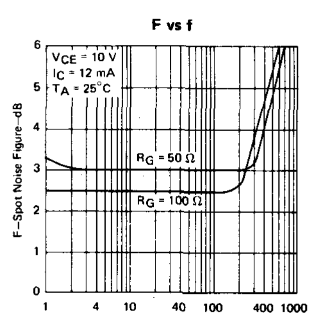


FIGURE 6

NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. Capacitance and $r_b'C_c$ measurements were made using chips mounted in *Silect* packages.
3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS AT 455 kHz, $T_A = 25°C$

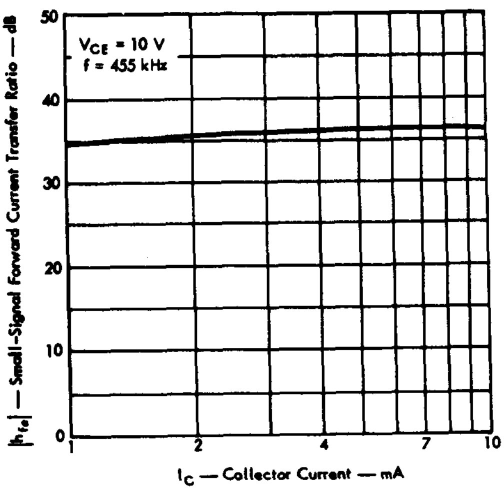


FIGURE 7

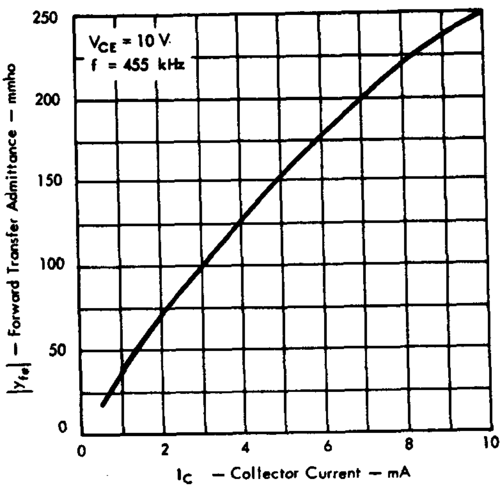


FIGURE 8

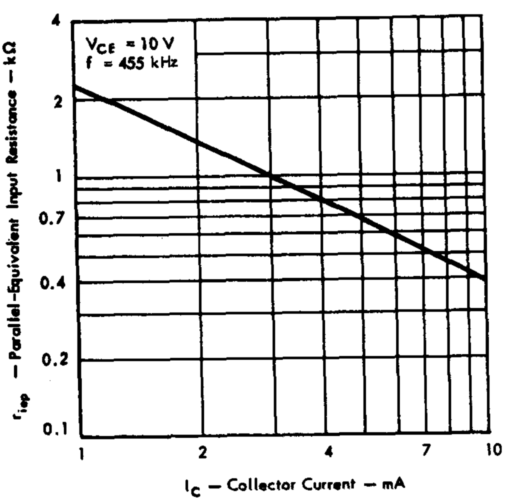


FIGURE 9

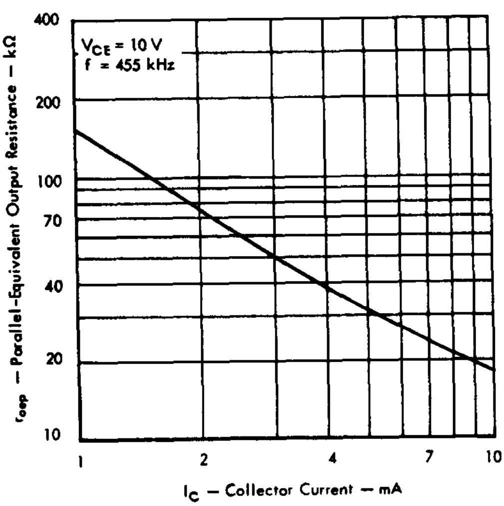


FIGURE 10

TYPICAL CHARACTERISTICS AT 10 MHz, $T_A = 25°C$

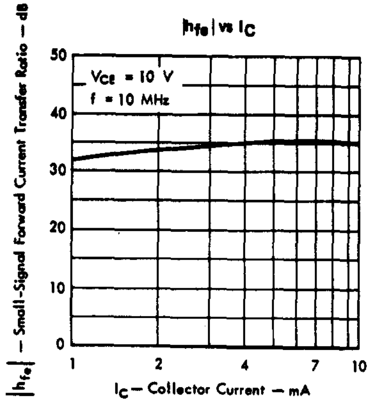


FIGURE 11

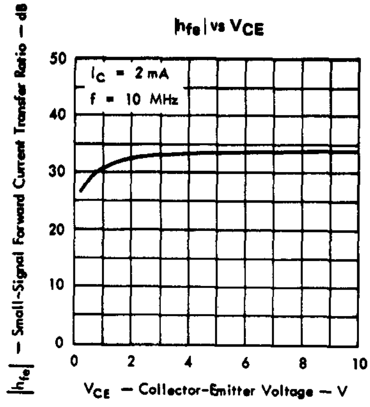


FIGURE 12

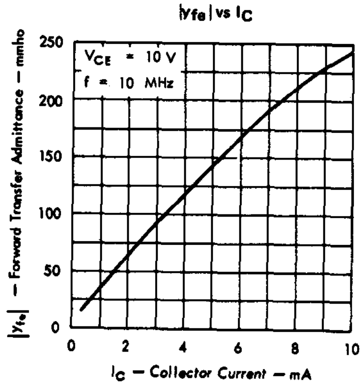


FIGURE 13

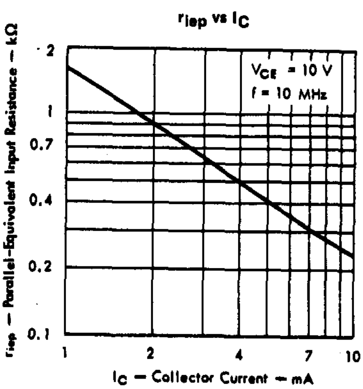


FIGURE 14

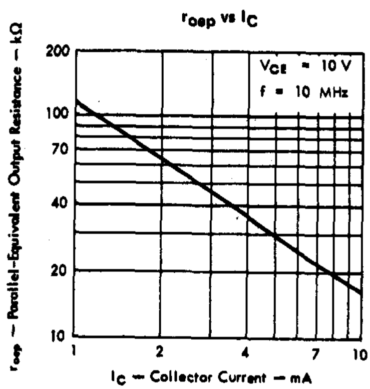


FIGURE 15

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TYPICAL CHARACTERISTICS AT 45 MHz, $T_A = 25°C$

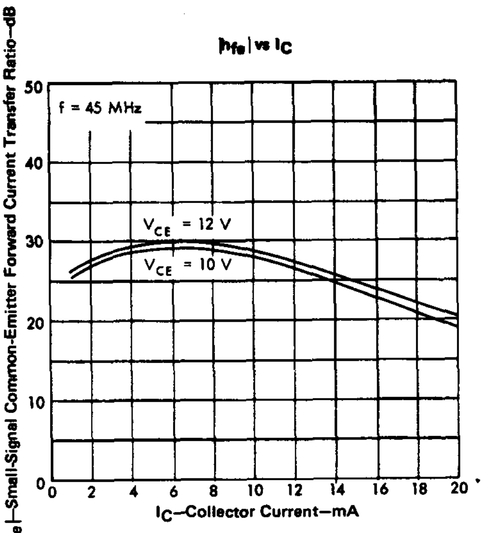


FIGURE 16

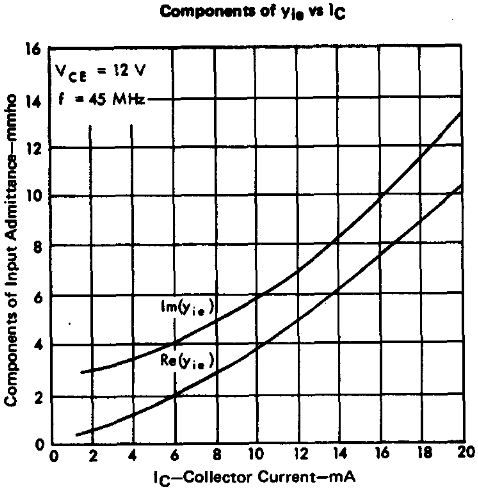


FIGURE 17

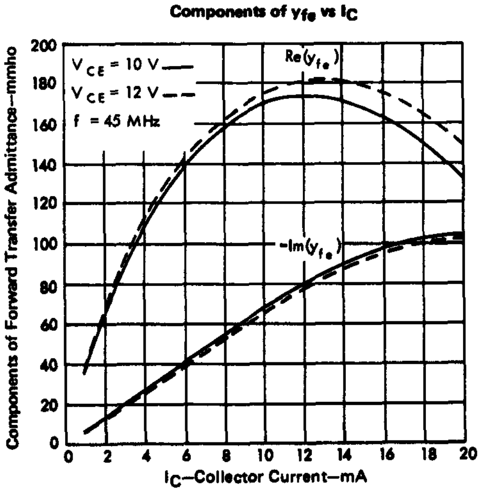


FIGURE 18

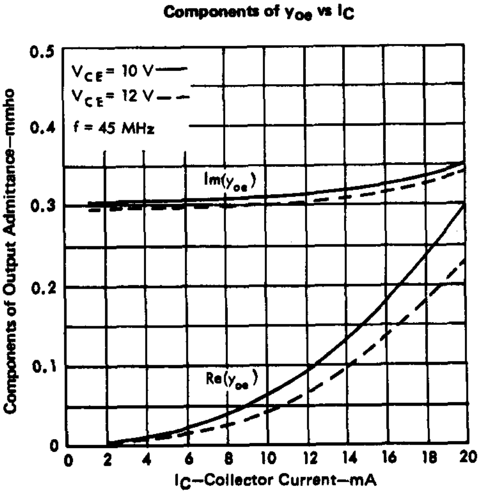


FIGURE 19

TYPICAL CHARACTERISTICS AT 100 MHz, $T_A = 25°C$

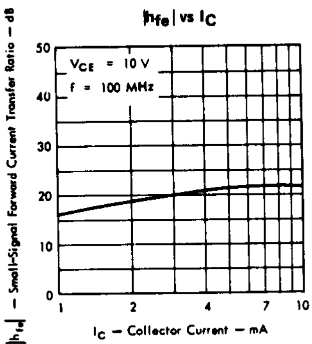


FIGURE 20

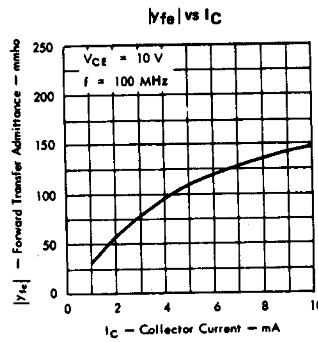


FIGURE 21

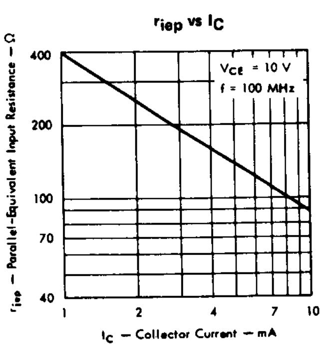


FIGURE 22

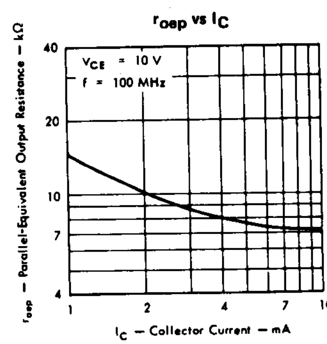


FIGURE 23

TYPICAL CHARACTERISTICS AT 200 MHz, $T_A = 25°C$

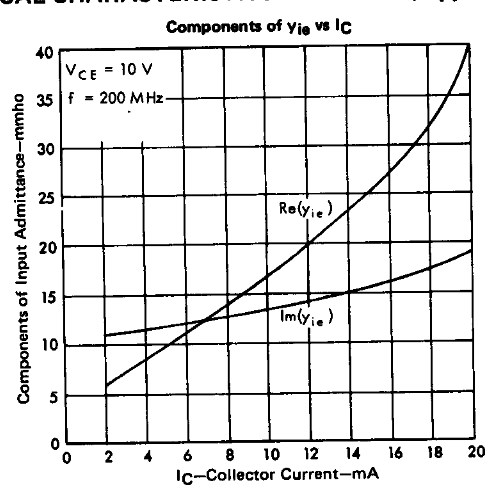
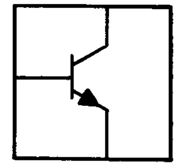


FIGURE 24

CHIP TYPE N17
N-P-N SILICON TRANSISTORS

- N17 is a 16 X 16-mil, epitaxial, planar, expanded-contact chip
- Available in *Silect*† packages with base-emitter-collector lead configuration
- For VHF/UHF RF/IF amplifiers requiring low feedback capacitance and forward-AGC characteristics



electrical and operating characteristics at 25°C free-air temperature

	PARAMETER	CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	40♦	80		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 1	30♦	80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	4♦	5.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ V, $I_E = 0$		<0.1	50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA, See Note 1	25	100		
		$V_{CE} = 10$ V, $I_C = 8$ mA, See Note 1		70		
		$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 1		50		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 4$ mA, See Note 1		0.75	0.84	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.4$ mA, $I_C = 4$ mA		1.0		V
f_T	Transition Frequency	$V_{CE} = 10$ V, $I_C = 4$ mA, f = 100 MHz	350	600		MHz
$\lvert y_{ie} \rvert$	Small-Signal Common-Emitter Input Admittance	$V_{CE} = 10$ V, $I_C = 4$ mA, f = 45 MHz		6		mmho
		$V_{CE} = 10$ V, $I_C = 4$ mA, f = 200 MHz		20		mmho
$\lvert y_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Admittance	$V_{CE} = 10$ V, $I_C = 4$ mA, f = 45 MHz	80	105		mmho
		$V_{CE} = 10$ V, $I_C = 4$ mA, f = 200 MHz	60	80		mmho
ϕy_{fe}	Phase Angle of Small-Signal Common-Emitter Forward Current Transfer Admittance	$V_{CE} = 10$ V, $I_C = 4$ mA, f = 45 MHz	−10°	−18°	−25°	
		$V_{CE} = 10$ V, $I_C = 4$ mA, f = 200 MHz	−50°	−60°	−80°	
$\lvert y_{oe} \rvert$	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10$ V, $I_C = 4$ mA, f = 45 MHz		0.32		mmho
		$V_{CE} = 10$ V, $I_C = 4$ mA, f = 200 MHz		1.4		mmho
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		0.2	0.4	pF
C_{res}	Common-Emitter Short-Circuit Reverse Transfer Capacitance	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 MHz, See Note 2		0.2	0.4	pF
F	Spot Noise Figure	$V_{CE} = 10$ V, $I_C = 3$ mA, $R_G = 50\ \Omega$, f = 200 MHz		3	4	dB

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
2. Capacitance measurements were made using chips mounted in *Silect* packages.
3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

5

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

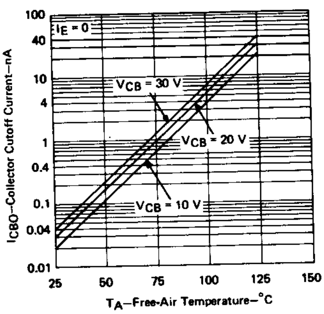


FIGURE 1

h_{FE} vs I_C

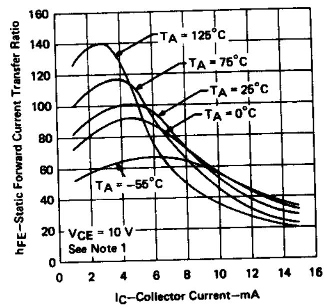


FIGURE 2

V_{BE} vs I_C

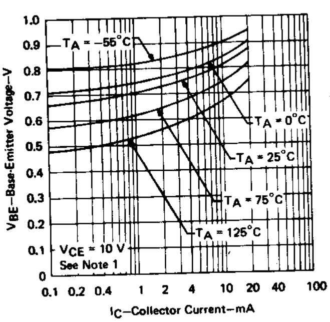


FIGURE 3

$V_{CE(sat)}$ vs I_C

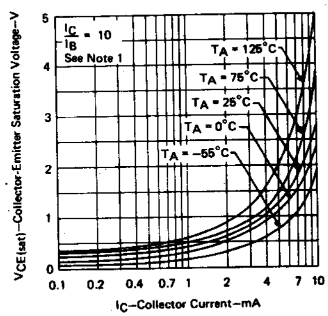


FIGURE 4

f_T vs I_C

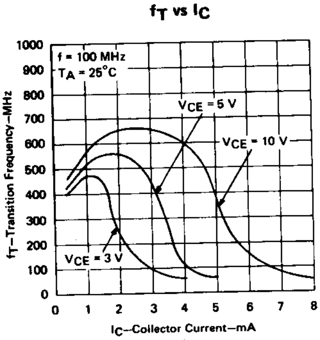


FIGURE 5

C_{cb} vs V_{CB}

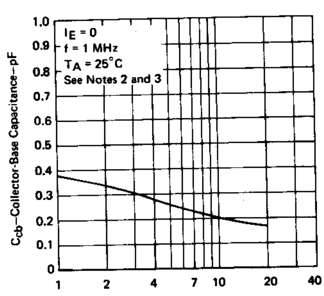


FIGURE 6

C_{res} vs I_C

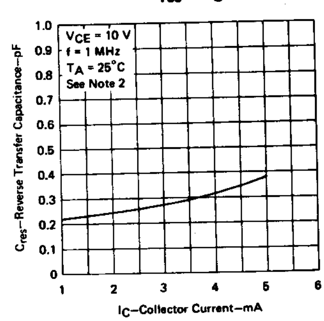


FIGURE 7

NOTES:
1. These parameters were measured using pulse techniques. $t_w = 300$ µs, duty cycle $\leq 2\%$.
2. Capacitance measurements were made using chips mounted in *Silect* packages.
3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

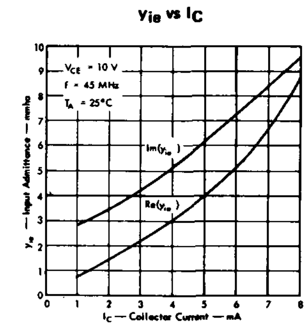


FIGURE 8

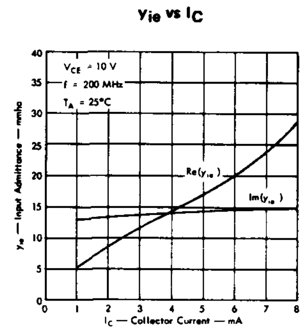


FIGURE 9

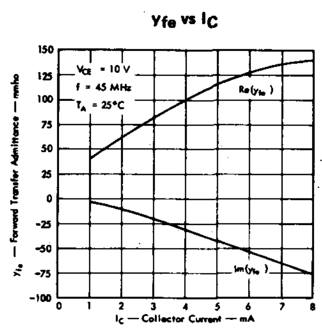


FIGURE 10

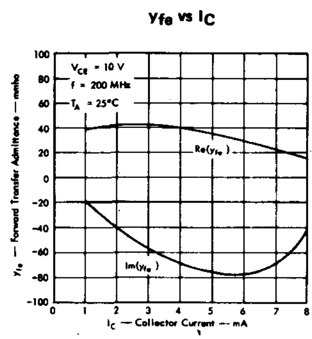


FIGURE 11

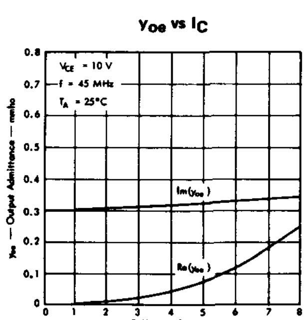


FIGURE 12

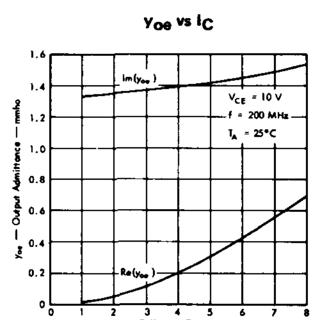
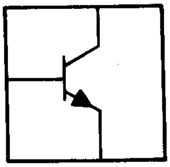


FIGURE 13

CHIP TYPE N18
N-P-N SILICON TRANSISTORS



- N18 is a 19 X 19-mil, epitaxial, planar, direct-contact chip
- Available in TO-18 and TO-46 packages
- For use in low-level chopper circuits in inverted connection (collector and emitter terminals reversed). May also be used as a low-level amplifier

electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	120♦	180		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 1	60♦	75		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	18♦	22		V
I_{CES}	Collector Cutoff Current	$V_{CE} = 25$ V, $V_{BE} = 0$		<0.1	10	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 15$ V, $I_C = 0$		<0.1	2	nA
I_{ECS}	Emitter Cutoff Current	$V_{EC} = 15$ V, $V_{BC} = 0$		<0.1	2	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 10\ \mu A$	30	140		
		$V_{CE} = 5$ V, $I_C = 1$ mA	50	210	500	
$h_{FE(inv)}$	Static Forward Current Transfer Ratio (Inverted Connection)	$V_{EC} = 5$ V, $I_E = 0.2$ mA	2	4		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 1$ mA		0.6	0.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ mA, $I_C = 10$ mA		0.08	0.15	V
$V_{EC(ofs)}$	Emitter-Collector Offset Voltage (Inverted Connection)	$I_B = 200\ \mu A$, $I_E = 0$		0.2	0.6	mV
		$I_B = 1$ mA, $I_E = 0$		0.5	1.2	
$r_{ec(on)}$	Small-Signal Emitter-Collector On-State Resistance	$I_B = 1$ mA, $I_E = 0$, f = 1 kHz, $I_e = 100\ \mu A$		8	20	Ω
f_T	Transition Frequency	$V_{CE} = 5$ V, $I_C = 1$ mA, f = 20 MHz	20	60		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 0$, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		6	12	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0$, $I_C = 0$, f = 1 MHz, See Notes 2 and 3		7	12	pF

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES:
1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in TO-18 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

I_{CES} vs T_A

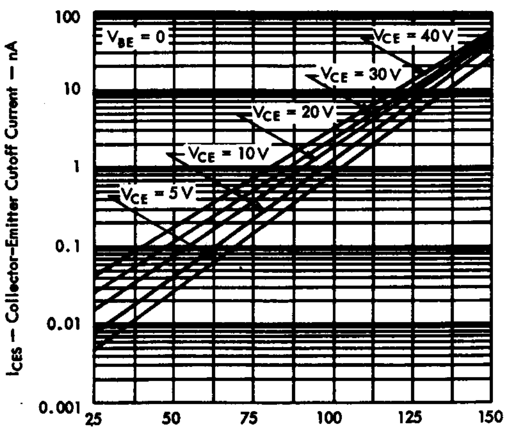


FIGURE 1

I_{ECS} vs T_A

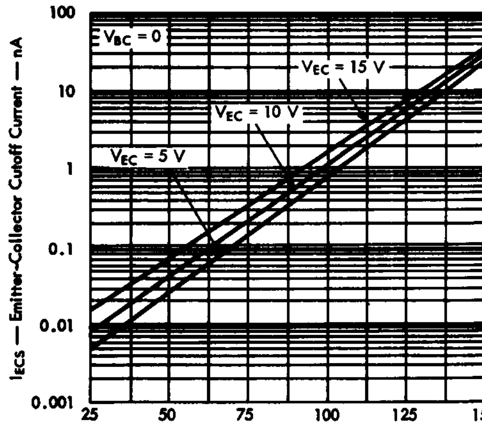


FIGURE 2

h_{FE} vs I_C

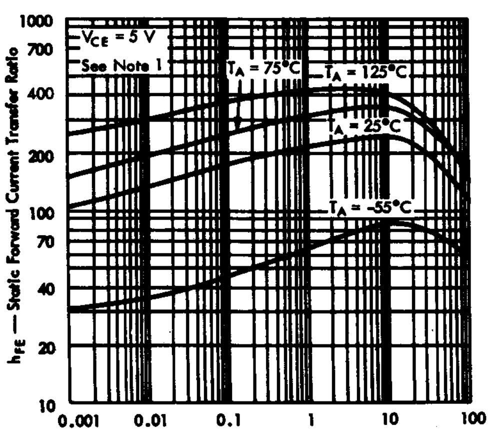


FIGURE 3

h_{FE} vs I_C

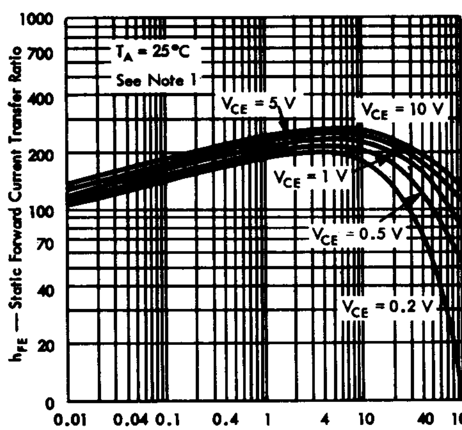


FIGURE 4

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

$h_{FE(inv)}$ vs I_E

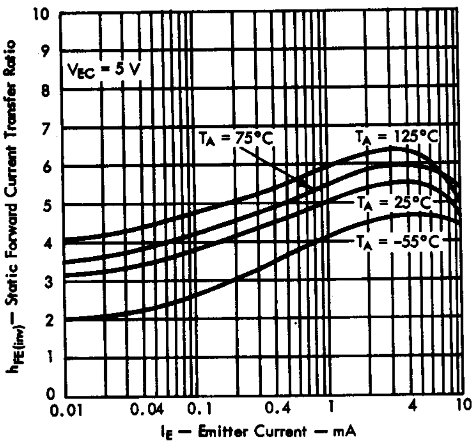


FIGURE 5

V_{BE} vs I_C

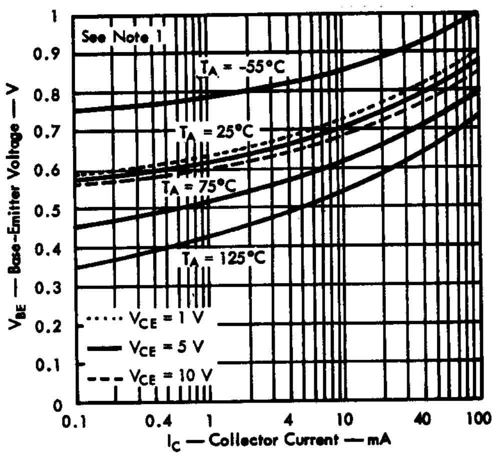


FIGURE 6

$V_{CE(sat)}$ vs I_C

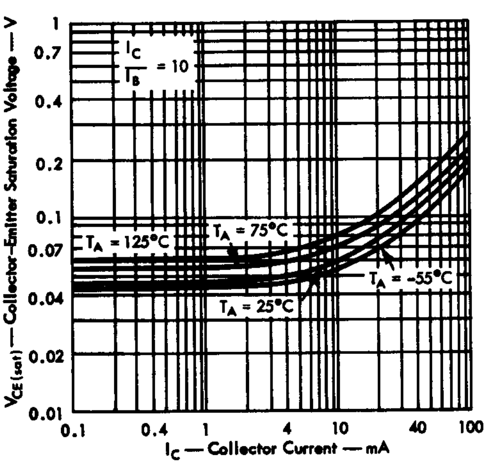


FIGURE 7

$V_{CE(sat)}$ vs I_C

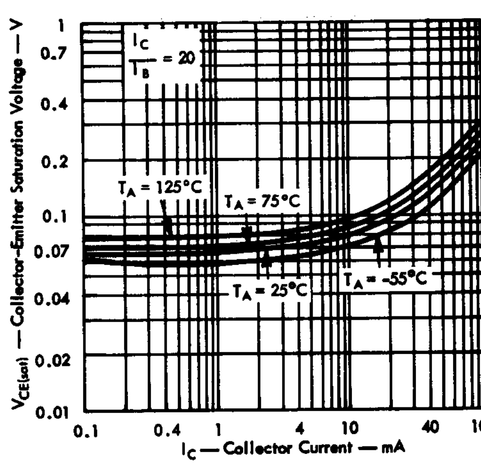


FIGURE 8

NOTE 1 These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

V_{BC} vs I_C

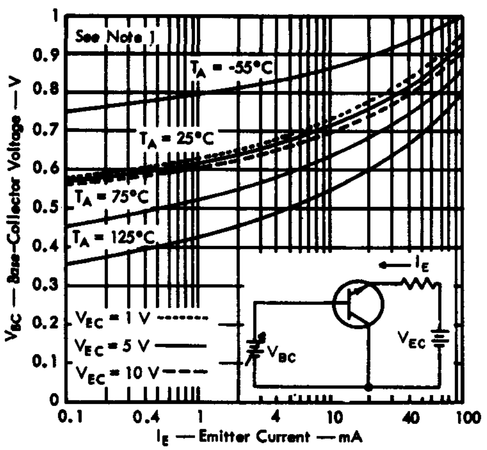


FIGURE 9

$V_{EC(ofs)}$ vs I_B

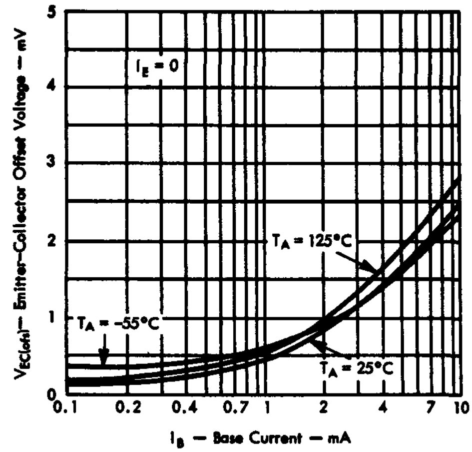


FIGURE 10

V_{EC} vs I_B

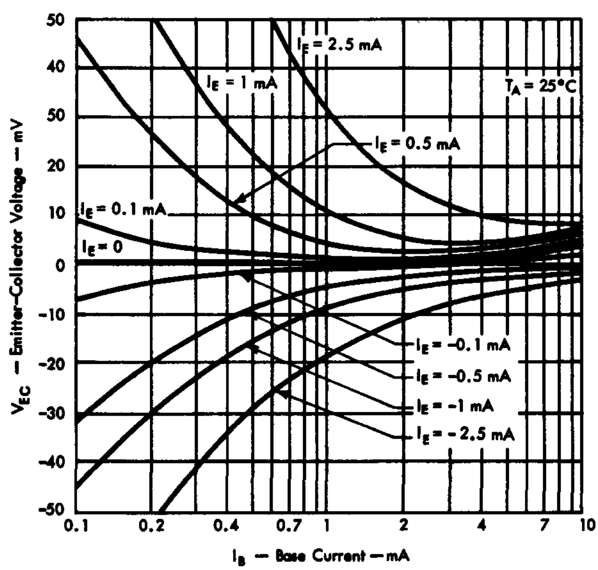


FIGURE 11

NOTE 1: These parameters were measured using pulse techniques. t_W = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

$r_{ec(on)}$ vs I_B

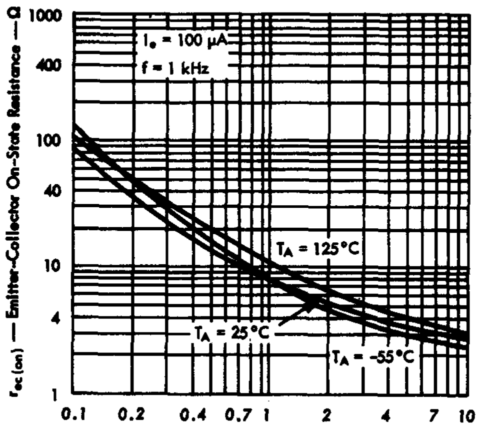


FIGURE 12

C_{cb} vs V_{CB}

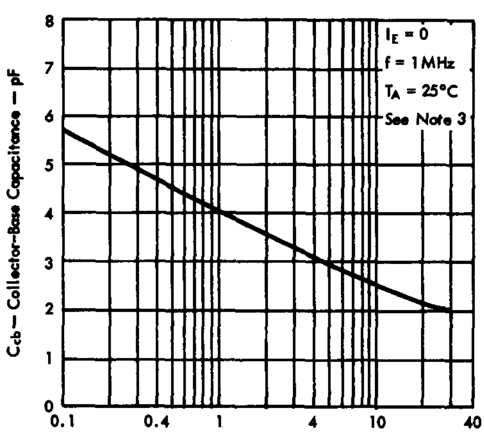


FIGURE 13

C_{eb} vs V_{EB}

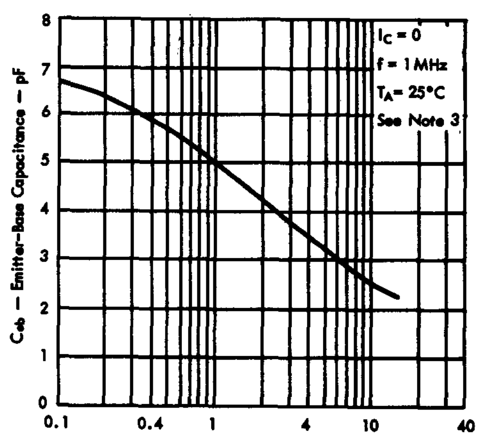


FIGURE 14

NOTES: 2. Capacitance measurements were made using chips mounted in TO-18 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

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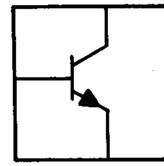
- N19 is a 19 X 19-mil, epitaxial, planar, direct-contact chip
- Available in TO-5 and TO-18 packages
- For use in medium-power switching and general purpose amplifier circuits



electrical and operating characteristics at 25°C free-air temperature

	PARAMETER	CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	60♦	90		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$, $I_B = 0$, See Note 1	30♦	40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	5♦	7.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 40\ V$, $I_E = 0$		<100	250	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$, $I_C = 1\ mA$	20	45		
		$V_{CE} = 10\ V$, $I_C = 10\ mA$, See Note 1	30	70		
		$V_{CE} = 10\ V$, $I_C = 150\ mA$, See Note 1	30	85		
		$V_{CE} = 10\ V$, $I_C = 500\ mA$, See Note 1	20	75		
V_{BE}	Base-Emitter Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$, See Note 1		0.9	1.3	V
		$I_B = 50\ mA$, $I_C = 500\ mA$, See Note 1		1.1	2.6	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15\ mA$, $I_C = 150\ mA$, See Note 1		0.25	0.45	V
		$I_B = 50\ mA$, $I_C = 500\ mA$, See Note 1		0.5	1.6	V
f_T	Transition Frequency	$V_{CE} = 20\ V$, $I_C = 20\ mA$, $f = 100\ MHz$	250	350		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10\ V$, $I_E = 0$, $f = 1\ MHz$, See Note 2		4.5	8	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5\ V$, $I_C = 0$, $f = 1\ MHz$, See Note 2		24	30	pF
t_d	Delay Time	$V_{CC} = 10\ V$, $I_C \approx 150\ mA$, $I_{B(1)} \approx 15\ mA$, $I_{B(2)} \approx -15\ mA$, $V_{BE(off)} \approx -4.1\ V$, Figure 1 Circuit		10		ns
t_r	Rise Time			12		ns
t_s	Storage Time			16		ns
t_f	Fall Time			8		ns

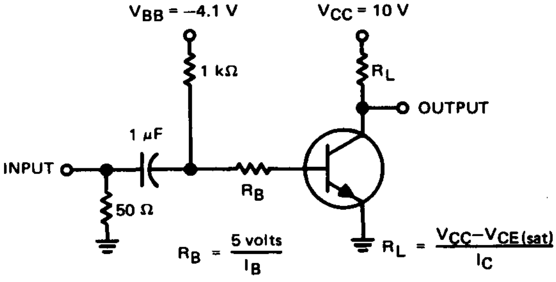
♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

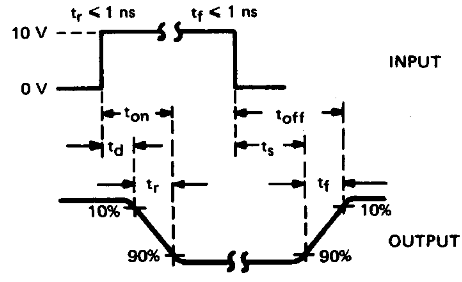
2. Capacitance measurements were made using chips mounted in TO-5 packages.

CHIP TYPE N19
N-P-N SILICON TRANSISTORS

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)

VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_w \approx 200$ ns, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

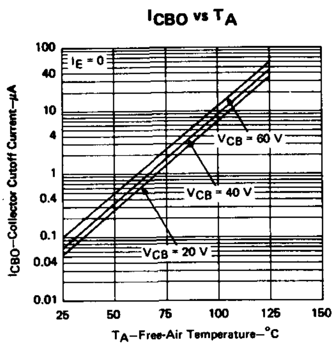


FIGURE 2

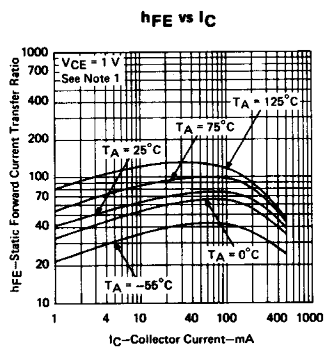


FIGURE 3

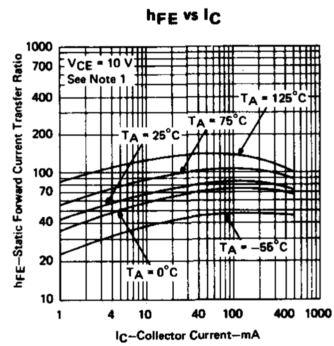


FIGURE 4

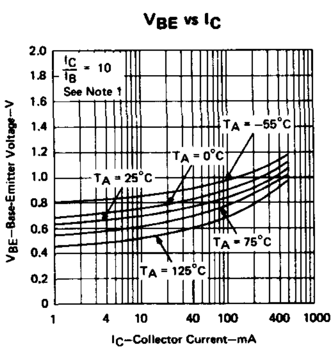


FIGURE 5

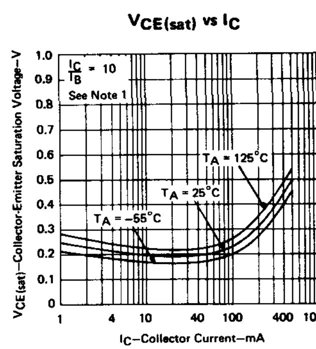


FIGURE 6

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

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TYPICAL CHARACTERISTICS

f_T vs I_C

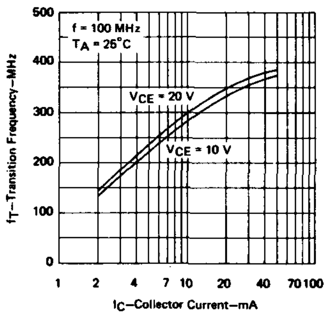


FIGURE 7

C_{obo} vs V_{CB}

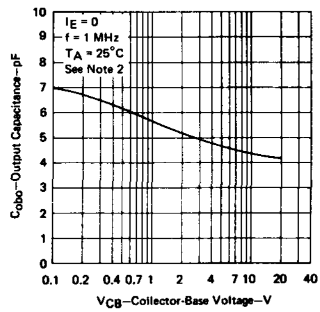


FIGURE 8

C_{ibo} vs V_{EB}

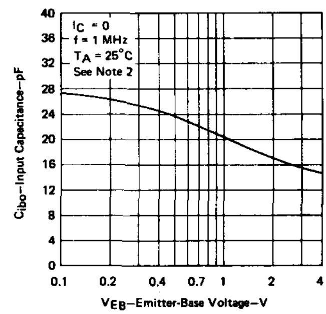


FIGURE 9

t_d, t_r, t_s, t_f vs T_A

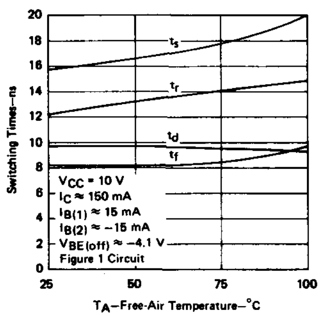


FIGURE 10

t_d vs I_C

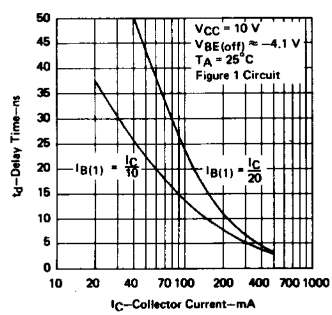


FIGURE 11

t_r vs I_C

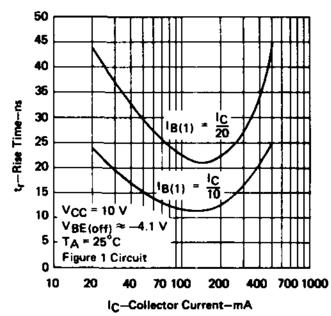


FIGURE 12

t_s vs I_C

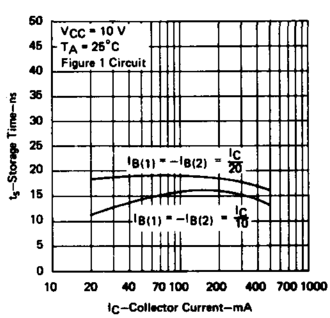


FIGURE 13

t_f vs I_C

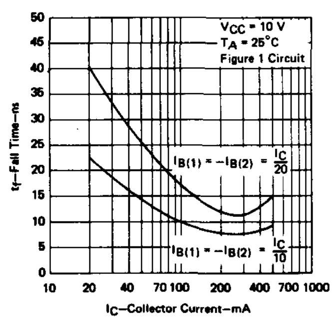
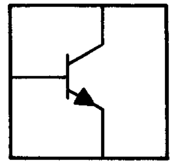


FIGURE 14

NOTE 2: Capacitance measurements were made using chips mounted in TO-5 packages.

CHIP TYPE N20
N-P-N SILICON TRANSISTORS

- N20 is a 16 X 16-mil, epitaxial, planar, expanded-contact chip
- Available in *Silect*† packages
- For use in TV mixer and Non-AGC IF circuits



electrical characteristics at 25°C free-air temperature

	PARAMETER	CONDITIONS		OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$		45♦	70		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$,	See Note 1	45♦	65		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$		4♦	5.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 25$ V, $I_E = 0$			<0.1	50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 15$ V, $I_C = 10$ mA	See Note 1	30	45	150	
		$V_{CE} = 15$ V, $I_C = 30$ mA		30	50	150	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 15$ V, $I_C = 10$ mA	See Note 1		0.73	0.8	V
		$V_{CE} = 15$ V, $I_C = 30$ mA			0.77		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 20$ mA	See Note 1			0.5	V
		$I_B = 2$ mA, $I_C = 20$ mA			0.11		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 45 MHz		15		
f_T	Transition Frequency	$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 100 MHz	300	650		MHz
		$V_{CE} = 15$ V, $I_C = 30$ mA,	f = 100 MHz	300	600		
$\frac{f_{T(2)}}{f_{T(1)}}$	Ratio of Transition Frequencies	$V_{CE} = 15$ V, $I_{C(1)} = 10$ mA, $I_{C(2)} = 30$ mA, f = 100 MHz		0.65	1.0	1.3	
$y_{ie(real)}$	Real Part of Small-Signal Common-Emitter Input Admittance	$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 45 MHz		11		mmho
		$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 200 MHz		25		
$\lvert y_{fe} \rvert$	Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 45 MHz		240		mmho
ϕ_{yfe}	Phase Angle of Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 45 MHz		40°		
$y_{oe(real)}$	Real Part of Small-Signal Common-Emitter Output Admittance	$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 45 MHz		0.15		mmho
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, See Notes 2 and 3	f = 1 MHz,		0.7	1	pF
C_{ies}	Parallel-Equivalent Common-Emitter Short-Circuit Input Capacitance‡	$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 45 MHz		32		pF
C_{oes}	Parallel-Equivalent Common-Emitter Short-Circuit Output Capacitance‡	$V_{CE} = 15$ V, $I_C = 10$ mA,	f = 45 MHz		2.4		pF

†Trademark of Texas Instruments
♦This value does not modify guaranteed limits for specific devices and does not justify operation in excess of absolute maximum ratings.
‡C_{ies} and C_{oes} are defined as the imaginary parts of the small-signal, common-emitter, short-circuit admittances divided by $2\pi f$.

NOTES:
1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
2. Capacitance measurements were made using chips mounted in *Silect* packages.
3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

I_{CBO} vs I_C

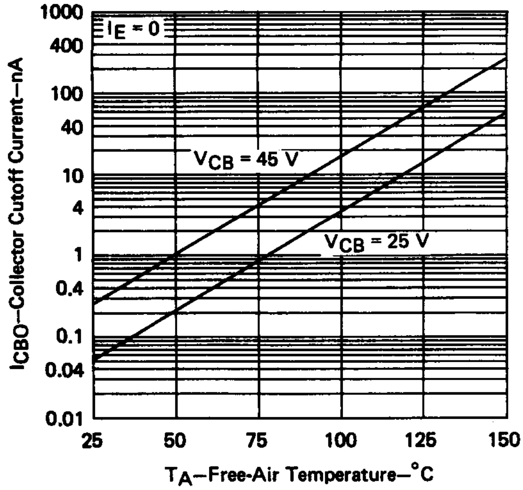


FIGURE 1

h_{FE} vs I_C

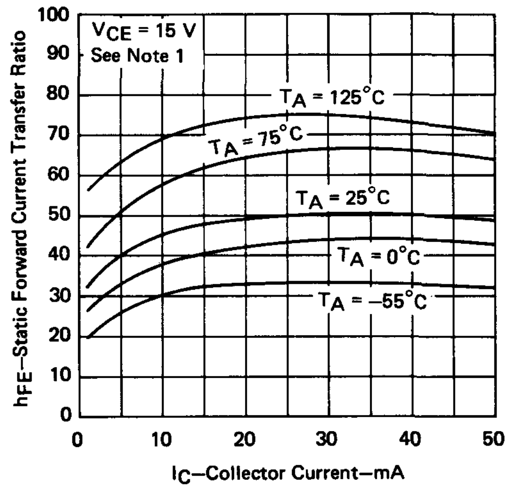


FIGURE 2

V_{BE} vs I_C

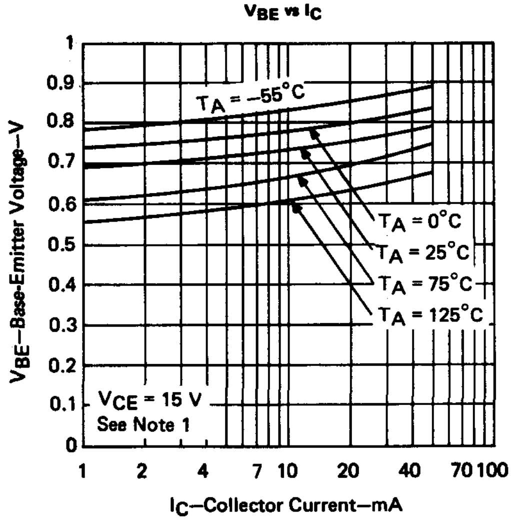


FIGURE 3

$V_{CE(sat)}$ vs I_C

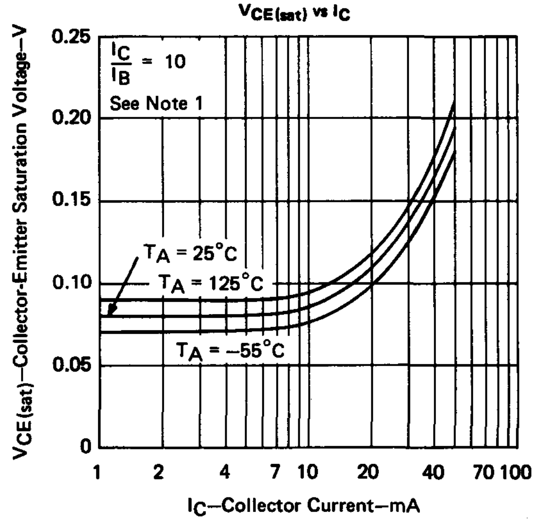


FIGURE 4

5

NOTE 1: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

TYPICAL CHARACTERISTICS

$|h_{fe}|$ vs I_C

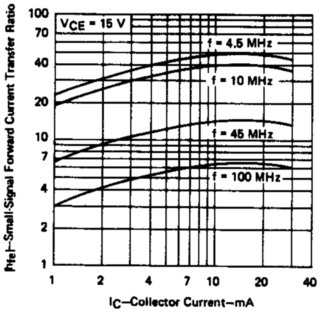


FIGURE 5

f_T vs I_C

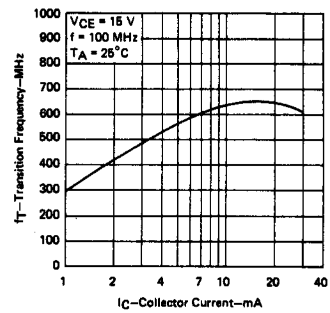


FIGURE 6

y_{ie} vs I_C

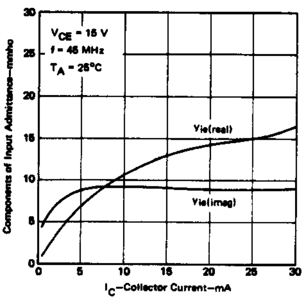


FIGURE 7

y_{fe} vs I_C

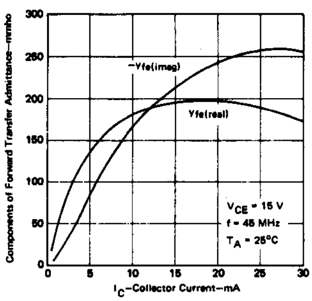


FIGURE 8

y_{oe} vs I_C

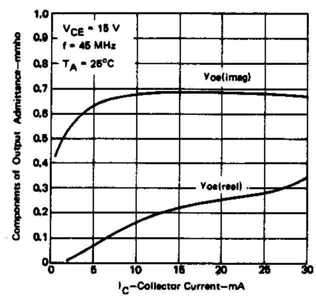


FIGURE 9

y_{ie} vs I_C

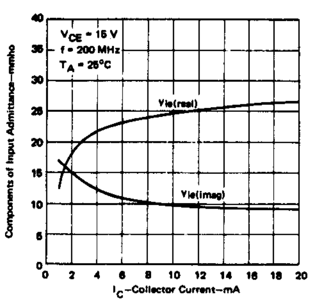


FIGURE 10

C_{cb} vs V_{CB}

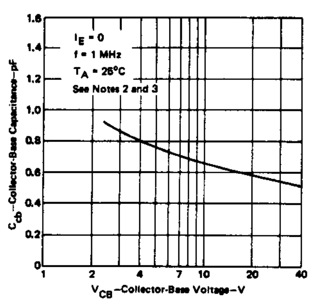
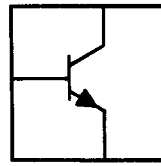


FIGURE 11

NOTES: 2. Capacitance measurements were made using chips mounted in *Silect* packages.
3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

- N21 is an 18 X 18-mil, eptiaxial, planar, direct-contact chip
- Available in *Silect*† packages
- For low-noise, medium-current (to 100 mA) amplifier circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	80♦	100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 1	40♦	60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	6♦	6.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ V, $I_E = 0$		<0.1	100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 5$ V, $I_C = 0$		<0.1	100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 10\ \mu A$	20	240		
		$V_{CE} = 5$ V, $I_C = 100\ \mu A$	40	340		
		$V_{CE} = 5$ V, $I_C = 1$ mA	50	475	1000	
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 1	60	600		
		$V_{CE} = 5$ V, $I_C = 100$ mA, See Note 1	40			
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 100\ \mu A$		0.55	0.65	V
		$V_{CE} = 5$ V, $I_C = 1$ mA		0.6	0.7	V
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 1		0.7	0.8	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA		0.06		V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, f = 1 kHz		115		kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, f = 1 kHz		440		
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, f = 1 kHz		30×10^{-4}		
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, f = 1 kHz		11		µmho
f_T	Transition Frequency	$V_{CE} = 5$ V, $I_C = 10$ mA, f = 100 MHz	200	330		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 5$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		3.5	4.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, f = 1 MHz, See Notes 2 and 3		8	16	pF
F	Spot Noise Figure	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, $R_G = 10$ kΩ, f = 1 kHz		0.5	2	dB
$\overline{F}$	Average Noise Figure	$V_{CE} = 5$ V, $I_C = 100\ \mu A$, $R_G = 10$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 4		0.5	3	dB

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in *Silect* packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.
4. Average Noise Figure was measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

5

TYPICAL CHARACTERISTICS

Normalized h_{FE} vs I_C

(Device having $h_{FE} \approx 340$ at 5 V, 100 μA)

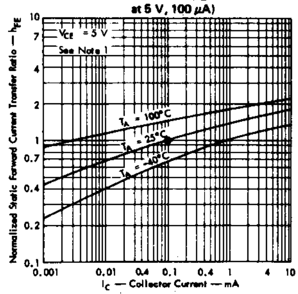


FIGURE 1

Normalized h_{FE} vs I_C

(Device having $h_{FE} \approx 200$ at 5 V, 1 mA)

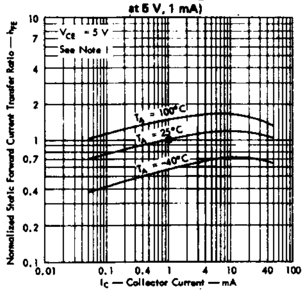


FIGURE 2

Normalized h_{FE} vs I_C

(Device having $h_{FE} \approx 125$ at 5 V, 10 mA)

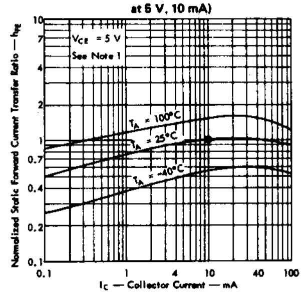


FIGURE 3

V_{BE} vs I_C

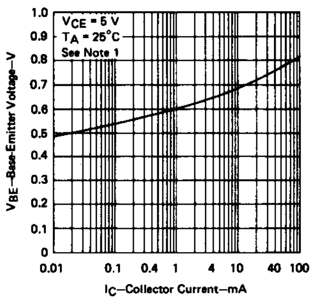


FIGURE 4

V_{BE} vs I_C

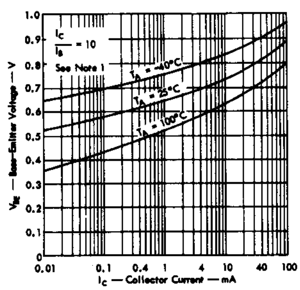


FIGURE 5

V_{BE} vs I_C

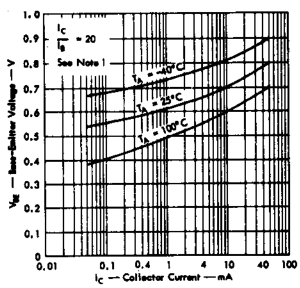


FIGURE 6

$V_{CE(sat)}$ vs I_C

(Device having $h_{FE} \approx 200$ at 5 V, 1 mA)

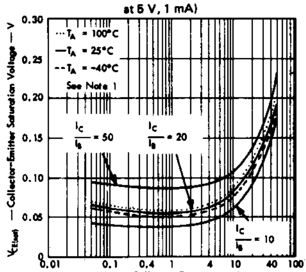


FIGURE 7

$V_{CE(sat)}$ vs I_C

(Device having $h_{FE} \approx 125$ at 5 V, 10 mA)

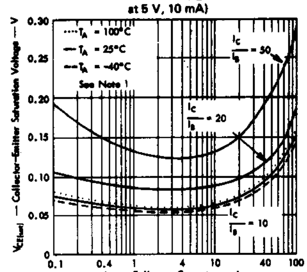


FIGURE 8

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300$ μs, duty cycle $\leq$ 2%.

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TYPICAL CHARACTERISTICS

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

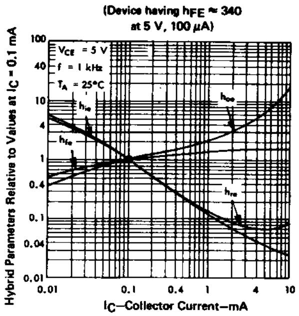

FIGURE 9

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

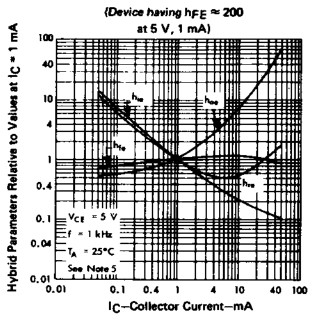

FIGURE 10

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

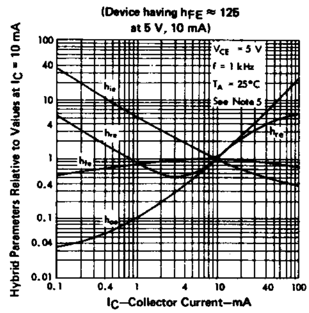

FIGURE 11

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs V_{CE}

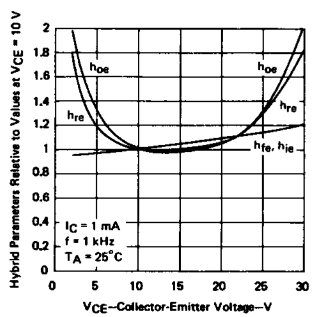

FIGURE 12

f_T vs I_C

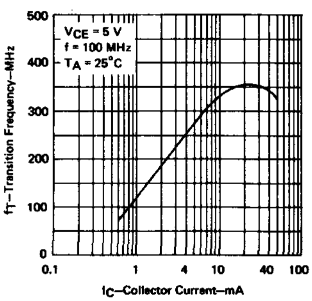

FIGURE 13

C_{cb} vs V_{CB}

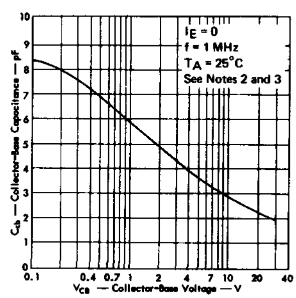

FIGURE 14

C_{eb} vs V_{EB}

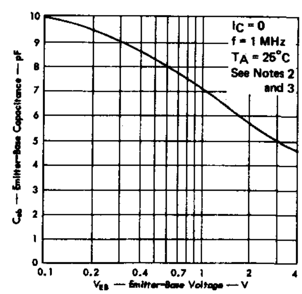

FIGURE 15

NOTES: 2. Capacitance measurements were made using chips mounted in *Silect*† packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.
5. To obtain reproducible results, these parameters were measured with bias conditions applied for less than five seconds.

TYPICAL CHARACTERISTICS

Contours of Constant F vs I_C

(Device having $h_{FE} \approx 340$ at 5 V, 100 μA)

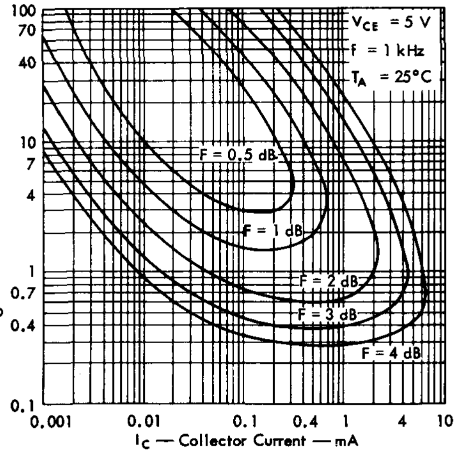

FIGURE 16

Contours of Constant F vs I_C

(Device having $h_{FE} \approx 340$ at 5 V, 100 μA)

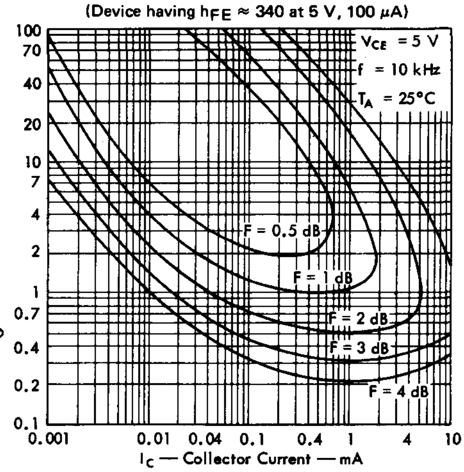

FIGURE 17

F vs f

(Device having $h_{FE} \approx 340$ at 5 V, 100 μA)

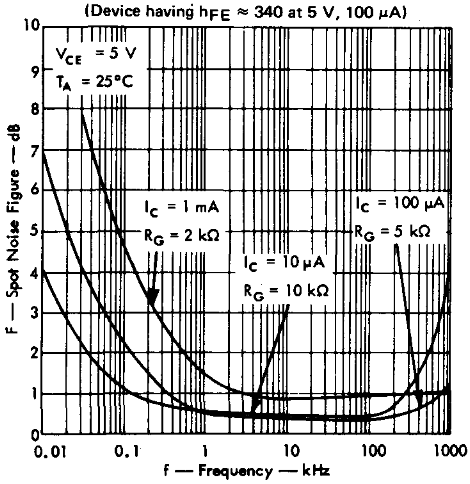

FIGURE 18

$\overline{F}$ vs R_G

(Device having $h_{FE} \approx 340$ at 5 V, 100 μA)

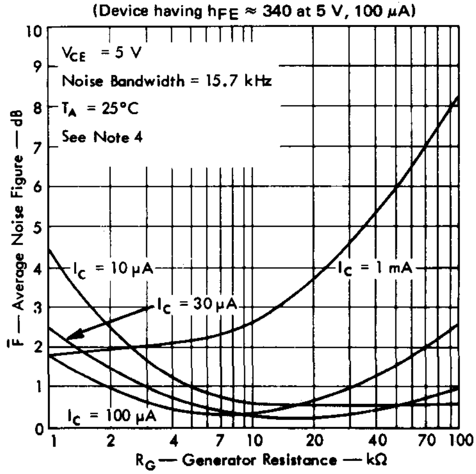

FIGURE 19

NOTES: 1. These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
4. Average Noise Figure was measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

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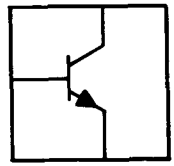
CHIP TYPE N22
N-P-N SILICON TRANSISTORS

- **N22 is a 10 X 15-mil, epitaxial, planar, expanded-contact chip**
- **Available in TO-72, a short-can version of TO-78, and *Silect*† packages**
- **For use in high-frequency (to 1 GHz) amplifier and oscillator circuits**



electrical and operating characteristics at 25°C free-air temperature

	PARAMETER	CONDITIONS‡			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 µA,	I_E = 0		30◆	35		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 4 mA,	I_B = 0,	See Note 1	12◆	25		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 100 µA,	I_C = 0		3◆	4		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 10 V,	I_E = 0			0.1	50	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 1 V,	I_C = 3 mA		20	95	200	
		V_{CE} = 10 V,	I_C = 4 mA		30	110	225	
V_{BE}	Base-Emitter Voltage	V_{CE} = 10 V,	I_C = 4 mA			0.75		V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 1 mA,	I_C = 10 mA			0.1		V
f_T	Transition Frequency	V_{CE} = 10 V,	I_C = 4 mA,	f = 100 MHz	500	1100		MHz
$\lvert y_{fe} \rvert$	Small-Signal Common-Emitter Forward Transfer Admittance	V_{CE} = 10 V,	I_C = 4 mA,	f = 10 MHz		130		mmho
$\lvert h_{fe} \rvert^2$	Square of Common-Emitter Forward Transmission Coefficient§	V_{CE} = 10 V,	I_C = 4 mA	f = 200 MHz		10		dB
				f = 400 MHz		5		
C_{cb}	Collector-Base Capacitance	V_{CB} = 10 V, See Note 2	I_E = 0,	f = 1 MHz,		0.6	1.5	pF
C_{iep}	Parallel-Equivalent Common-Emitter Short-Circuit Input Capacitance	V_{CE} = 10 V,	I_C = 4 mA,	f = 10 MHz		15		pF
C_{oep}	Parallel-Equivalent Common-Emitter Short-Circuit Output Capacitance					2		pF
r_{iep}	Parallel-Equivalent Common-Emitter Short-Circuit Input Resistance					400		Ω
r_{oep}	Parallel-Equivalent Common-Emitter Short-Circuit Output Resistance					50		kΩ
$r_b'C_c$	Collector-Base Time Constant	V_{CB} = 10 V,	I_E = −4 mA,	f = 79.8 MHz		8	32	ps
F	Spot Noise Figure	V_{CE} = 10 V, f = 100 MHz	I_C = 2 mA,	R_G = 300 Ω,		4	6	dB

†Trademark of Texas Instruments
‡All dynamic characteristics were measured using chips mounted in *Silect* packages.
◆These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.
§ $\lvert h_{fe} \rvert^2$ is equal to the insertion power gain of the transistor alone.
NOTES: 1. These parameters were measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%.
2. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

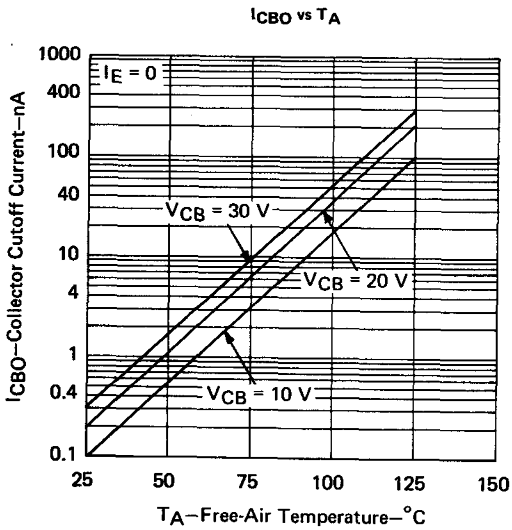


FIGURE 1

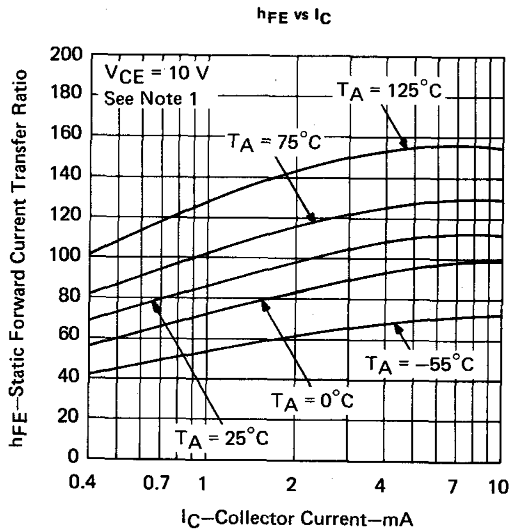


FIGURE 2

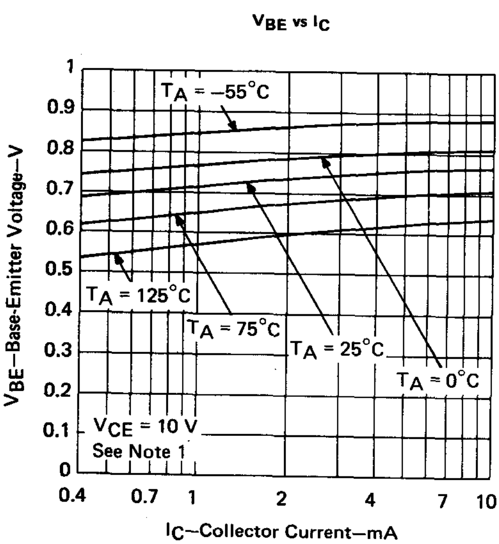


FIGURE 3

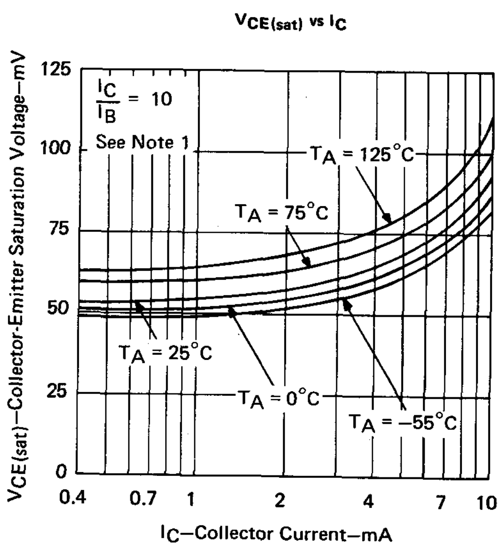


FIGURE 4

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

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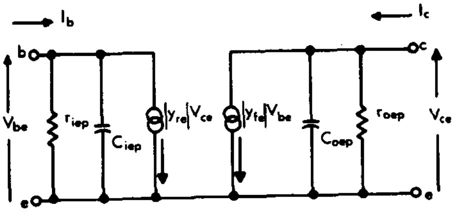
COMMON-EMITTER EQUIVALENT CIRCUIT USING SHORT-CIRCUIT "y" PARAMETERS



$$I_b = |y_{ie}|V_{be} + |y_{re}|V_{ce}$$

$$I_c = |y_{fe}|V_{be} + |y_{oe}|V_{ce}$$

$$|y_{ie}| = \frac{I_b}{V_{be}}\bigg|_{V_{ce}=0} = \frac{1}{r_{iep}} + j\omega C_{iep} \qquad |y_{fe}| = \frac{I_c}{V_{be}}\bigg|_{V_{ce}=0}$$

$$|y_{re}| = \frac{I_b}{V_{ce}}\bigg|_{V_{be}=0} \qquad |y_{oe}| = \frac{I_c}{V_{ce}}\bigg|_{V_{be}=0} = \frac{1}{r_{oep}} + j\omega C_{oep}$$

TYPICAL CHARACTERISTICS AT $T_A = 25°C$

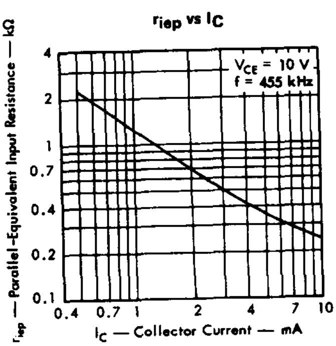


FIGURE 5

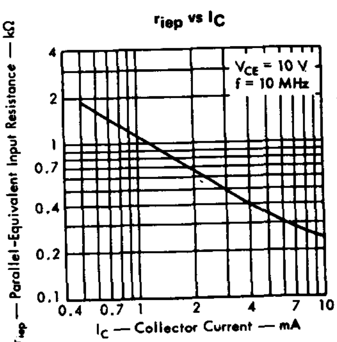


FIGURE 6

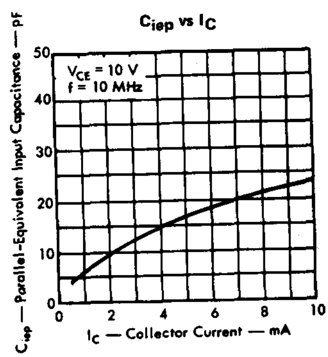


FIGURE 7

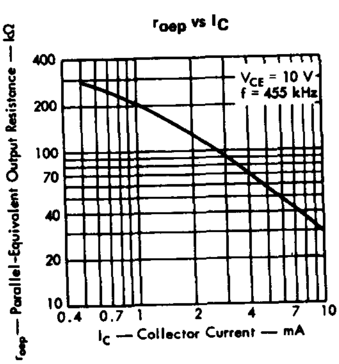


FIGURE 8

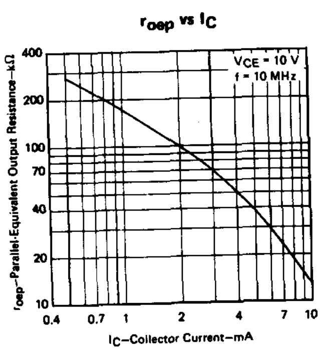


FIGURE 9

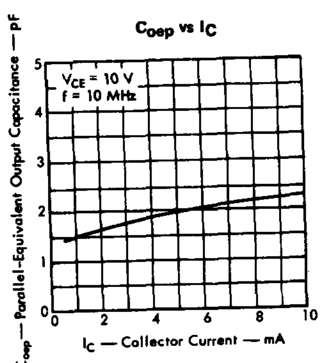


FIGURE 10

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TYPICAL CHARACTERISTICS AT $T_A = 25°C$

$|y_{fe}|$ vs I_C

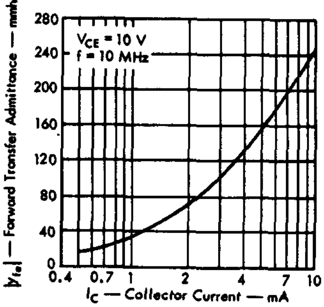


FIGURE 11

C_{cb} vs V_{CB}

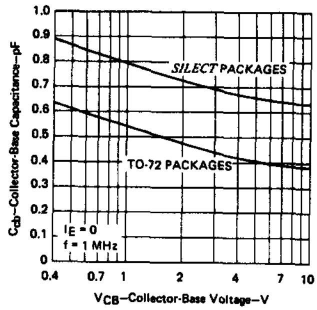


FIGURE 12

$|h_{fe}|$ vs I_C

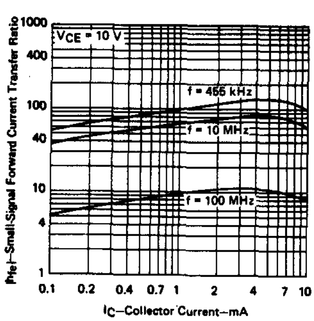


FIGURE 13

f_T vs I_C

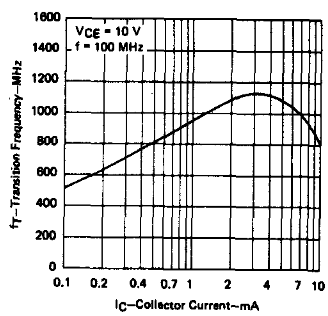


FIGURE 14

$|s_{fe}|^2$ vs f

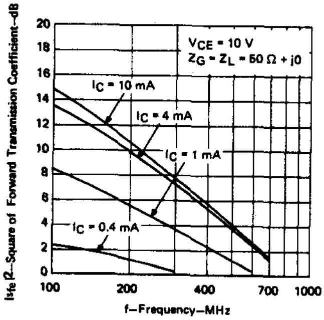


FIGURE 15

$|s_{re}|^2$ vs f

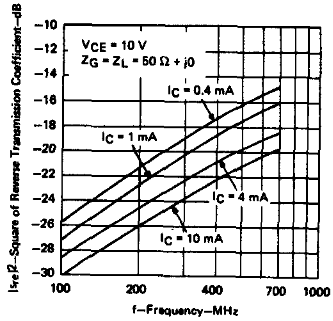
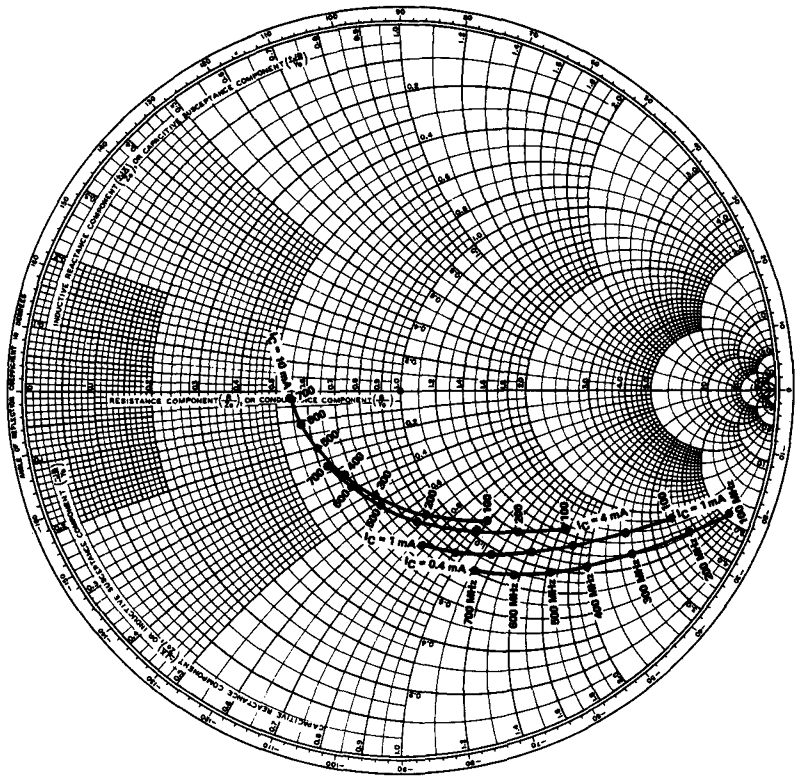


FIGURE 16

TYPICAL CHARACTERISTICS

COMMON-EMITTER INPUT REFLECTION COEFFICIENT, s_{ie}
and
NORMALIZED INPUT IMPEDANCE
$V_{CE} = 10$ V, $Z_G = Z_L = 50\ \Omega + j0$, $T_A = 25°C$



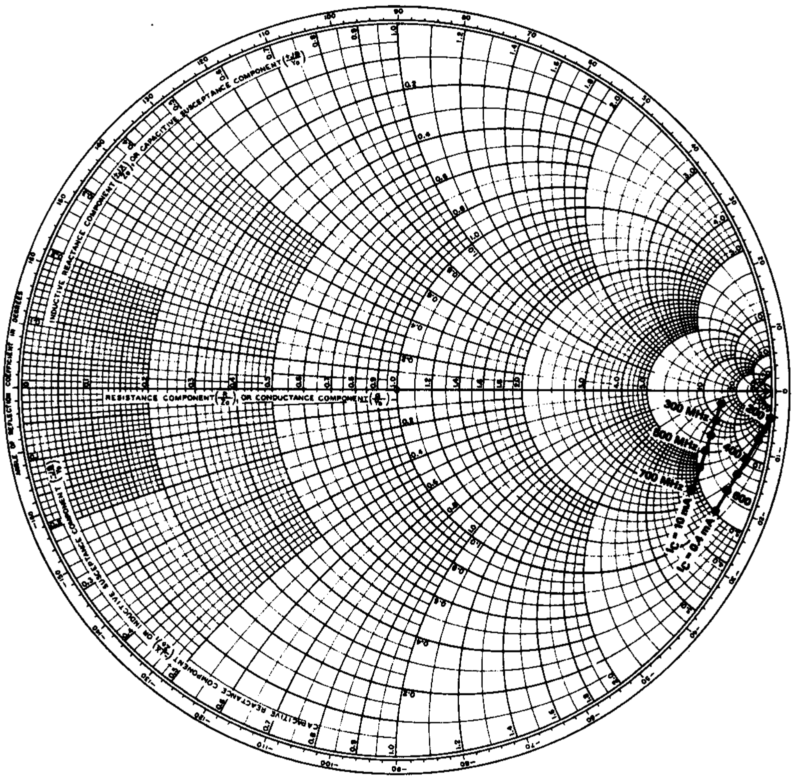
Frequency	I_C = 0.4 mA		I_C = 1 mA		I_C = 4 mA		I_C = 10 mA	
	$\lvert s_{ie}\rvert$	ϕ_{sie}	$\lvert s_{ie}\rvert$	ϕ_{sie}	$\lvert s_{ie}\rvert$	ϕ_{sie}	$\lvert s_{ie}\rvert$	ϕ_{sie}
100 MHz	0.94	−21°	0.80	−26°	0.58	−40°	0.43	−57°
200 MHz	0.87	−27°	0.72	−33°	0.50	−51°	0.35	−79°
300 MHz	0.76	−36°	0.63	−43°	0.43	−63°	0.30	−104°
400 MHz	0.69	−44°	0.57	−52°	0.36	−84°	0.28	−123°
500 MHz	0.63	−51°	0.51	−62°	0.32	−100°	0.27	−145°
600 MHz	0.59	−59°	0.47	−72°	0.29	−117°	0.28	−162°
700 MHz	0.53	−68°	0.43	−83°	0.28	−134°	0.30	−177°

These measurements were made using chips mounted in *Silect* packages.

FIGURE 17

TYPICAL CHARACTERISTICS

COMMON-EMITTER OUTPUT REFLECTION COEFFICIENT, s_{oe}
and
NORMALIZED OUTPUT IMPEDANCE
$V_{CE} = 10$ V, $Z_G = Z_L = 50\ \Omega + j0$, $T_A = 25°C$

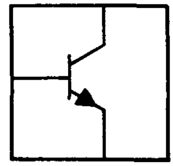


Frequency	$I_C = 0.4$ mA		$I_C = 1$ mA		$I_C = 4$ mA		$I_C = 10$ mA	
	$\lvert s_{oe}\rvert$	ϕ_{soe}	$\lvert s_{oe}\rvert$	ϕ_{soe}	$\lvert s_{oe}\rvert$	ϕ_{soe}	$\lvert s_{oe}\rvert$	ϕ_{soe}
200 MHz	0.99	−4°	0.97	−4°	0.89	−3°	0.87	−2°
300 MHz	0.98	−8°	0.95	−7°	0.88	−6°	0.86	−5°
400 MHz	0.95	−11°	0.93	−10°	0.87	−9°	0.85	−8°
500 MHz	0.94	−14°	0.91	−13°	0.86	−12°	0.84	−11°
600 MHz	0.93	−17°	0.90	−16°	0.85	−15°	0.84	−14°
700 MHz	0.92	−21°	0.88	−20°	0.85	−20°	0.83	−19°

These measurements were made using chips mounted in *Silect* packages.

FIGURE 18

CHIP TYPE N23
N-P-N SILICON TRANSISTORS



- **N23 is a 26 X 26-mil, epitaxial, planar, direct-contact chip**
- **Available in TO-18, TO-39, a short-can version of TO-78, and *Silect*† packages**
- **For use in general purpose amplifier and switching circuits**

electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 μA,	I_E = 0		90♦	165		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 10 mA,	I_B = 0,	See Note 1	70♦	85		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 100 μA,	I_C = 0		7♦	8.5		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 40 V,	I_E = 0			<0.1	10	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 10 V,	I_C = 100 μA		15	40		
		V_{CE} = 10 V,	I_C = 10 mA	See Note 1	30	70		
		V_{CE} = 10 V,	I_C = 150 mA		50	80	300	
		V_{CE} = 10 V,	I_C = 500 mA		25	55		
		V_{CE} = 10 V,	I_C = 1 A		10	20		
		V_{CE} = 1 V,	I_C = 150 mA		15	50		
V_{BE}	Base-Emitter Voltage	V_{CE} = 10 V,	I_C = 10 mA	See Note 1		0.7	1	V
		I_B = 15 mA,	I_C = 150 mA			0.85	1.3	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 15 mA,	I_C = 150 mA,	See Note 1		0.1	1	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	V_{CE} = 10 V,	I_C = 10 mA,	f = 1 kHz	100	230	1000	Ω
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio				30	80		
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio					1×10^{-4}	5×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance					20	120	μmho
f_T	Transition Frequency	V_{CE} = 10 V,	I_C = 50 mA,	f = 20 MHz	40	120		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	V_{CB} = 10 V, See Note 2	I_E = 0,	f = 1 MHz,		5.5	15	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	V_{EB} = 0.5 V, See Note 2	I_C = 0,	f = 1 MHz,		40	60	pF
t_d	Delay Time	V_{CC} = 7 V,	$I_C \approx$ 150 mA,	2N2192 Data Sheet Circuit		3		ns
t_r	Rise Time	V_{IN} = 7.5 V,	V_{BB} = 7.5 V			6		
t_s	Storage Time					10		
t_f	Fall Time					3		
t_d	Delay Time	V_{CC} = 10 V,	$I_C \approx$ 150 mA,	$I_{B(1)} \approx$ 15 mA,		22		ns
t_r	Rise Time	$I_{B(2)} \approx -15$ mA,	$V_{BE(off)} \approx -4.1$ V,	See Figure 1		28		
t_s	Storage Time					530		
t_f	Fall Time					53		

†Trademark of Texas Instruments

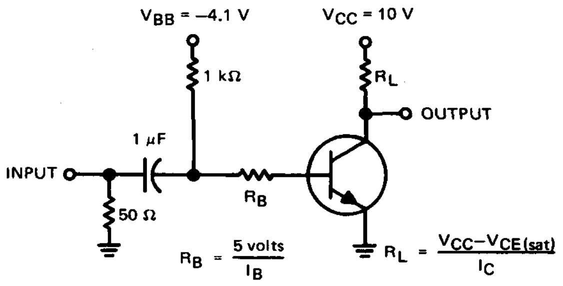
♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.
2. Capacitance measurements were made using chips mounted in TO-39 packages.

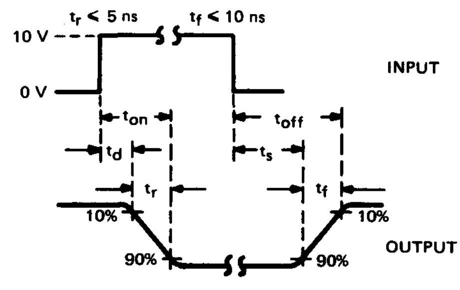
5

CHIP TYPE N23
N-P-N SILICON TRANSISTORS

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)

VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$; for measuring t_d and t_r, $t_w \approx 10$ ns, duty cycle $\leq 2\%$; for measuring t_s and t_f, $t_w \approx 10\ \mu s$, duty cycle $\leq 2\%$.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_w \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

$V_{(BR)CER}$ vs R_{BE}

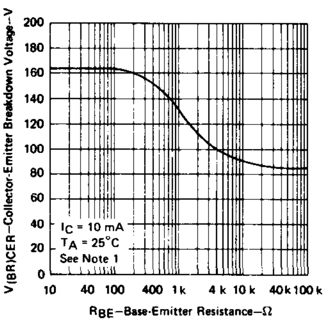


FIGURE 2

I_{CBO} vs T_A

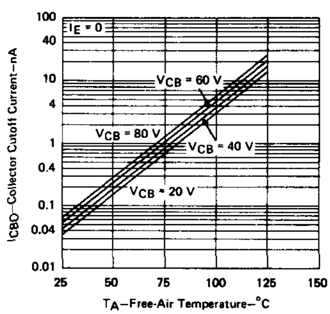


FIGURE 3

h_{FE} vs I_C

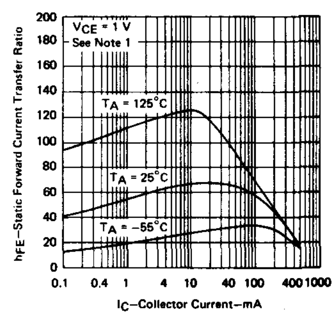


FIGURE 4

h_{FE} vs I_C

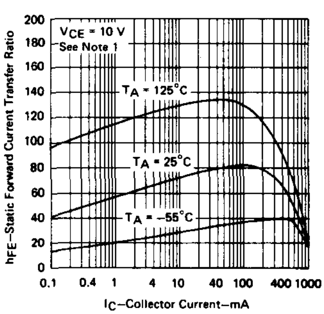


FIGURE 5

V_{BE} vs I_C

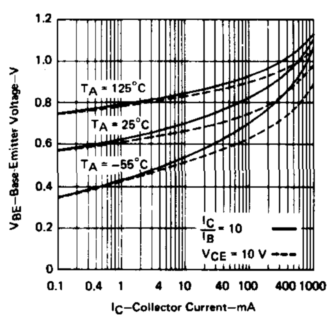


FIGURE 6

$V_{CE(sat)}$ vs I_C

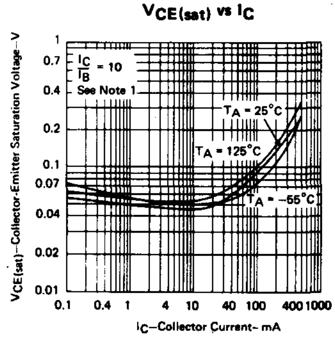


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

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TYPICAL CHARACTERISTICS

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

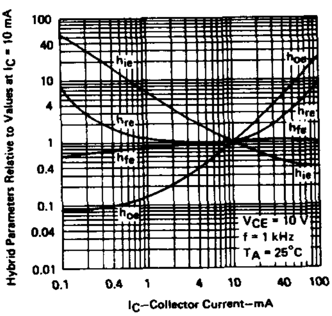


FIGURE 8

f_T vs I_C

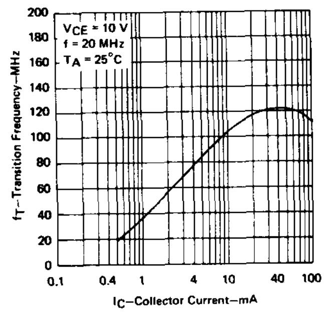


FIGURE 9

C_{obo} vs V_{CB}

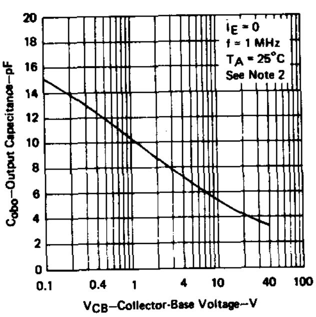


FIGURE 10

C_{ibo} vs V_{EB}

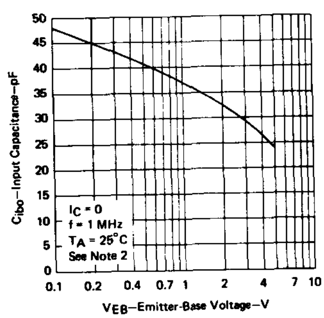


FIGURE 11

t_d vs I_C

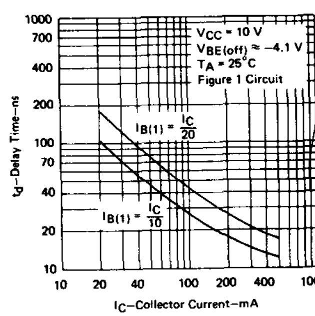


FIGURE 12

t_r vs I_C

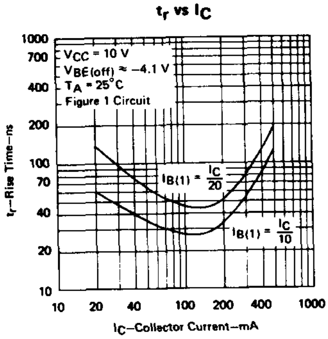


FIGURE 13

t_s vs I_C

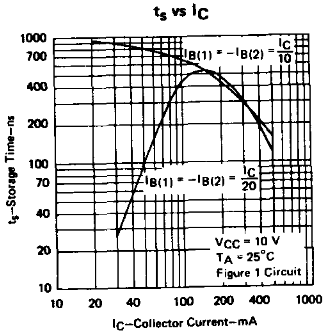


FIGURE 14

t_f vs I_C

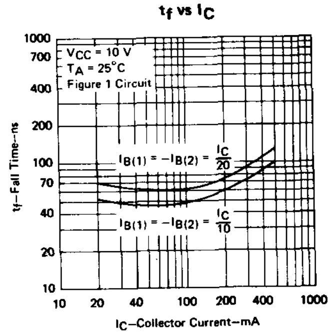
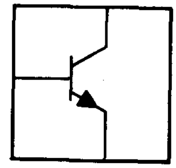


FIGURE 15

NOTE 2: Capacitance measurements were made using chips mounted in TO-39 packages.

CHIP TYPE N24
N-P-N SILICON TRANSISTORS

- N24 is a 19 X 19-mil, epitaxial, planar, direct-contact chip
- Available in TO-5, TO-18, TO-39, a short-can version of TO-78, plastic dual-in-line quad, and *Silect*† packages
- For use in general purpose amplifier and medium-current switching circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	80♦	100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 1	35♦	45		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$, $I_C = 0$	6♦	6.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 50$ V, $I_E = 0$		<1	100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ V, $I_C = 0$		<1	100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA	20	70		
		$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 1	50	100		
		$V_{CE} = 10$ V, $I_C = 150$ mA, See Note 1	50	120	600	
		$V_{CE} = 10$ V, $I_C = 500$ mA, See Note 1	20	95		
V_{BE}	Base-Emitter Voltage	$I_B = 15$ mA, $I_C = 150$ mA, See Note 1		0.95	1	V
		$I_B = 50$ mA, $I_C = 500$ mA, See Note 1		1.15		V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 15$ mA, $I_C = 150$ mA, See Note 1		0.15	0.3	V
		$I_B = 50$ mA, $I_C = 500$ mA, See Note 1		0.4		V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 kHz	0.5	2		kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 kHz	20	75		
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 kHz		0.8×10^{-4}	6×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = 10$ V, $I_C = 1$ mA, f = 1 kHz		6	20	µmho
f_T	Transition Frequency	$V_{CE} = 10$ V, $I_C = 50$ mA, f = 100 MHz	100	400		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		4.5	12	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, f = 1 MHz, See Notes 2 and 3		20	30	pF
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		4.0		pF
t_d	Delay Time	$V_{CC} = 30$ V, $I_C \approx 150$ mA, $I_{B(1)} \approx 15$ mA, $V_{BE(off)} \approx -0.5$ V, 2N2218A Data Sheet Circuit		5		ns
t_r	Rise Time			15		ns
t_s	Storage Time	$V_{CC} = 30$ V, $I_C \approx 150$ mA, $I_{B(1)} \approx 15$ mA, $I_{B(2)} \approx -15$ mA, 2N2218A Data Sheet Circuit		190		ns
t_f	Fall Time			23		ns
t_d	Delay Time	$V_{CC} = 30$ V, $I_C \approx 150$ mA, $V_{BE(off)} \approx -4.1$ V, See Figure 1		6		ns
t_r	Rise Time			15		ns
t_s	Storage Time	$V_{CC} = 30$ V, $I_C \approx 150$ mA, $I_{B(1)} \approx 15$ mA, $I_{B(2)} \approx -15$ mA		190		ns
t_f	Fall Time			23		ns

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-5 packages.

3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.

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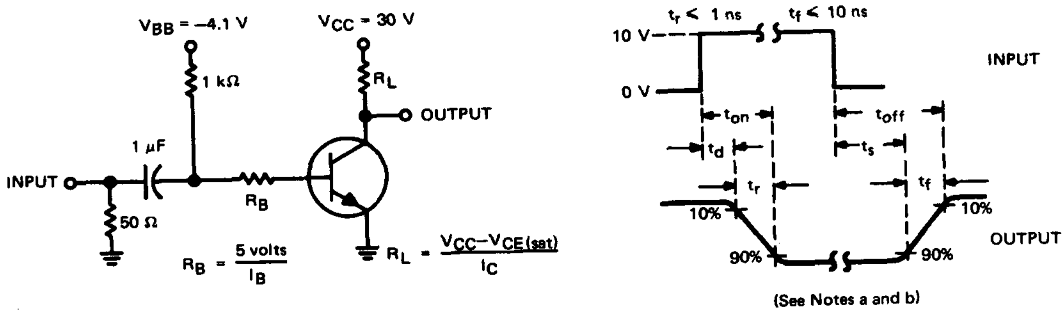
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω; for measuring t_d and t_r, $t_w \approx$ 200 ns, duty cycle ≤ 2%; for measuring t_s and t_f, $t_w \approx$ 10 μs, duty cycle ≤ 2%.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \approx$ 1 ns, R_{in} ≤ 100 kΩ, C_{in} ≤ 7 pF.

FIGURE 1–SWITCHING TIMES

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

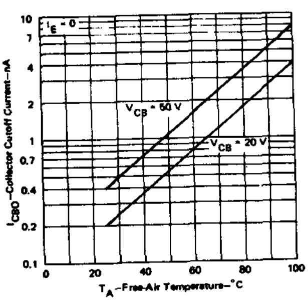


FIGURE 2

Normalized h_{FE} vs I_C

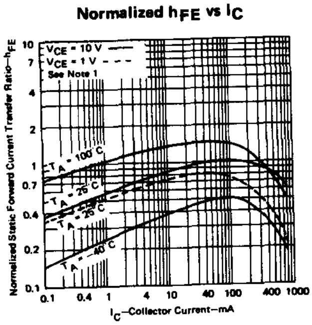


FIGURE 3

V_{BE} vs I_C

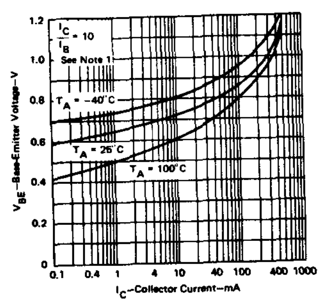


FIGURE 4

V_{BE} vs I_C

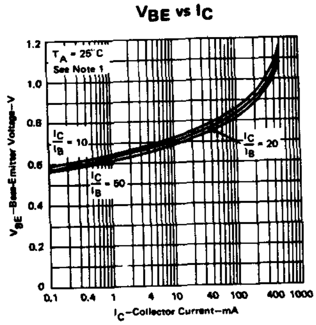


FIGURE 5

$V_{CE(sat)}$ vs I_C

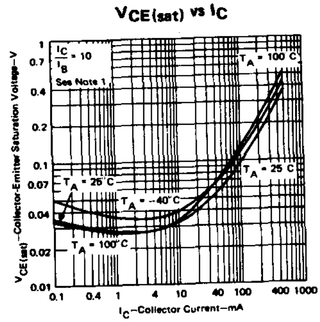


FIGURE 6

$V_{CE(sat)}$ vs I_C

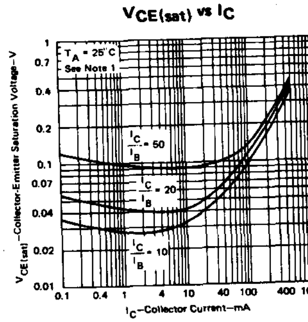


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

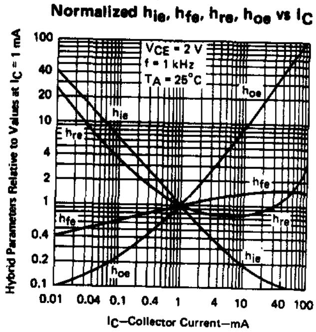


FIGURE 8

f_T vs I_C

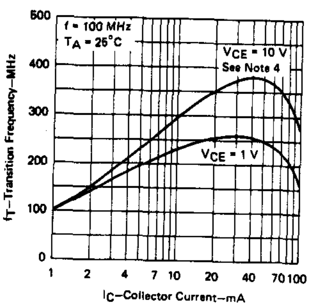


FIGURE 9

C_{obo}, C_{ibo}, C_{cb} vs V_R

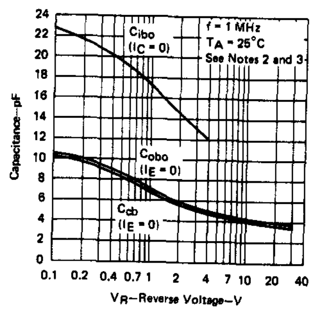


FIGURE 10

t_d vs I_C

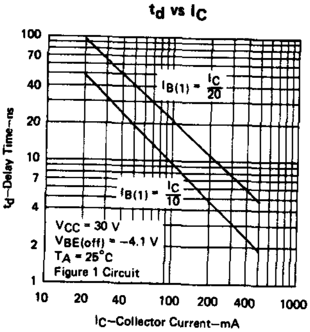


FIGURE 11

t_r vs I_C

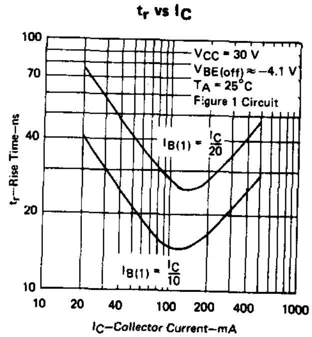


FIGURE 12

t_s vs I_C

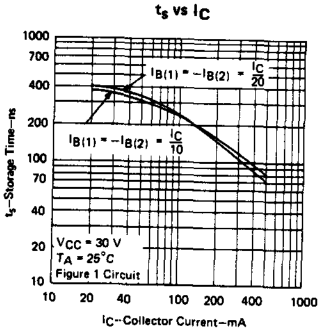


FIGURE 13

t_f vs I_C

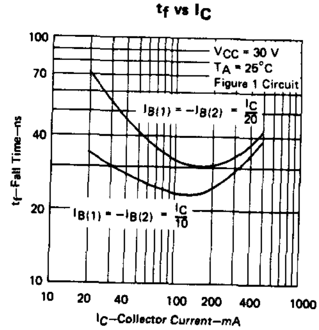


FIGURE 14

NOTES: 2. Capacitance measurements were made using chips mounted in TO-5 packages.

3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.

4. To avoid overheating the transistor, this parameter was measured with bias conditions applied for less than 5 seconds.

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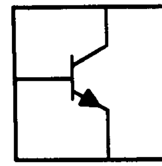
- N26 is a 10 X 12-mil, epitaxial, planar, expanded-contact chip
- Available in *Silect*† packages
- For use in high-frequency (to 500 MHz), low-noise, common-base amplifier circuits requiring forward AGC characteristics



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$, $I_E = 0$	40♦	55		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$, See Note 1	30♦	50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	4♦	5.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 10$ V, $I_E = 0$		<1	50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10$ V, $I_C = 4$ mA	30	100		
		$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 1		80		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10$ V, $I_C = 4$ mA		0.75	0.8	V
		$V_{CE} = 10$ V, $I_C = 10$ mA, See Note 1		0.8		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.4$ mA, $I_C = 4$ mA		0.65		V
		$I_B = 1$ mA, $I_C = 10$ mA, See Note 1		2.5		
f_T	Transition Frequency	$V_{CE} = 10$ V, $I_C = 4$ mA, f = 100 MHz	450	550		MHz
		$V_{CE} = 10$ V, $I_C = 10$ mA, f = 100 MHz		70		
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		0.9		pF
C_{ce}	Collector-Emitter Capacitance	$V_{CE} = 10$ V, $I_B = 0$, f = 1 MHz, See Notes 2 and 3		0.2	0.3	pF
$\|s_{fb}\|^2$	Square of Common-Base Forward Transmission Coefficient‡	$V_{CB} = 10$ V, $I_E = -4$ mA, $Z_G = Z_L = 50\ \Omega + j0$, See Note 2, f = 200 MHz		4		dB
		f = 400 MHz		3		
F	Spot Noise Figure	$V_{CE} = 10$ V, $I_C = 3$ mA, $R_G = 50\ \Omega$, f = 200 MHz		3	4	dB

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

‡$|s_{fb}|^2$ is equal to the insertion power gain of the transistor alone.

NOTES:
1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. Capacitance and s-parameter measurements were made using chips mounted in TIS125 packages.
3. C_{cb} and C_{ce} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or base, respectively) is connected to the guard terminal of the bridge.

5

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

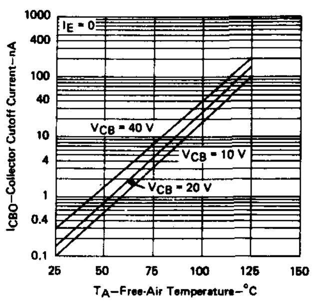


FIGURE 1

h_{FE} vs I_C

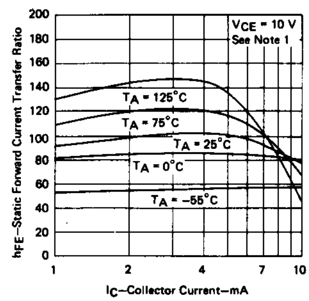


FIGURE 2

V_{BE} vs I_C

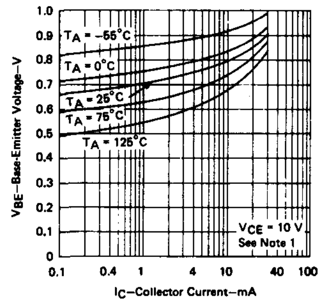


FIGURE 3

$V_{CE(sat)}$ vs I_C

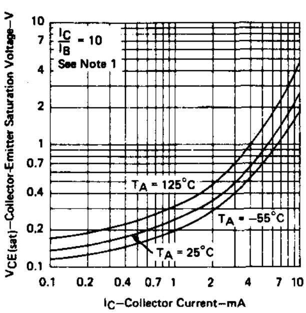


FIGURE 4

f_T vs I_C

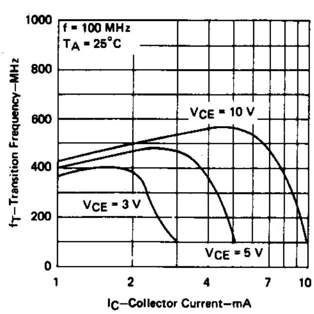


FIGURE 5

C_{cb}, C_{ce} vs V_R

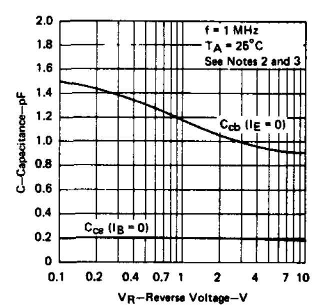


FIGURE 6

$|s_{fb}|^2$ vs f

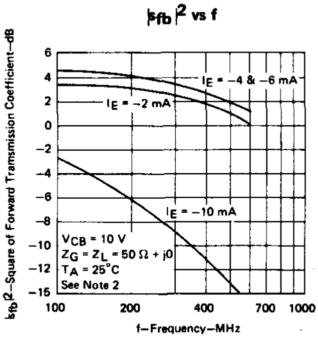


FIGURE 7

$|s_{rb}|^2$ vs f

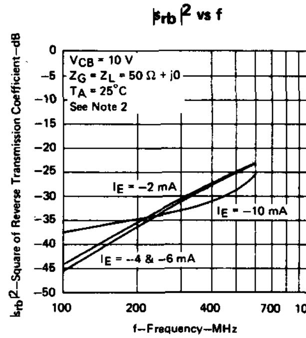
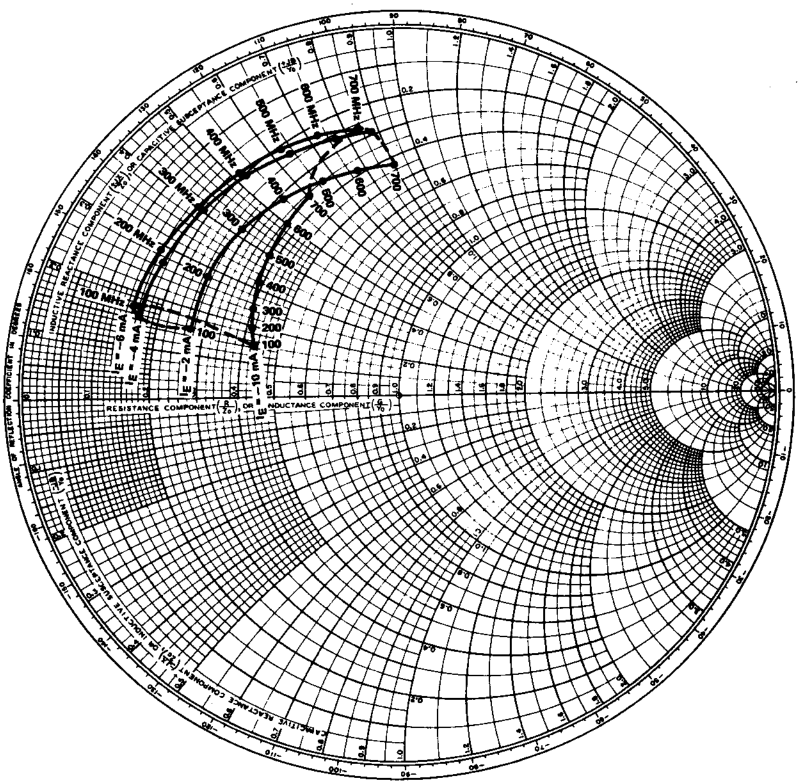


FIGURE 8

NOTES
1. These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. Capacitance and s-parameter measurements were made using chips mounted in TIS125 packages.
3. C_{cb} and C_{ce} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or base, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

COMMON-BASE INPUT REFLECTION COEFFICIENT, s_{ib}
and
NORMALIZED INPUT IMPEDANCE
V_{CB} = 10 V, Z_G = Z_L = 50 Ω + j0, T_A = 25°C



Frequency	I_E = −2 mA		I_E = −4 mA		I_E = −6 mA		I_E = −10 mA	
	$\lvert s_{ib}\rvert$	ϕ_{sib}	$\lvert s_{ib}\rvert$	ϕ_{sib}	$\lvert s_{ib}\rvert$	ϕ_{sib}	$\lvert s_{ib}\rvert$	ϕ_{sib}
100 MHz	0.58	161°	0.73	162°	0.75	160°	0.42	160°
200 MHz	0.61	147°	0.73	149°	0.75	147°	0.44	154°
300 MHz	0.62	132°	0.73	135°	0.74	135°	0.46	148°
400 MHz	0.62	119°	0.73	123°	0.74	124°	0.49	140°
500 MHz	0.62	108°	0.73	113°	0.74	114°	0.52	131°
600 MHz	0.63	99°	0.73	103°	0.74	106°	0.56	122°
700 MHz	0.63	90°	0.73	95°	0.74	98°	0.60	113°

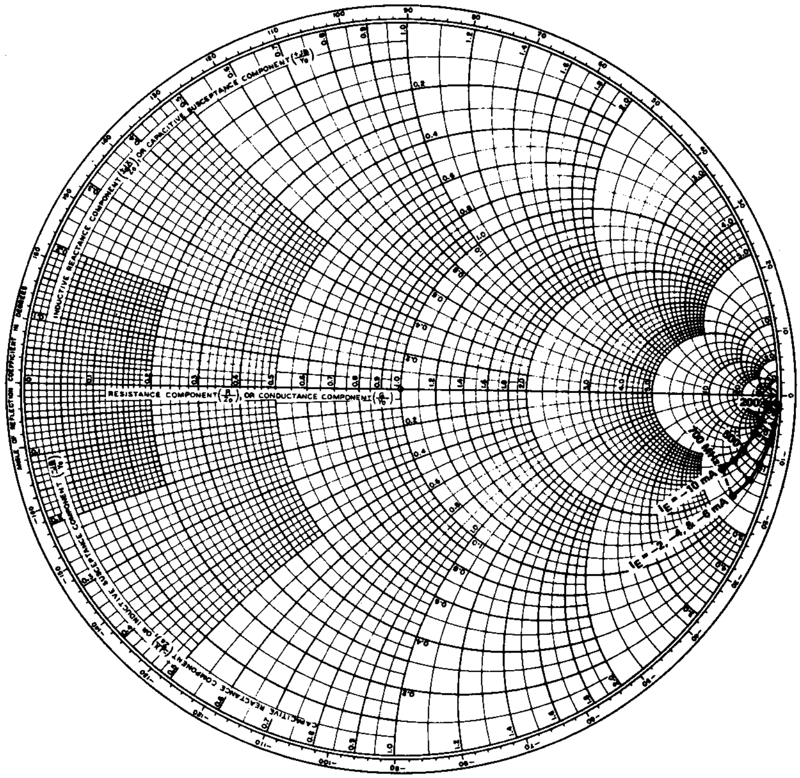
These measurements were made using chips mounted in TIS125 packages.

FIGURE 9

5

TYPICAL CHARACTERISTICS

COMMON-BASE OUTPUT REFLECTION COEFFICIENT, s_{ob}
and
NORMALIZED OUTPUT IMPEDANCE
$V_{CB} = 10$ V, $Z_G = Z_L = 50\ \Omega + j0$, $T_A = 25°C$



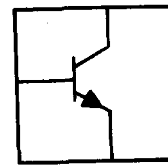
Frequency	$I_E = -2$ mA		$I_E = -4$ mA		$I_E = -6$ mA		$I_E = -10$ mA	
	$\lvert s_{ob} \rvert$	ϕ_{sob}	$\lvert s_{ob} \rvert$	ϕ_{sob}	$\lvert s_{ob} \rvert$	ϕ_{sob}	$\lvert s_{ob} \rvert$	ϕ_{sob}
200 MHz	0.99	−1°	0.99	−1°	0.99	−1°	0.97	−1°
300 MHz	0.99	−5°	0.99	−5°	0.99	−5°	0.96	−4°
400 MHz	0.99	−7°	0.99	−7°	0.99	−7°	0.94	−6°
500 MHz	0.98	−11°	0.98	−11°	0.98	−11°	0.93	−9°
600 MHz	0.96	−14°	0.96	−14°	0.96	−14°	0.91	−11°
700 MHz	0.93	−17°	0.93	−17°	0.93	−17°	0.88	−13°

These measurements were made using chips mounted in TIS125 packages.

FIGURE 10

CHIP TYPE N27
N-P-N SILICON TRANSISTORS

- **N27 is an 18 X 18-mil, epitaxial, planar, direct-contact chip**
- **Available in *Silect*† packages**
- **For use in high-voltage amplifier circuits**



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$, $I_E = 0$	160♦	190		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 1$ mA, $I_B = 0$, See Note 1	140♦	190		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$, $I_C = 0$	6♦	7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 100$ V, $I_E = 0$		<0.1	50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = 4$ V, $I_C = 0$		<0.1	50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 5$ V, $I_C = 1$ mA	50	85		
		$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 1	50	100	250	
		$V_{CE} = 5$ V, $I_C = 50$ mA, See Note 1	15	35		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 5$ V, $I_C = 10$ mA, See Note 1		0.7	1.0	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 1$ mA, $I_C = 10$ mA		0.12	0.2	V
		$I_B = 5$ mA, $I_C = 50$ mA, See Note 1		0.2	0.3	
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = 5$ V, $I_C = 10$ mA, $f = 1$ kHz		360		Ω
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		50	100	250	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			1.2×10^{-4}		
h_{oe}	Small-Signal Common-Emitter Output Admittance			28		µmho
f_T	Transition Frequency	$V_{CE} = 10$ V, $I_C = 10$ mA, $f = 20$ MHz	100	160		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10$ V, $I_E = 0$, $f = 1$ MHz, See Notes 2 and 3		1.7	4.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5$ V, $I_C = 0$, $f = 1$ MHz, See Notes 2 and 3		13	30	pF

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

2. Capacitance measurements were made using chips mounted in TO-92 packages.

3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

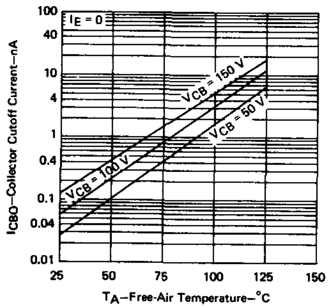


FIGURE 1

h_{FE} vs I_C

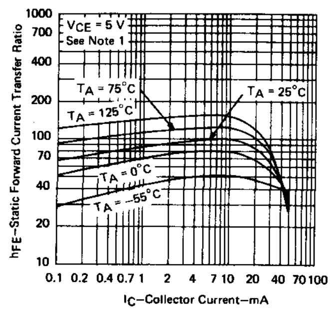


FIGURE 2

V_{BE} vs I_C

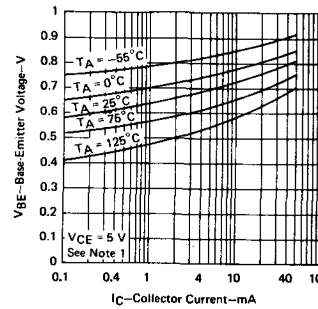


FIGURE 3

$V_{CE(sat)}$ vs I_C

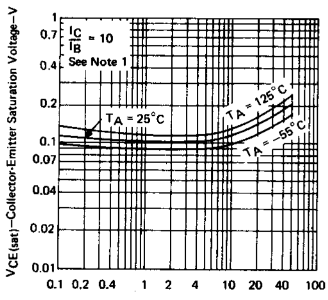


FIGURE 4

h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

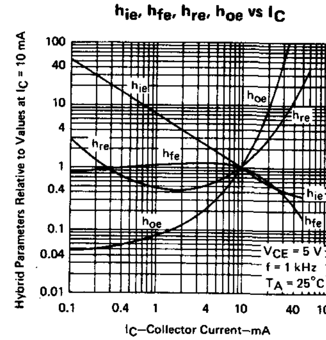


FIGURE 5

f_T vs I_C

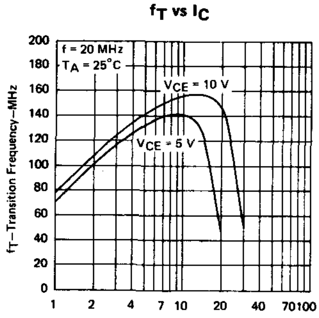


FIGURE 6

C_{cb} vs V_{CB}

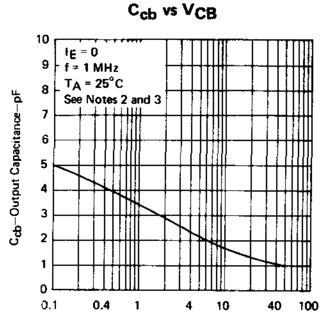


FIGURE 7

C_{eb} vs V_{EB}

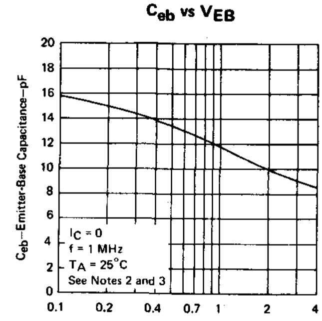


FIGURE 8

NOTES:
1. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ⩽ 2%.
2. Capacitance measurements were made using chips mounted in TO-92 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third-electrode (emitter or collector, respectively) is connected to the guard terminal fo the bridge.

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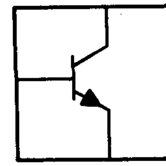
- N28 is an 11 X 15-mil, epitaxial, planar, expanded-contact chip
- Available in TO-72 and *Silect*† packages
- For use in UHF amplifier, oscillator, and mixer circuits requiring low noise and high gain



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10\ \mu A$,	$I_E = 0$		25♦	35		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 2$ mA,	$I_B = 0$,	See Note 1	13♦	20		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10\ \mu A$,	$I_C = 0$		3♦	5.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 6$ V,	$I_E = 0$			<0.1	10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 6$ V,	$I_C = 1$ mA			85		
		$V_{CE} = 6$ V,	$I_C = 5$ mA		20	95	300	
		$V_{CE} = 6$ V,	$I_C = 10$ mA	See Note 1		95		
		$V_{CE} = 6$ V,	$I_C = 20$ mA			85		
V_{BE}	Base-Emitter Voltage	$V_{CE} = 6$ V,	$I_C = 5$ mA	See Note 1		0.75	0.95	V
		$V_{CE} = 6$ V,	$I_C = 20$ mA			0.8		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 0.5$ mA,	$I_C = 5$ mA	See Note 1		0.07		V
		$I_B = 2$ mA,	$I_C = 20$ mA			0.12		
f_T	Transition Frequency	$V_{CE} = 6$ V,	$I_C = 5$ mA,	f = 400 MHz	1.0	1.7		GHz
$\lvert s_{fe}\rvert^2$	Square of Common-Emitter Forward Transmission Coefficient‡	$V_{CE} = 6$ V, $Z_G = Z_L = 50\ \Omega + j0$, See Note 2	$I_C = 10$ mA,	f = 400 MHz		11		dB
				f = 1 GHz		3.5		
C_{cb}	Collector-Base Capacitance	$V_{CB} = 6$ V,	$I_E = 0$	f = 1 MHz, See Notes 2 and 3		0.2	0.9	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5$ V,	$I_C = 0$			2		pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = 6$ V, See Note 2	$I_E = -5$ mA,	f = 79.8 MHz,		8	13	ps
F	Spot Noise Figure	$V_{CB} = 6$ V, $I_E = -2$ mA	$R_G = 100\ \Omega$,	f = 450 MHz		3.5	6	dB
			$R_G = 50\ \Omega$,	f = 1 GHz		6.5		

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

‡$\lvert s_{fb}\rvert^2$ is equal to the insertion power gain of the transistor alone.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance, $r_b'C_c$, and s-parameter measurements were made using chips mounted in TO-72 packages.

3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

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TYPICAL CHARACTERISTICS

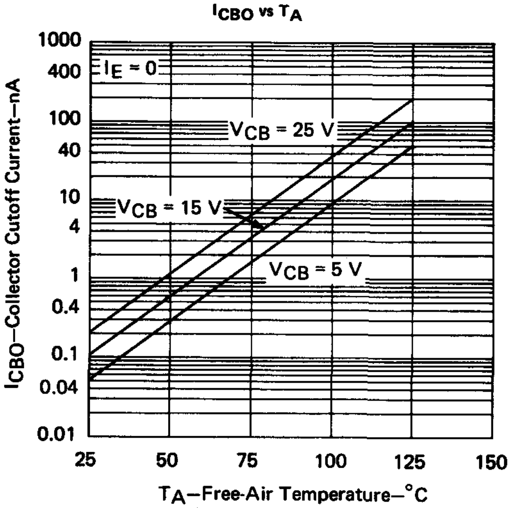

FIGURE 1

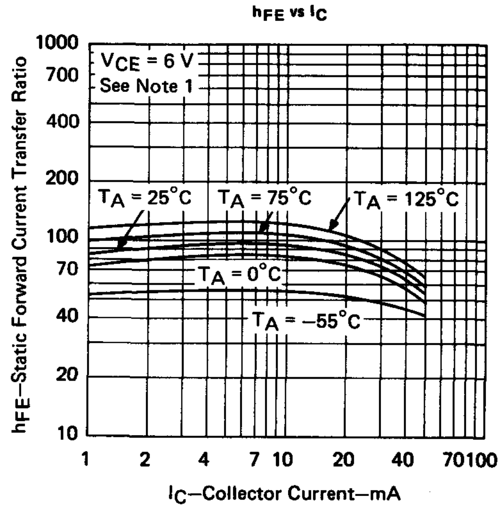

FIGURE 2

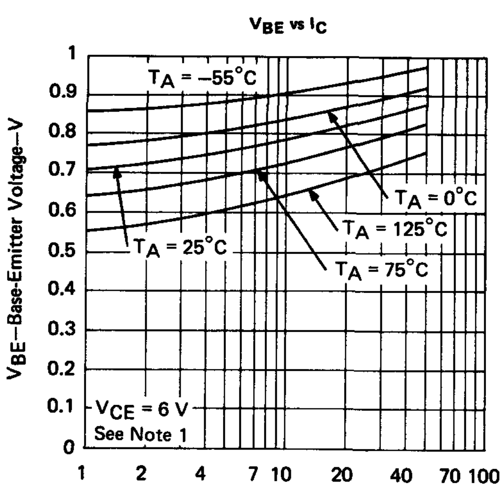

FIGURE 3

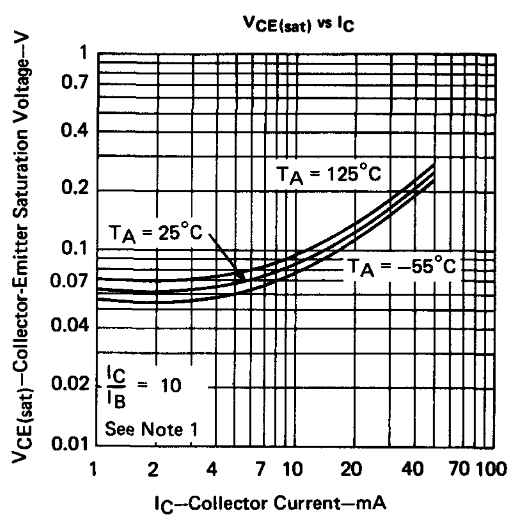

FIGURE 4

NOTE 1: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

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TYPICAL CHARACTERISTICS

f_T vs I_C

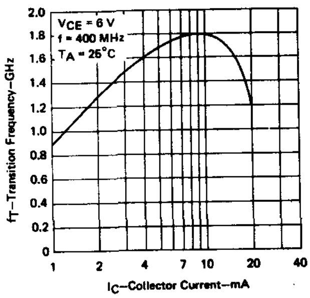


FIGURE 5

F vs f

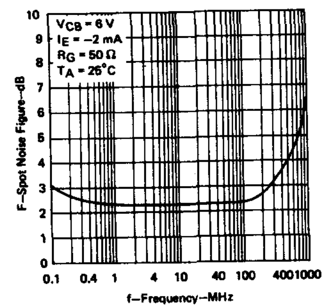


FIGURE 6

C_{cb} vs V_{CB}

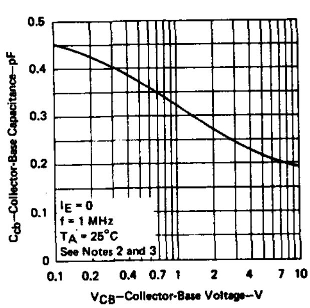


FIGURE 7

C_{eb} vs V_{EB}

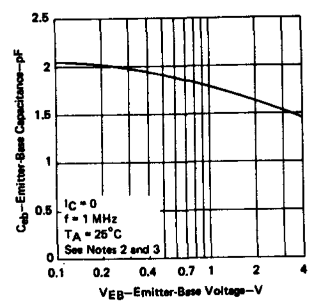


FIGURE 8

$|s_{fe}|^2$ vs f

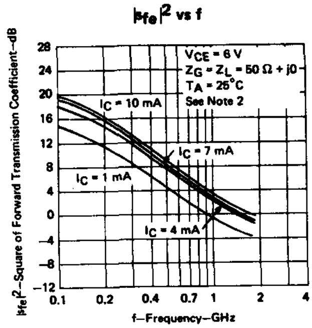


FIGURE 9

$|s_{re}|^2$ vs f

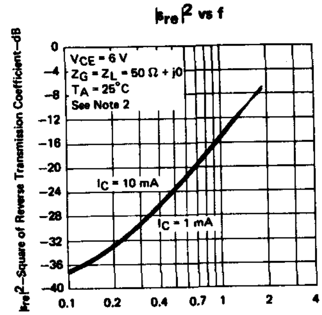
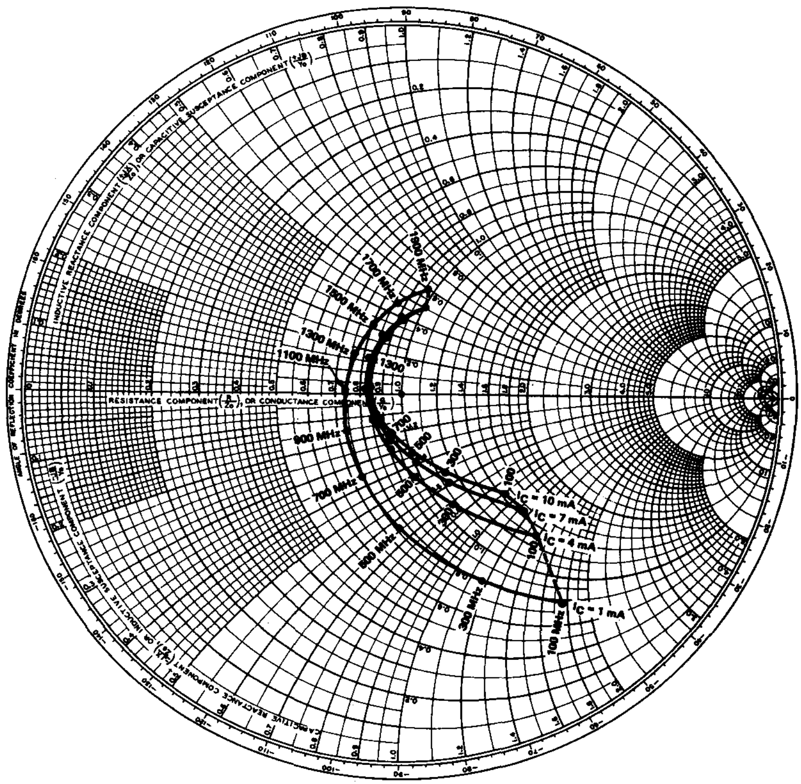


FIGURE 10

NOTES: 2. Capacitance, $r_b'C_c$, and s-parameter measurements were made using chips mounted in TO-72 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

COMMON-EMITTER INPUT REFLECTION COEFFICIENT, s_{ie}
and
NORMALIZED INPUT IMPEDANCE
V_{CE} = 6 V, Z_G = Z_L = 50 Ω + j0, T_A = 25°C



Frequency	I_C = 1 mA		I_C = 4 mA		I_C = 7 mA		I_C = 10 mA	
	$\lvert s_{ie}\rvert$	ϕ_{sie}	$\lvert s_{ie}\rvert$	ϕ_{sie}	$\lvert s_{ie}\rvert$	ϕ_{sie}	$\lvert s_{ie}\rvert$	ϕ_{sie}
100 MHz	0.71	−53°	0.53	−46°	0.46	−44°	0.39	−44°
300 MHz	0.55	−67°	0.33	−65°	0.27	−62°	0.25	−62°
500 MHz	0.36	−90°	0.22	−81°	0.19	−79°	0.17	−80°
700 MHz	0.25	−114°	0.15	−102°	0.13	−102°	0.11	−105°
900 MHz	0.18	−145°	0.10	−137°	0.09	−140°	0.08	−149°
1100 MHz	0.16	176°	0.10	176°	0.09	166°	0.09	160°
1300 MHz	0.17	139°	0.13	132°	0.13	130°	0.12	129°
1500 MHz	0.21	113°	0.17	110°	0.17	107°	0.17	106°
1700 MHz	0.25	93°	0.21	91°	0.21	90°	0.20	90°
1900 MHz	0.29	77°	0.25	76°	0.24	76°	0.23	76°

These measurements were made using chips mounted in TO-72 packages.

FIGURE 11

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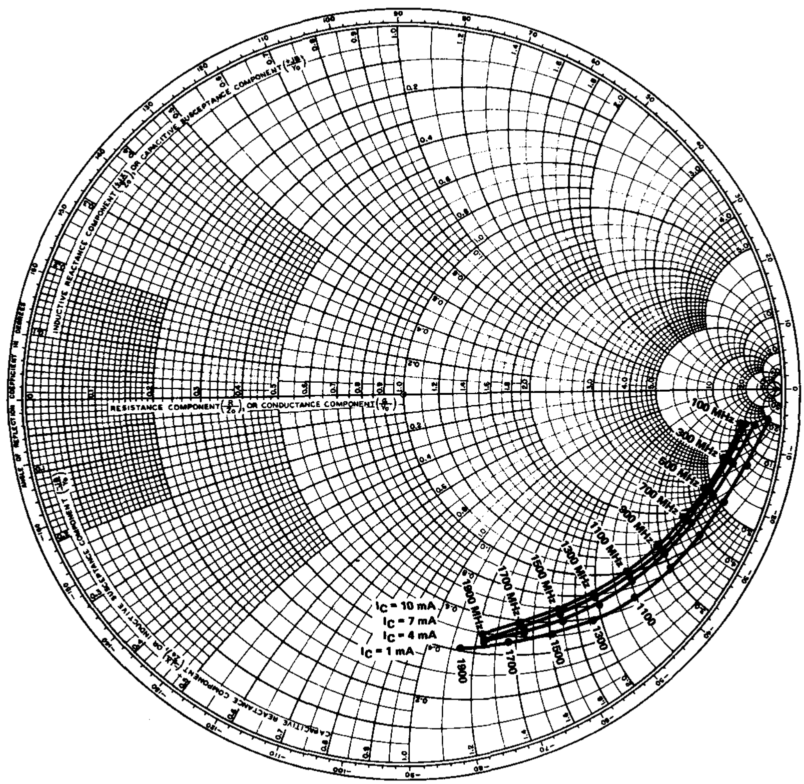
TYPICAL CHARACTERISTICS

COMMON-EMITTER OUTPUT REFLECTION COEFFICIENT, s_{oe}
and
NORMALIZED OUTPUT IMPEDANCE
V_{CE} = 6 V, Z_G = Z_L = 50 Ω + j0, T_A = 25°C



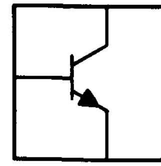
Frequency	I_C = 1 mA		I_C = 4 mA		I_C = 7 mA		I_C = 10 mA	
	$\|s_{oe}\|$	ϕ_{soe}	$\|s_{oe}\|$	ϕ_{soe}	$\|s_{oe}\|$	ϕ_{soe}	$\|s_{oe}\|$	ϕ_{soe}
100 MHz	0.97	−5°	0.93	−6°	0.91	−6°	0.90	−6°
300 MHz	0.93	−13°	0.89	−13°	0.88	−13°	0.87	−13°
500 MHz	0.90	−20°	0.86	−19°	0.85	−19°	0.84	−19°
700 MHz	0.87	−27°	0.84	−26°	0.83	−26°	0.82	−26°
900 MHz	0.85	−35°	0.82	−33°	0.80	−33°	0.79	−33°
1100 MHz	0.83	−43°	0.79	−41°	0.78	−41°	0.77	−41°
1300 MHz	0.80	−52°	0.77	−49°	0.75	−48°	0.74	−48°
1500 MHz	0.76	−60°	0.74	−57°	0.73	−56°	0.72	−56°
1700 MHz	0.73	−69°	0.72	−65°	0.71	−65°	0.70	−65°
1900 MHz	0.71	−79°	0.71	−74°	0.70	−74°	0.69	−74°

These measurements were made using chips mounted in TO-72 packages.

FIGURE 12

CHIP TYPE N29
N-P-N SILICON TRANSISTORS

- N29 is a 10 X 12-mil, epitaxial, planar, expanded-contact chip
- Available in *Silect*† packages
- For VHF mixers and IF amplifiers not requiring AGC characteristics



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 µA, I_E = 0	45◆	75		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 1 mA, I_B = 0, See Note 1	30◆	55		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 100 µA, I_C = 0	4◆	5		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 30 V, I_E = 0		<0.1	50	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 15 V, I_C = 1 mA	20	65		
		V_{CE} = 15 V, I_C = 10 mA, See Note 1	25	75		
V_{BE}	Base-Emitter Voltage	V_{CE} = 15 V, I_C = 10 mA, See Note 1	0.55	0.8	0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 3 mA, I_C = 30 mA		0.15	0.5	V
f_T	Transition Frequency	V_{CE} = 15 V, I_C = 10 mA, f = 100 MHz	600	800		MHz
$\frac{f_{T(2)}}{f_{T(1)}}$	Ratio of Transition Frequencies	V_{CE} = 15 V, $I_{C(1)}$ = 15 mA, $I_{C(2)}$ = 20 mA, f = 100 MHz	0.66	0.85		
$\|s_{fe}\|^2$	Square of Common-Emitter Forward Transmission Coefficient‡	V_{CE} = 10 V, $Z_G = Z_L$ = 50 Ω + j0, f = 200 MHz, See Note 2; I_C = 4 mA		12		dB
		I_C = 8 mA		12.5		dB
		I_C = 15 mA		13		dB
C_{cb}	Collector-Base Capacitance	V_{CB} = 10 V, I_E = 0, f = 1 MHz, See Notes 2 and 3		0.30	0.36	pF
C_{eb}	Emitter-Base Capacitance	V_{EB} = 0.5 V, I_C = 0, f = 1 MHz, See Notes 2 and 3		1.8		pF
$r_b'C_c$	Collector-Base Time Constant	V_{CB} = 15 V, I_E = −4 mA, f = 79.8 MHz, See Note 2		7	10	ps
F	Spot Noise Figure	V_{CE} = 15 V, I_C = 4 mA, R_G = 50 Ω, f = 200 MHz		4	5	dB

†Trademark of Texas Instruments
◆These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.
‡$|s_{fe}|^2$ is equal to the insertion power gain of the transistor alone.

NOTES:
1. These parameters were measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%.
2. Capacitance, $r_b'C_c$, and s-parameter measurements were made using chips mounted in TIS126 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

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TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

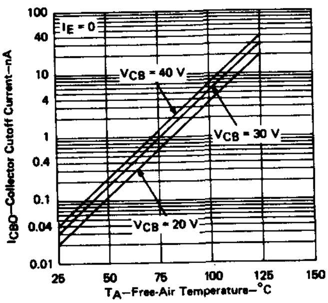


FIGURE 1

h_{FE} vs I_C

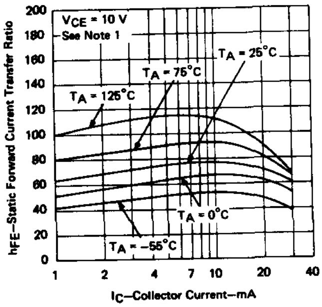


FIGURE 2

V_{BE} vs I_C

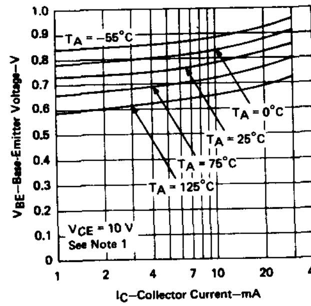


FIGURE 3

$V_{CE(sat)}$ vs I_C

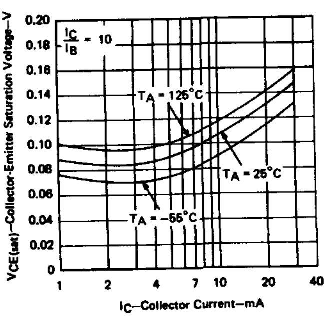


FIGURE 4

f_T vs I_C

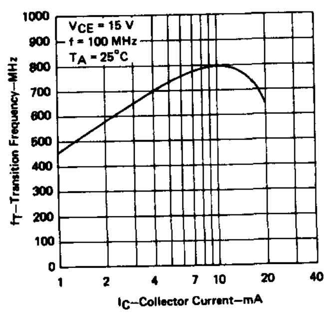


FIGURE 5

C_{cb} vs V_{CB}

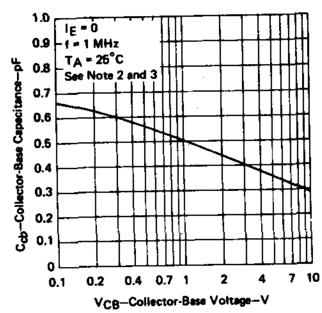


FIGURE 6

C_{eb} vs V_{EB}

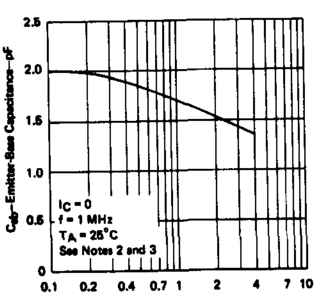


FIGURE 7

$|s_{fe}|^2$ vs f

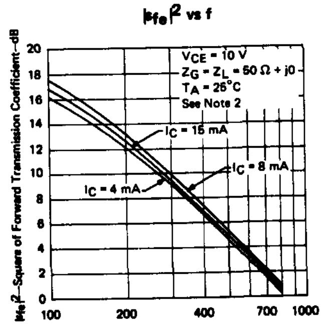


FIGURE 8

$|s_{re}|^2$ vs f

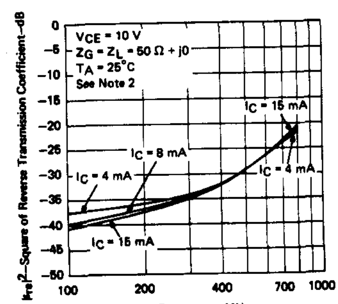
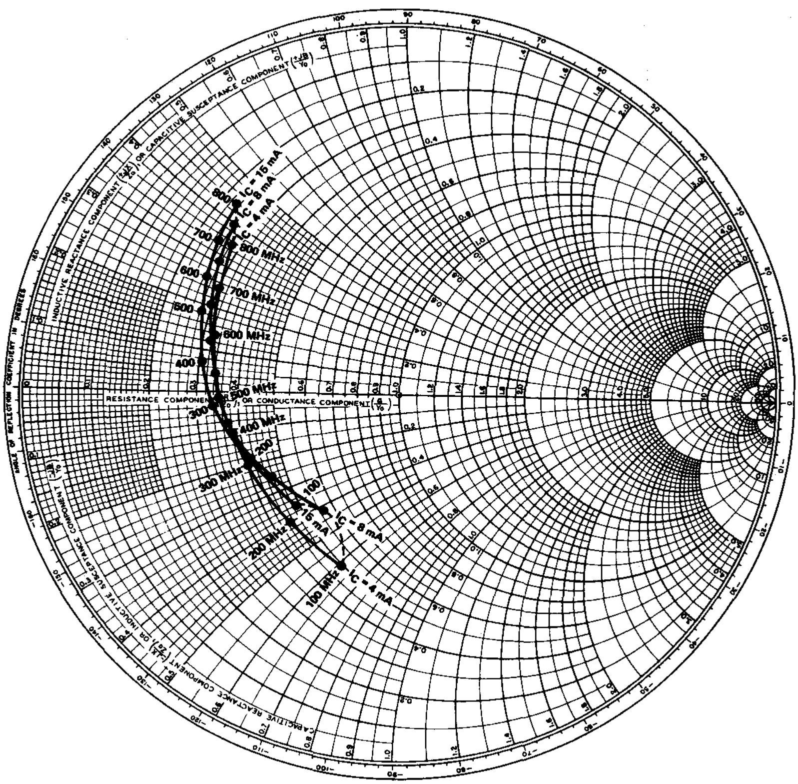


FIGURE 9

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
2. Capacitance, $r_b'C_c$, and s-parameter measurements were made using chips mounted in TIS126 packages.

TYPICAL CHARACTERISTICS

COMMON-EMITTER INPUT REFLECTION COEFFICIENT, s_{ie}
and
NORMALIZED INPUT IMPEDANCE
V_{CE} = 10 V, Z_G = Z_L = 50 Ω + j0, T_A = 25°C



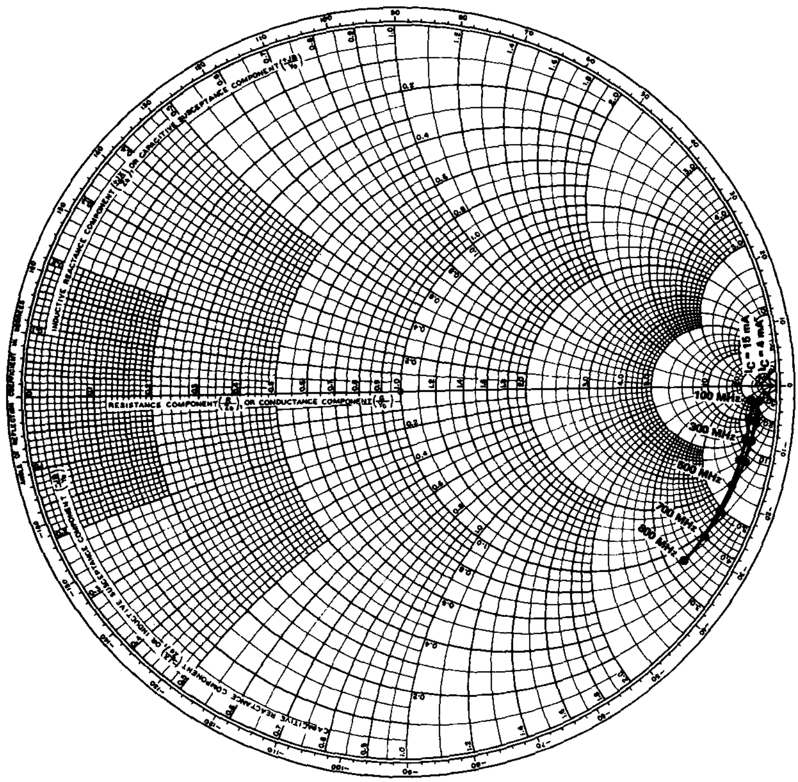
Frequency	I_C = 4 mA		I_C = 8 mA		I_C = 15 mA	
	$\lvert s_{ie}\rvert$	ϕ_{sie}	$\lvert s_{ie}\rvert$	ϕ_{sie}	$\lvert s_{ie}\rvert$	ϕ_{sie}
100 MHz	0.50	−107°	0.37	−121°	0.41	−131°
200 MHz	0.45	−129°	0.41	−145°	0.44	−155°
300 MHz	0.45	−153°	0.46	−169°	0.50	−176°
400 MHz	0.46	−165°	0.49	175°	0.54	171°
500 MHz	0.48	−178°	0.53	165°	0.58	158°
600 MHz	0.52	162°	0.56	155°	0.61	149°
700 MHz	0.56	150°	0.60	144°	0.64	140°
800 MHz	0.61	139°	0.65	134°	0.68	130°

These measurements were made using chips mounted in TIS126 packages.

FIGURE 10

TYPICAL CHARACTERISTICS

COMMON-EMITTER OUTPUT REFLECTION COEFFICIENT, s_{oe}
and
NORMALIZED OUTPUT IMPEDANCE
$V_{CE} = 10$ V, $Z_G = Z_L = 50\ \Omega + j0$, $T_A = 25°C$



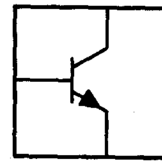
Frequency	$I_C = 4$ mA		$I_C = 8$ mA		$I_C = 15$ mA	
	$\|s_{oe}\|$	ϕ_{soe}	$\|s_{oe}\|$	ϕ_{soe}	$\|s_{oe}\|$	ϕ_{soe}
100 MHz	0.96	−2°	0.95	−2°	0.93	−2°
200 MHz	0.95	−6°	0.95	−6°	0.93	−5°
300 MHz	0.94	−9°	0.94	−9°	0.92	−9°
400 MHz	0.93	−12°	0.93	−12°	0.92	−12°
500 MHz	0.92	−17°	0.92	−17°	0.92	−17°
600 MHz	0.91	−21°	0.91	−21°	0.91	−21°
700 MHz	0.90	−27°	0.90	−27°	0.90	−27°
800 MHz	0.88	−32°	0.88	−32°	0.88	−32°

These measurements were made using chips mounted in TIS126 packages.

FIGURE 11

CHIP TYPE N30
N-P-N SILICON TRANSISTORS

- N30 is a 10 X 12-mil, epitaxial, planar, expanded-contact chip
- Available in *Silect*† packages
- For use in VHF/UHF common-base oscillator and amplifier circuits



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 100 µA,	I_E = 0		40◆	55		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 1 mA,	I_B = 0,	See Note 1	25◆	40		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 µA,	I_C = 0		4◆	5.5		V
I_{CBO}	Collector Cutoff Current	V_{CB} = 25 V,	I_E = 0			<0.1	100	nA
h_{FE}	Static Forward Current Transfer Ratio	V_{CE} = 10 V,	I_C = 4 mA	See Note 1	60	150		
		V_{CE} = 10 V,	I_C = 10 mA			155		
V_{BE}	Base-Emitter Voltage	V_{CE} = 10 V,	I_C = 4 mA,	See Note 1		0.75	0.9	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_B = 1 mA,	I_C = 10 mA,	See Note 1		0.1	0.5	V
f_T	Transition Frequency	V_{CE} = 10 V,	I_C = 4 mA,	f = 100 MHz	0.8			GHz
		V_{CE} = 10 V,	I_C = 10 mA,	f = 400 MHz		1.8		
$\lvert s_{fe}\rvert^2$	Square of Common-Emitter Forward Transmission Coefficient‡	V_{CE} = 10 V, See Note 2	I_C = 4 mA,	f = 400 MHz,		10		dB
C_{cb}	Collector-Base Capacitance	V_{CB} = 10 V,	I_E = 0	f = 1 MHz, See Notes 2 and 3		0.6	0.9	pF
C_{ce}	Collector-Emitter Capacitance	V_{CE} = 10 V,	I_B = 0			0.3	0.4	pF
$r_b'C_c$	Collector-Base Time Constant	V_{CB} = 10 V, See Note 2	I_E = −10 mA,	f = 79.8 MHz,		6	9	ps

†*Trademark of Texas Instruments*

◆These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

‡ $\lvert s_{fe}\rvert^2$ is equal to the insertion power gain of the transistor alone.

NOTES: 1. These parameters were measured using pulse techniques. t_w = 300 µs, duty cycle ≤ 2%.
2. Capacitance, $r_b'C_c$, and s-parameter measurements were made using chips mounted in *Silect* packages.
3. C_{cb} and C_{ce} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or base, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

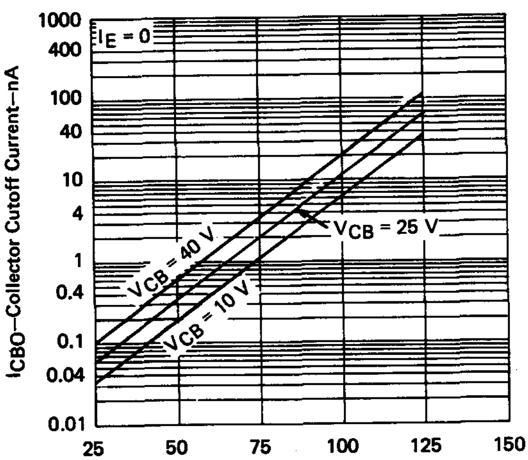


FIGURE 1

h_{FE} vs I_C

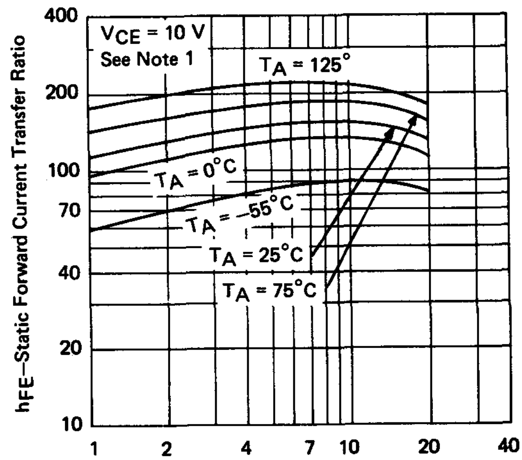


FIGURE 2

V_{BE} vs I_C

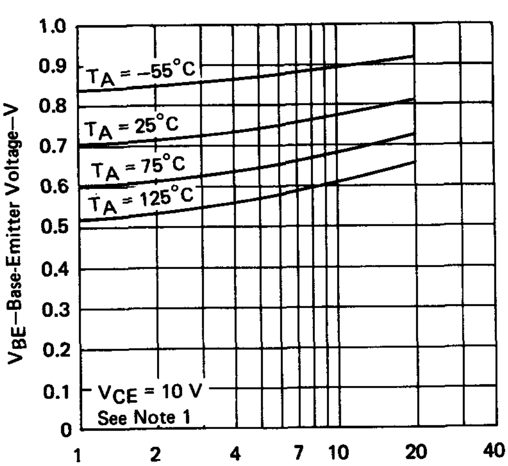


FIGURE 3

$V_{CE(sat)}$ vs I_C

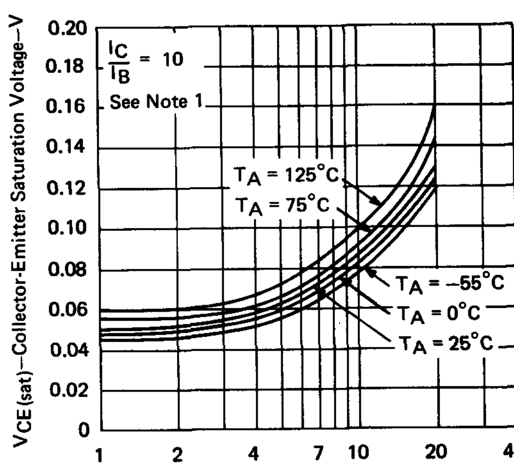


FIGURE 4

NOTE 1: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

CHIP TYPE N30
N-P-N SILICON TRANSISTORS

TYPICAL CHARACTERISTICS

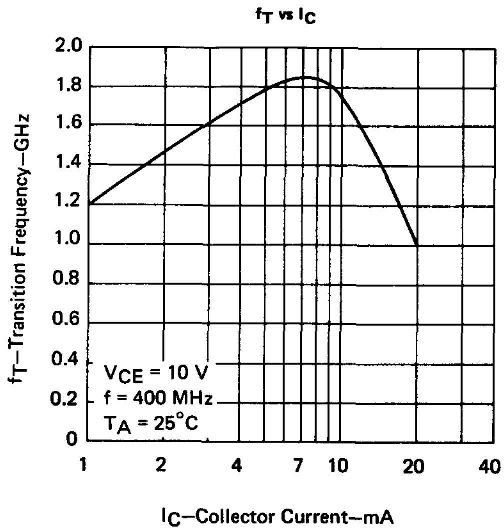


FIGURE 5

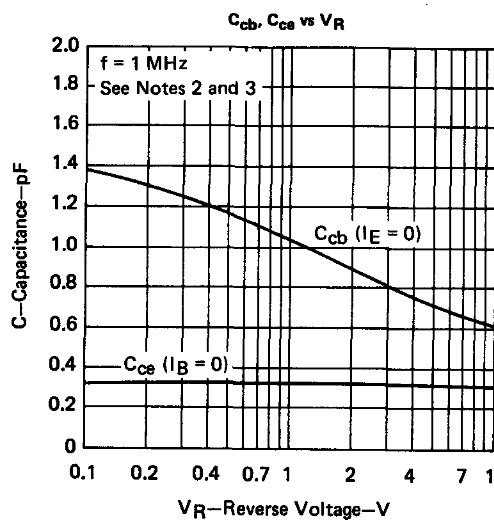


FIGURE 6

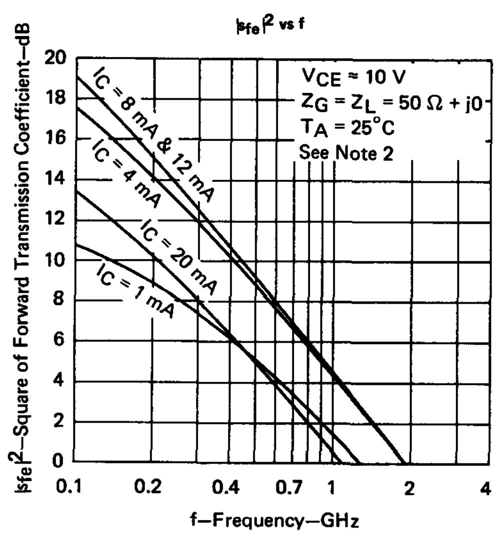


FIGURE 7

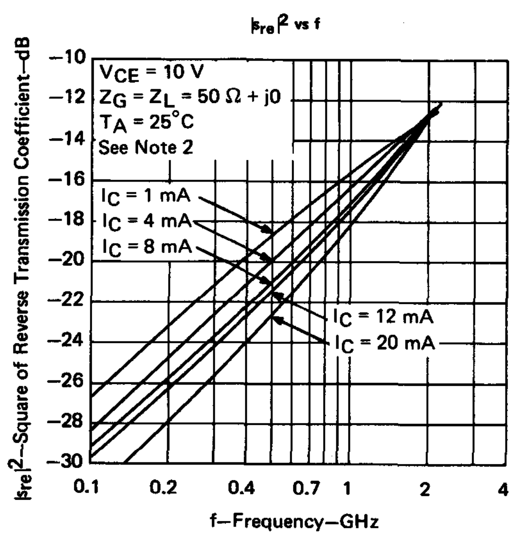


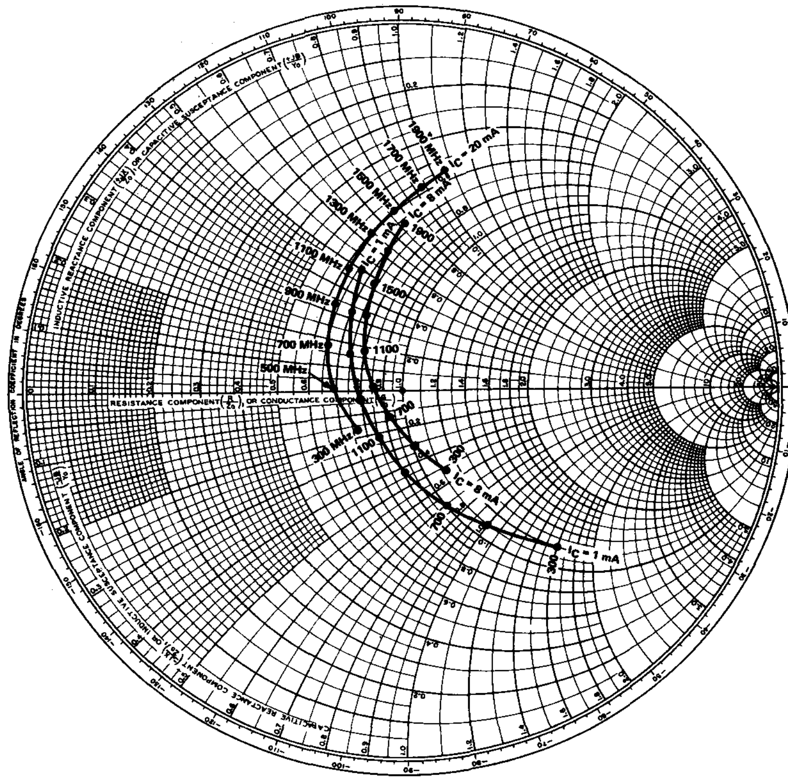
FIGURE 8

NOTES: 2. Capacitance, $r_b'C_c$, and s-parameter measurements were made using chips mounted in *Silect* packages.

3. C_{cb} and C_{ce} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or base, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

COMMON-EMITTER INPUT REFLECTION COEFFICIENT, s_{ie}
and
NORMALIZED INPUT IMPEDANCE
V_{CE} = 10 V, Z_G = Z_L = 50 Ω + j0, T_A = 25°C



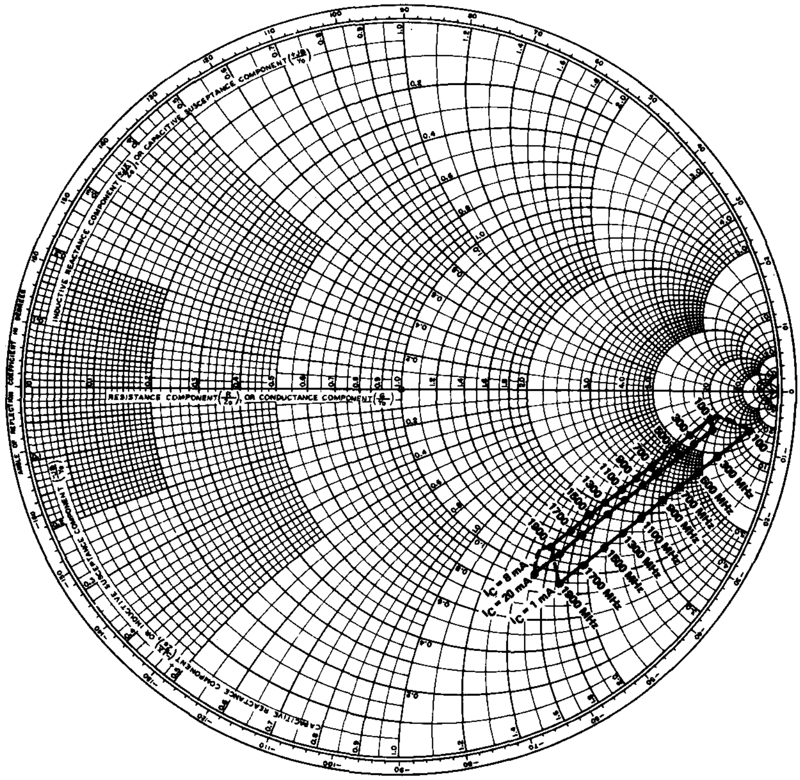
Frequency	I_C = 1 mA		I_C = 4 mA		I_C = 8 mA		I_C = 12 mA		I_C = 20 mA	
	$\|s_{ie}\|$	ϕ_{sie}	$\|s_{ie}\|$	ϕ_{sie}	$\|s_{ie}\|$	ϕ_{sie}	$\|s_{ie}\|$	ϕ_{sie}	$\|s_{ie}\|$	ϕ_{sie}
300 MHz	0.60	−46°	0.35	−55°	0.25	−64°	0.20	−73°	0.16	−139°
500 MHz	0.43	−60°	0.24	−66°	0.15	−82°	0.12	−107°	0.18	180°
700 MHz	0.33	−71°	0.15	−84°	0.09	−119°	0.09	−166°	0.23	148°
900 MHz	0.23	−89°	0.08	−122°	0.08	171°	0.13	145°	0.30	127°
1100 MHz	0.15	−118°	0.09	164°	0.15	132°	0.20	122°	0.36	113°
1300 MHz	0.12	−168°	0.16	126°	0.23	115°	0.28	107°	0.44	100°
1500 MHz	0.17	144°	0.24	110°	0.31	103°	0.35	98°	0.49	92°
1700 MHz	0.25	122°	0.33	100°	0.38	96°	0.43	91°	0.56	85°
1900 MHz	0.35	109°	0.41	93°	0.46	89°	0.50	85°	0.61	79°

These measurements were made using chips mounted in *Silect* packages.

FIGURE 9

TYPICAL CHARACTERISTICS

COMMON-EMITTER OUTPUT REFLECTION COEFFICIENT, s_{oe}
and
NORMALIZED OUTPUT IMPEDANCE
V_{CE} = 10 V, $Z_G = Z_L$ = 50 Ω + j0, T_A = 25°C



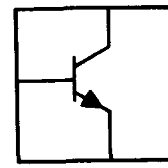
Frequency	I_C = 1 mA		I_C = 4 mA		I_C = 8 mA		I_C = 12 mA		I_C = 20 mA	
	$\lvert s_{oe} \rvert$	ϕ_{soe}	$\lvert s_{oe} \rvert$	ϕ_{soe}	$\lvert s_{oe} \rvert$	ϕ_{soe}	$\lvert s_{oe} \rvert$	ϕ_{soe}	$\lvert s_{oe} \rvert$	ϕ_{soe}
100 MHz	0.94	−7°	0.83	−6°	0.83	−5°	0.82	−5°	0.84	−7°
300 MHz	0.86	−12°	0.79	−10°	0.79	−9°	0.79	−9°	0.80	−10°
500 MHz	0.82	−16°	0.75	−13°	0.74	−13°	0.74	−13°	0.77	−13°
700 MHz	0.79	−20°	0.71	−18°	0.70	−17°	0.69	−17°	0.72	−18°
900 MHz	0.76	−24°	0.68	−22°	0.67	−21°	0.67	−21°	0.70	−22°
1100 MHz	0.73	−29°	0.66	−26°	0.65	−25°	0.65	−25°	0.67	−27°
1300 MHz	0.71	−34°	0.64	−31°	0.63	−29°	0.63	−30°	0.65	−32°
1500 MHz	0.70	−39°	0.62	−36°	0.61	−35°	0.61	−35°	0.63	−39°
1700 MHz	0.68	−45°	0.61	−42°	0.59	−41°	0.59	−41°	0.62	−47°
1900 MHz	0.68	−52°	0.60	−49°	0.59	−48°	0.59	−48°	0.62	−55°

These measurements were made using chips mounted in *Silect* packages.

FIGURE 10

CHIP TYPE N31
N-P-N SILICON TRANSISTORS

- N31 is a 26 X 26-mil, epitaxial, planar, direct-contact chip
- Available in TO-39 and *Silect*† packages
- For use in high-voltage amplifier circuits



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 100\ \mu A$,	$I_E = 0$		250♦	350		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10\ mA$,	$I_B = 0$,	See Note 1	250♦	350		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 100\ \mu A$,	$I_C = 0$		6♦	9.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 100\ V$,	$I_E = 0$			<0.1	50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = 10\ V$,	$I_C = 4\ mA$		20	165		
		$V_{CE} = 10\ V$,	$I_C = 20\ mA$	See Note 1	30	185	300	
		$V_{CE} = 10\ V$,	$I_C = 40\ mA$		30	150	200	
V_{BE}	Base-Emitter Voltage	$V_{CE} = 10\ V$,	$I_C = 20\ mA$,	See Note 1		0.7	1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = 2\ mA$,	$I_C = 20\ mA$,	See Note 1		0.11	1	V
f_T	Transition Frequency	$V_{CE} = 20\ V$,	$I_C = 20\ mA$,	f = 20 MHz	70	125		MHz
C_{cb}	Collector-Base Capacitance	$V_{CB} = 10\ V$,	$I_E = 0$	f = 1 MHz, See Notes 2 and 3		2.5	3.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = 0.5\ V$,	$I_C = 0$			25		pF

5

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

2. Capacitance measurements were made using chips mounted in TO-39 packages.

3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

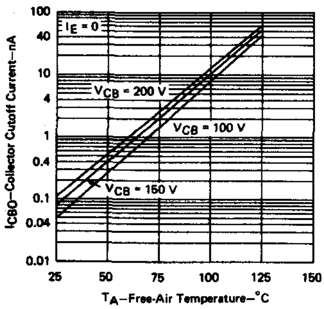


FIGURE 1

h_{FE} vs I_C

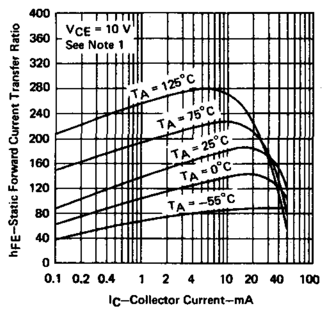


FIGURE 2

V_{BE} vs I_C

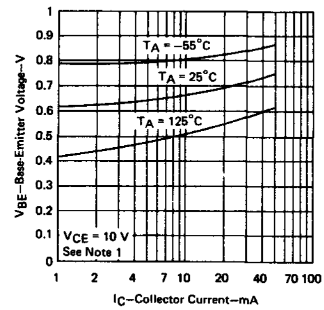


FIGURE 3

$V_{CE(sat)}$ vs I_C

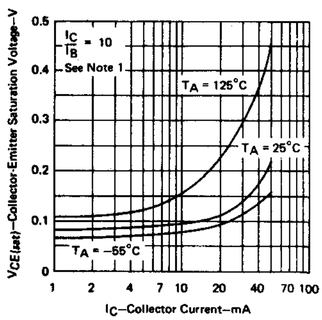


FIGURE 4

f_T vs I_C

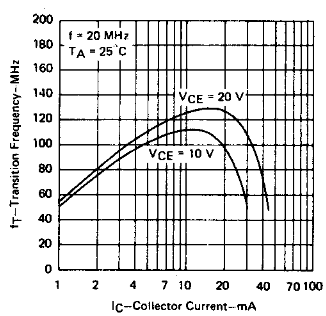


FIGURE 5

C_{cb} vs V_{CB}

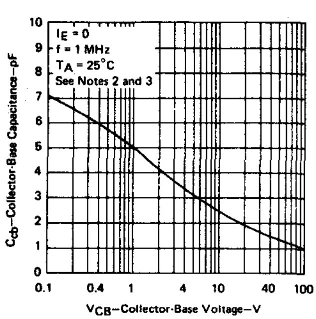


FIGURE 6

C_{eb} vs V_{EB}

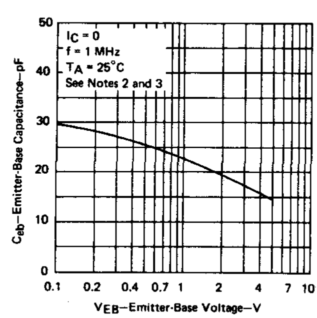


FIGURE 7

NOTES: 1. This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.
2. Capacitance measurements were made using chips mounted in TO-39 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

TEXAS INSTRUMENTS
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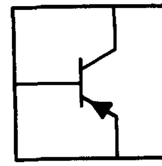
- P11 is a 13 X 21-mil, epitaxial, planar, expanded-contact chip
- Available in TO-18 packages
- For use in high-speed, medium-current switching circuits



electrical and operating characteristics at 25°C free-air temperature

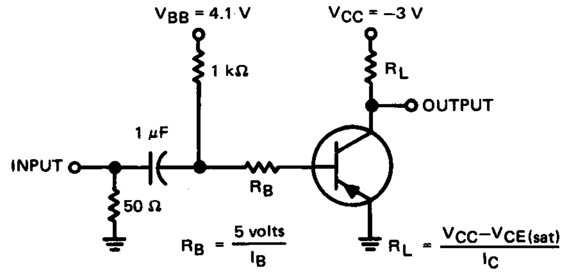
	PARAMETER	CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$		−18♦	−30		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA,	$I_B = 0$	See Note 1	−12♦	−17		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−5♦	−7.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -10$ V,	$I_E = 0$			−<0.1	−10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.5$ V,	$I_C = -10$ mA	See Note 1	40	75	200	
		$V_{CE} = -0.5$ V,	$I_C = -30$ mA		30	60		
		$V_{CE} = -1$ V,	$I_C = -100$ mA		10	40		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA,	$I_C = -10$ mA	See Note 1	−0.75	−0.8	−1.0	V
		$I_B = -10$ mA,	$I_C = -100$ mA			−1	−1.25	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA,	$I_C = -10$ mA	See Note 1		−0.07	−0.15	V
		$I_B = -10$ mA,	$I_C = -100$ mA			−0.25	−0.5	
f_T	Transition Frequency	$V_{CE} = -1$ V,	$I_C = -10$ mA,	f = 100 MHz		600		MHz
		$V_{CE} = -10$ V,	$I_C = -10$ mA,	f = 100 MHz	400			
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, See Note 2	$I_E = 0$,	f = 1 MHz,		3.3	6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, See Note 2	$I_C = 0$,	f = 1 MHz,		3.1	6	pF
t_d	Delay Time	$V_{CC} = -3$ V,	$I_C \approx -10$ mA,	2N3576 Data Sheet Circuit		9		ns
t_r	Rise Time	$I_{B(1)} \approx -1$ mA,	$V_{BE(off)} \approx 0$			12		
t_s	Storage Time	$V_{CC} = -3$ V,	$I_C \approx -10$ mA,			23		
t_f	Fall Time	$I_{B(1)} \approx -1$ mA,	$I_{B(2)} \approx 1$ mA			16		
t_d	Delay Time	$V_{CC} = -3$ V, $I_{B(2)} \approx 1$ mA,	$I_C \approx -10$ mA, $V_{BE(off)} \approx 4.1$ V,	$I_{B(1)} \approx -1$ mA, See Figure 1		25		ns
t_r	Rise Time					12		
t_s	Storage Time					23		
t_f	Fall Time					16		

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

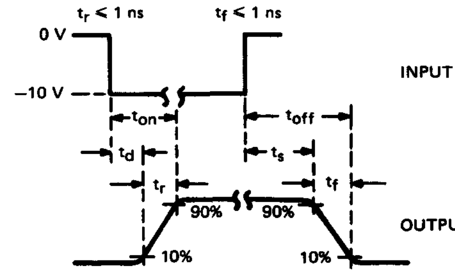
NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-18 packages.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_w \approx$ 200 ns, duty cycle ≤ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \approx$ 1 ns, $R_{in} \geq$ 100 kΩ, $C_{in} \leq$ 7 pF.

FIGURE 1–SWITCHING TIMES

TYPICAL CHARACTERISTICS

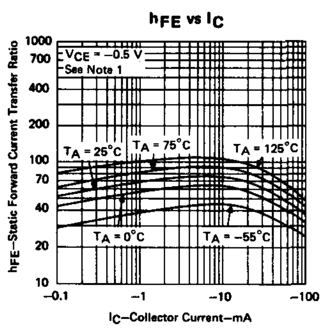


FIGURE 2

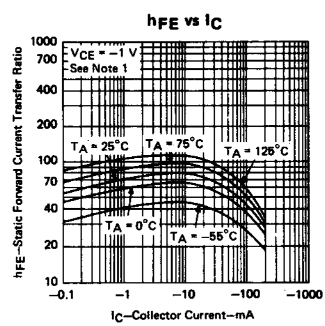


FIGURE 3

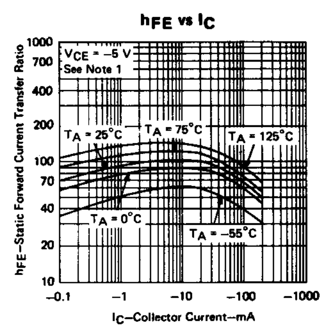


FIGURE 4

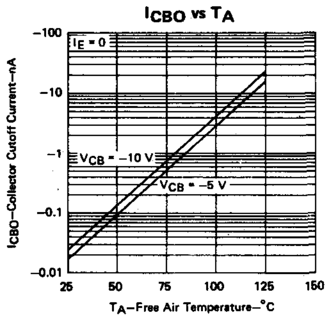


FIGURE 5

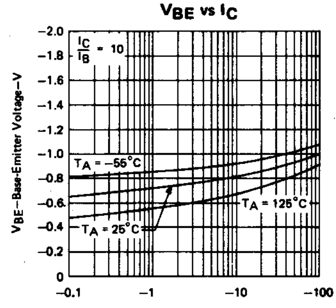


FIGURE 6

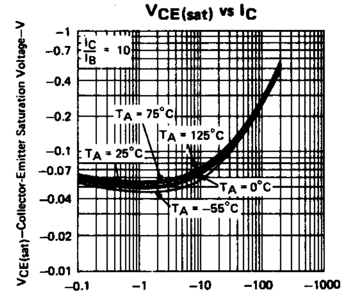


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

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TYPICAL CHARACTERISTICS

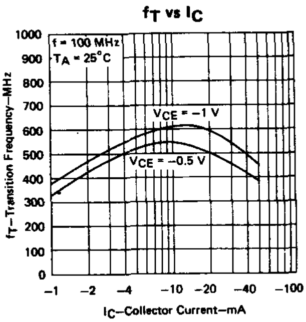


FIGURE 8

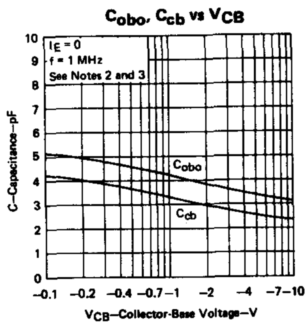


FIGURE 9

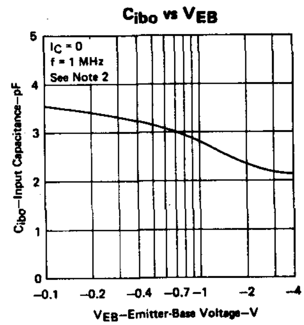


FIGURE 10

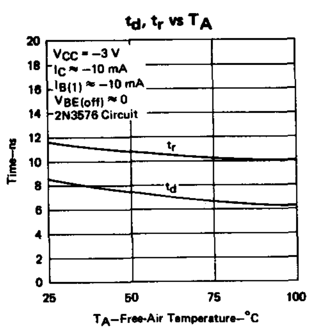


FIGURE 11

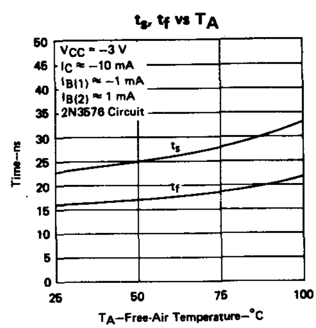


FIGURE 12

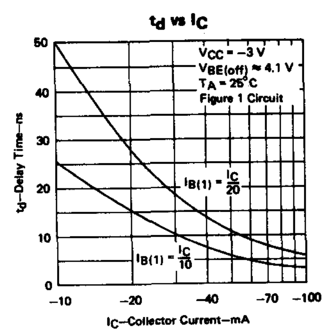


FIGURE 13

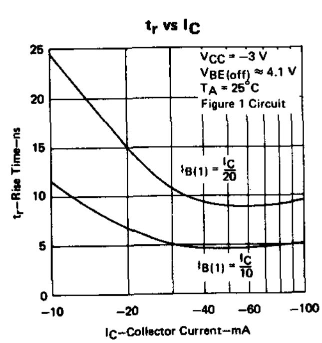


FIGURE 14

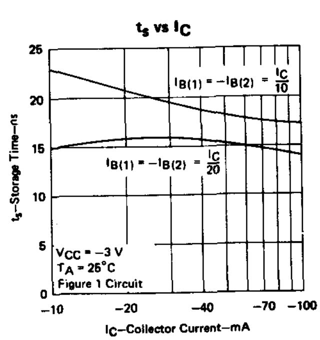


FIGURE 15

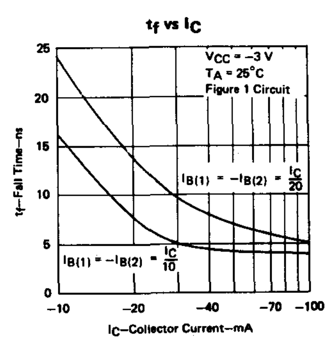
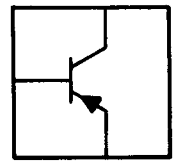


FIGURE 16

NOTES: 2. Capacitance measurements were made using chips mounted in TO-18 packages.
3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge. C_{obo} measurement is made with the third terminal floating.

CHIP TYPE P12
P-N-P SILICON TRANSISTORS

- P12 is a 26 X 26-mil, epitaxial, planar, direct-contact chip
- Available in TO-39 or plastic dual-in-line quad packages
- For use as a high-speed, high-current memory-core driver or other medium-current (to 1.5 A) switching circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$		−40♦	−70		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10\ mA$,	$I_B = 0$,	See Note 1	−40♦	−50		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−5♦	8		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -20\ V$,	$I_E = 0$			−10	−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4\ V$,	$I_C = 0$			−<10	−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1\ V$,	$I_C = -150\ mA$	See Note 1	25	70		
		$V_{CE} = -1\ V$,	$I_C = -500\ mA$		25	40	150	
		$V_{CE} = -5\ V$,	$I_C = -750\ mA$		20	50		
		$V_{CE} = -5\ V$,	$I_C = -1\ A$		15	40		
V_{BE}	Base-Emitter Voltage	$I_B = -15\ mA$,	$I_C = -150\ mA$	See Note 1		−0.80	−1.1	V
		$I_B = -50\ mA$,	$I_C = -500\ mA$			−0.88	−1.5	
		$I_B = -100\ mA$,	$I_C = -1\ A$			−1.15	−2.0	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15\ mA$,	$I_C = -150\ mA$	See Note 1		−0.18	−0.35	V
		$I_B = -50\ mA$,	$I_C = -500\ mA$			−0.35	−0.6	
		$I_B = -100\ mA$,	$I_C = -1\ A$			−0.65	−1.2	
f_T	Transition Frequency	$V_{CE} = -10\ V$,	$I_C = -50\ mA$,	f = 100 MHz	150	350		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10\ V$,	$I_E = 0$	f = 1 MHz, See Notes 2 and 3		12	25	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5\ V$,	$I_C = 0$			55	100	pF
C_{cb}	Collector-Base Capacitance	$V_{CB} = -10\ V$,	$I_E = 0$			11		pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5\ V$,	$I_C = 0$			50		pF
t_d	Delay Time	$V_{CC} = -30\ V$,	$I_C \approx -500\ mA$,	2N3244		5		ns
t_r	Rise Time	$I_{B(1)} \approx -50\ mA$,	$V_{BE(off)} \approx 2\ V$	Data		13		
t_s	Storage Time	$V_{CC} = -30\ V$,	$I_C \approx -500\ mA$,	Sheet		40		
t_f	Fall Time	$I_{B(1)} \approx -50\ mA$,	$I_{B(2)} \approx 50\ mA$	Circuit		13		
t_d	Delay Time	$V_{CC} = -30\ V$,	$I_C \approx -500\ mA$,	$I_{B(1)} \approx -50\ mA$,		7		ns
t_r	Rise Time	$I_{B(2)} \approx 50\ mA$,	$V_{BE(off)} \approx 4.1\ V$,	See Figure 1		13		
t_s	Storage Time					40		
t_f	Fall Time					13		

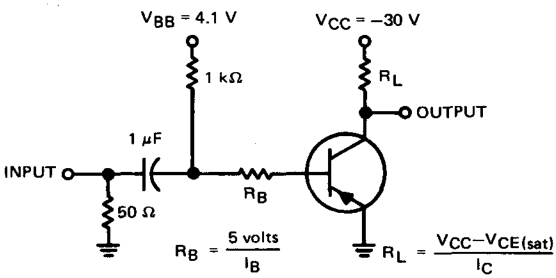
♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

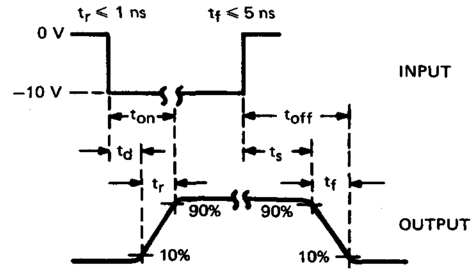
2. Capacitance measurements were made using chips mounted in TO-39 packages.

3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$; for measuring t_d and t_r, $t_w \approx 200$ ns, duty cycle $\leq 2\%$; for measuring t_s and t_f, $t_w \approx 10\ \mu s$, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \leq 100$ kΩ, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

$V_{(BR)CER}$ vs R_{BE}

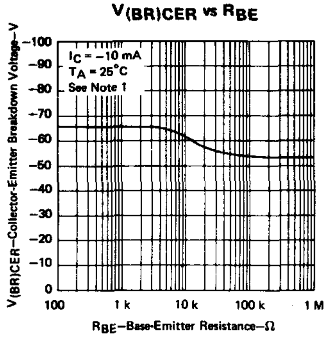


FIGURE 2

I_{CBO} vs T_A

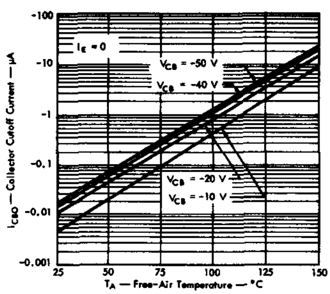


FIGURE 3

h_{FE} vs I_C

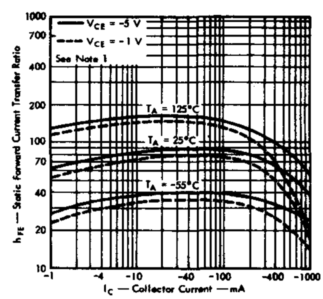


FIGURE 4

V_{BE} vs I_C

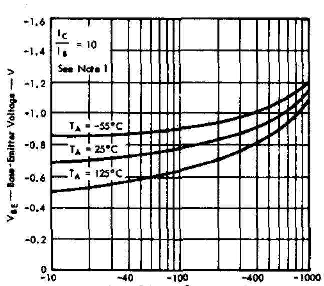


FIGURE 5

$V_{CE(sat)}$ vs I_C

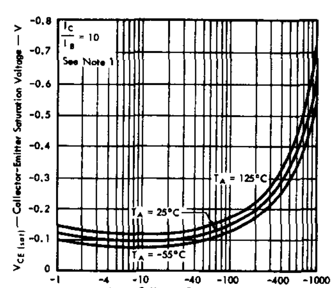


FIGURE 6

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

CHIP TYPE P12
P-N-P SILICON TRANSISTORS

TYPICAL CHARACTERISTICS

f_T vs I_C

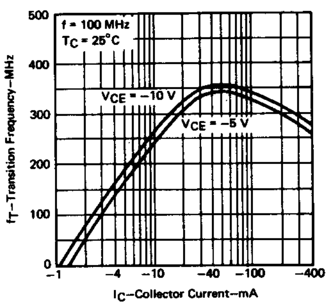


FIGURE 7

C_{obo}, C_{cb} vs V_{CB}

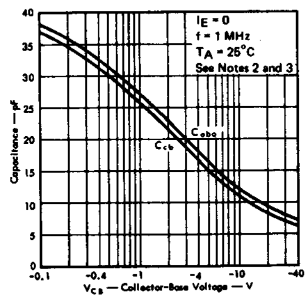


FIGURE 8

C_{ibo}, C_{eb} vs V_{EB}

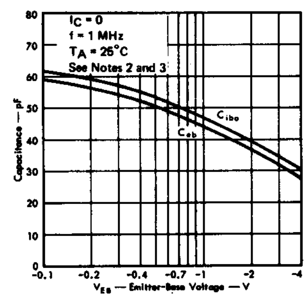


FIGURE 9

t_d, t_r vs T_A

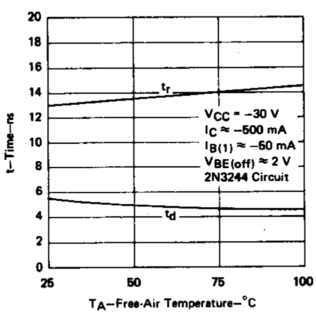


FIGURE 10

t_s, t_f vs T_A

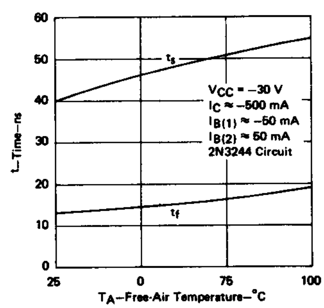


FIGURE 11

t_d vs I_C

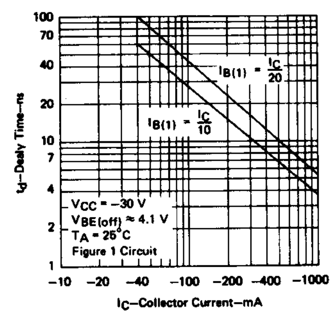


FIGURE 12

t_r vs I_C

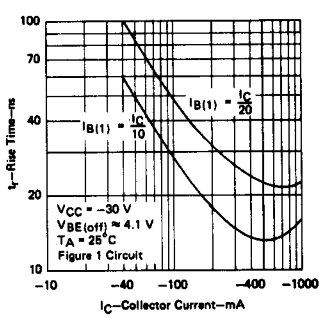


FIGURE 13

t_s vs I_C

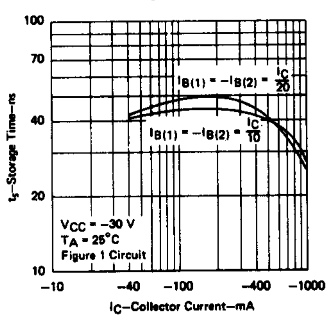


FIGURE 14

t_f vs I_C

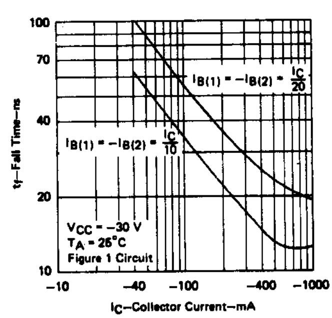
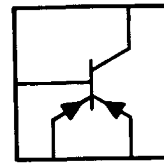


FIGURE 15

NOTES: 2. Capacitance measurements were made using chips mounted in TO-39 packages.

3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} abd C_{ibo} measurements are made with the third terminal floating.

- P13 is a 21 X 21-mil, epitaxial, planar, direct-contact, double-emitter chip
- Available in TO-72 packages
- For use in low-level, high-speed chopper circuits requiring the very low offset voltage of double-emitter transistors



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES			UNIT
					LOW	TYP	HIGH	
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -1\ \mu A$,	$I_{E1} = I_{E2} = 0$		-70♦	-90		V
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	$I_E = -1\ \mu A$,	$I_B = 0$,	See Note 1	-35♦	-50		V
$V_{(BR)E1E2}$	Emitter-Emitter Breakdown Voltage	$I_{E1} = \pm 1\ \mu A$,	$V_{CB} = 0$,	See Note 2	± 40♦	± 60		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V,	$I_{E1} = I_{E2} = 0$			-10	-250	pA
$I_{E1E2(off)}$	Emitter Cutoff Current	$V_{E1E2} = \pm 25$ V,	$V_{CB} = 0$,	See Note 2		± 4	± 100	pA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -6$ V,	$I_C = -1$ mA,	See Note 1	50	150		
$\lvert V_{E1E2(ofs)} \rvert$	Emitter-Emitter Offset Voltage	$I_B = -1$ mA,	$I_{E1} = I_{E2} = 0$			7	10	μV
$r_{e1e2(on)}$	Small-Signal Emitter-Emitter On-State Resistance	$I_B = -1$ mA, f = 1 kHz	$I_{E1} = I_{E2} = 0$, $I_e = 100\ \mu A$,		10	25	50	Ω
f_T	Transition Frequency	$V_{CE} = -6$ V, See Note 1	$I_C = -1$ mA,	f = 4 MHz,	12	24		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -6$ V, See Note 3	$I_{E1} = I_{E2} = 0$, f = 1 MHz,			8	10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -6$ V, See Notes 1 and 3	$I_C = 0$,	f = 1 MHz,		2	3	pF

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These values apply separately for each emitter with the other emitter open-circuited.
2. These parameters were measured with the collector short-circuited to the base but open-circuited with respect to the emitters. The values apply for both polarities of emitter-to-emitter voltage.
3. Capacitance measurements were made using chips mounted in TO-72 packages.

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

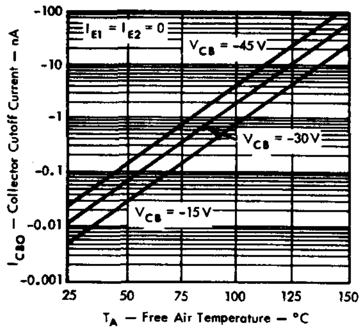


FIGURE 1

$I_{E1E2(off)}$ vs T_A

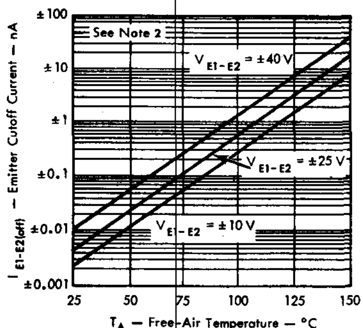


FIGURE 2

I_{E1} vs V_{E1E2}

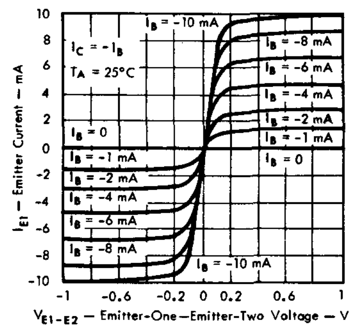


FIGURE 3

V_{BC} vs I_B

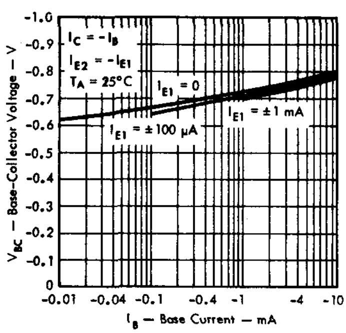


FIGURE 4

$V_{E1E2(ofs)}$ vs T_A

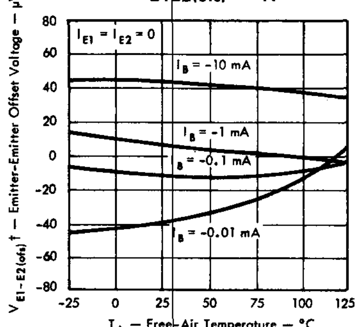


FIGURE 5

$V_{E1E2(ofs)}$ vs I_B

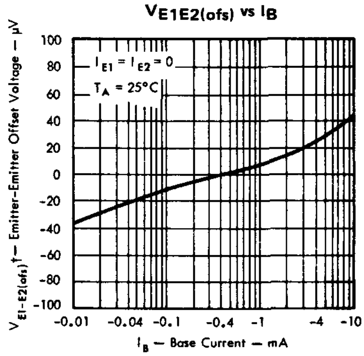


FIGURE 6

$r_{e1e2(on)}$ vs I_B

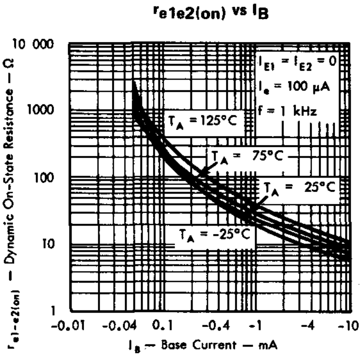


FIGURE 7

C_{obo} vs V_{CB}

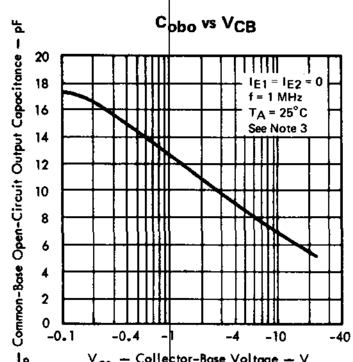


FIGURE 8

C_{ibo} vs V_{EB}

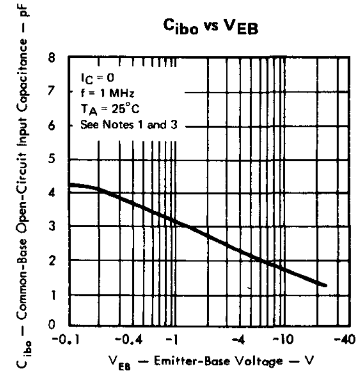


FIGURE 9

NOTES: 1. These values apply separately for each emitter with the other emitter open-circuited.
2. These parameters were measured with the collector short-circuited to the base but open-circuited with respect to the emitters. The values apply for both polarities of emitter-to-emitter voltage.
3. Capacitance measurements were made using chips mounted in TO-72 packages.

†The polarity of the offset voltage at $T_A = 25°C$ and $I_B = -1$ mA is arbitrarily assumed to be positive.

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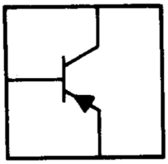
- P14 is a 19 X 19-mil, epitaxial, planar, direct-contact chip
- Available in TO-46 and *Silect*† Packages
- For use in low-level, high-speed chopper circuits in inverted connection (collector and emitter terminals reversed), and may also be used as a low-level amplifier



electrical characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−60♦	−80		V
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	$I_E = -100\ \mu A$, $I_B = 0$	−10♦	−25		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−40♦	−65		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -40$ V, $I_E = 0$		−0.02	−0.5	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -15$ V, $I_C = 0$		−0.01	−0.1	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -0.5$ V, $I_C = -1$ mA	30	120		
$h_{FE(inv)}$	Static Forward Current Transfer Ratio (Inverted Connection)	$V_{EC} = -0.5$ V, $I_E = -1$ mA	6	40		
$V_{EC(ofs)}$	Emitter-Collector Offset Voltage	$I_B = -200\ \mu A$, $I_E = 0$		−0.4	−0.8	mV
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -1$ mA		−0.6	−1.0	V
V_{BC}	Base-Collector Voltage	$V_{EC} = -0.5$ V, $I_E = -1$ mA		−0.6		V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.05$ mA, $I_C = -1$ mA		−0.02	−0.25	V
$r_{ec(on)}$	Small-Signal Emitter-Collector On-State Resistance	$I_B = -1$ mA, $I_E = 0$, $I_e = 100\ \mu A$, f = 1 kHz		3	20	Ω
f_T	Transition Frequency	$V_{CE} = -6$ V, $I_C = -1$ mA, f = 10 MHz	20	80		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -6$ V, $I_E = 0$, f = 1 MHz, See Note 1		5	10	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -6$ V, $I_C = 0$, f = 1 MHz, See Note 1		4	6	pF

†Trademark of Texas Instruments
♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.
NOTE 1: Capacitance measurements were made using chips mounted in TO-46 packages.

TYPICAL CHARACTERISTICS

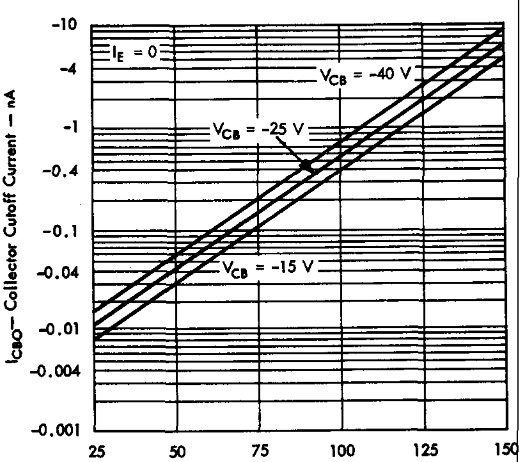


FIGURE 1

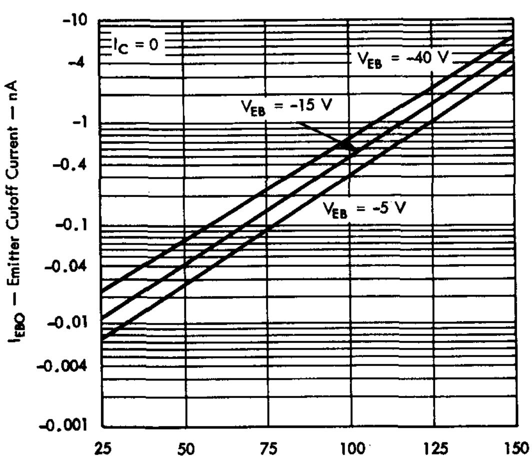


FIGURE 2

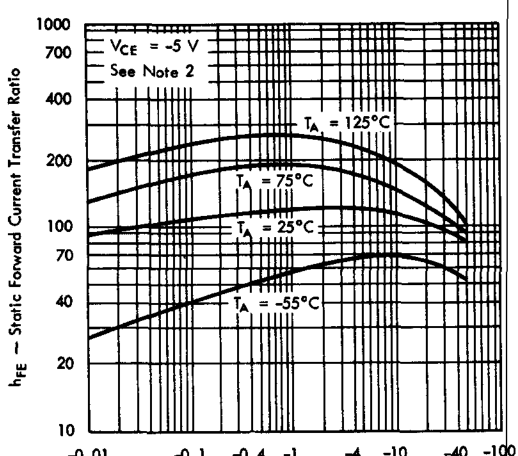


FIGURE 3

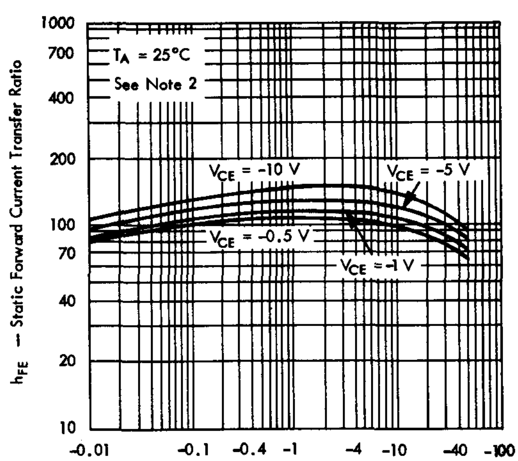


FIGURE 4

NOTE 2: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

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TYPICAL CHARACTERISTICS

$h_{FE(inv)}$ vs I_E

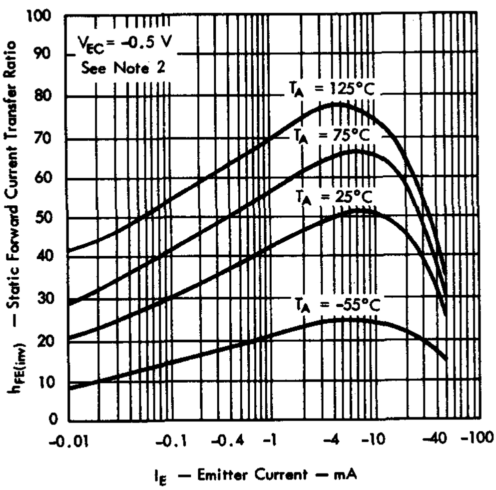

FIGURE 5

V_{BE} vs I_C

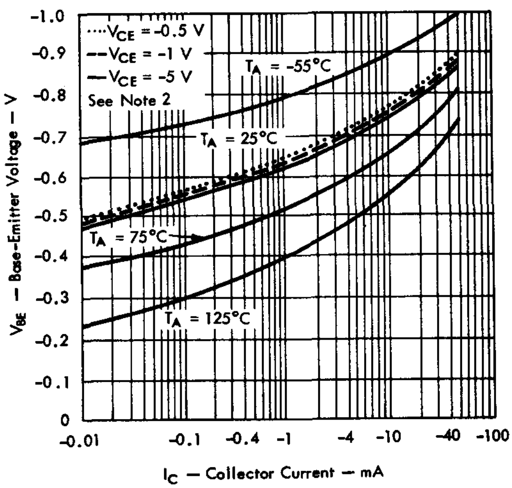

FIGURE 6

$V_{CE(sat)}$ vs I_C

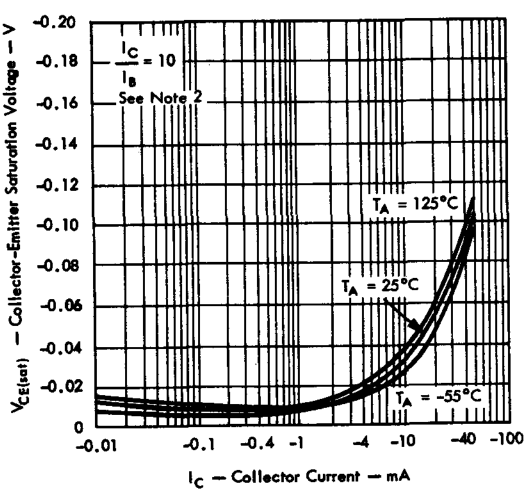

FIGURE 7

$V_{CE(sat)}$ vs I_C

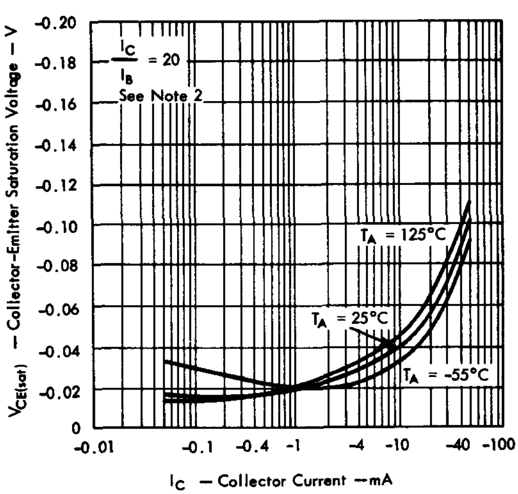

FIGURE 8

NOTE 2: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

V_{EC} vs I_B

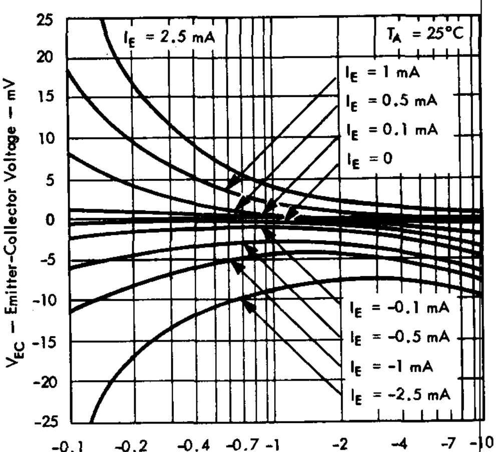

FIGURE 9

$V_{EC(ofs)}$ vs I_B

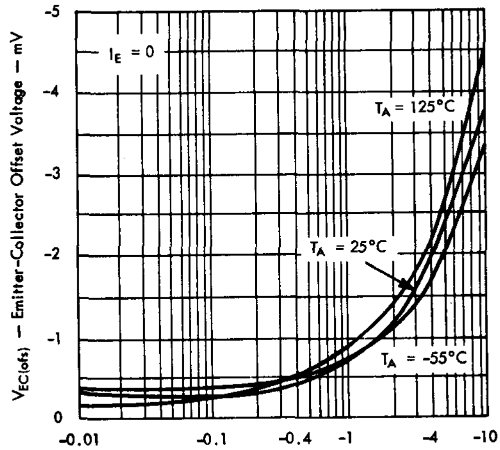

FIGURE 10

V_{BC} vs I_E

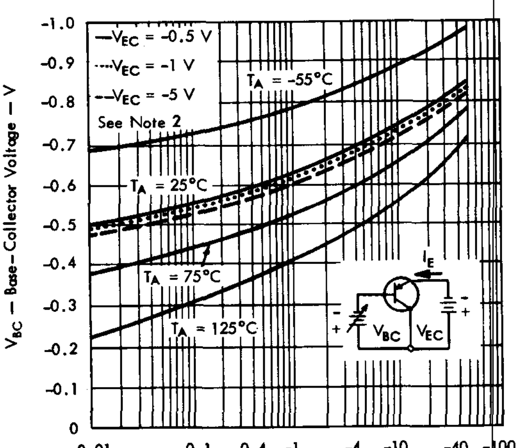

FIGURE 11

$r_{ec(on)}$ vs I_B

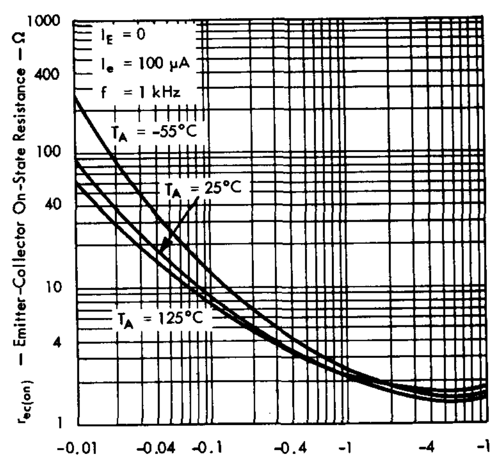

FIGURE 12

NOTE 2: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

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TYPICAL CHARACTERISTICS

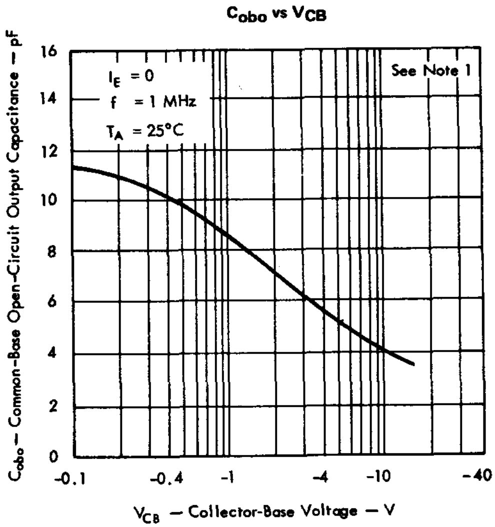


FIGURE 13

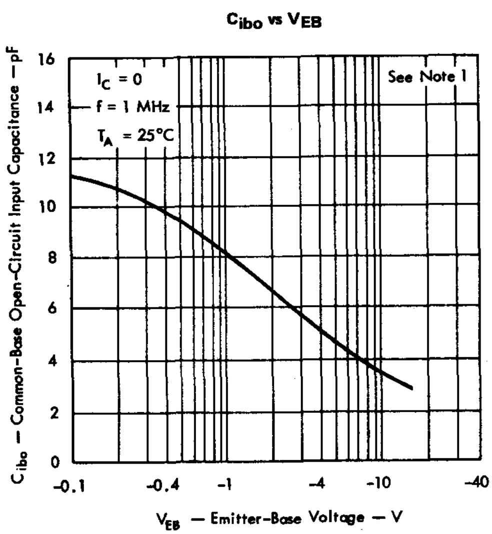
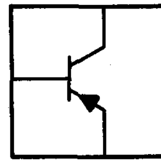


FIGURE 14

NOTE 1: Capacitance measurements were made using chips mounted in TO-46 packages.

CHIP TYPE P15
P-N-P SILICON TRANSISTORS

- **P15 is a 19 X 19-mil, epitaxial, planar, direct-contact chip**
- **Available in *Silect*† packages**
- **For use in general purpose, saturated switching, and amplifier circuits**



5

electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−40◆	−75		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 1	−35◆	−60		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−5◆	−9		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V, $I_E = 0$		−<0.1	−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -100\ \mu A$	30	115		
		$V_{CE} = -1$ V, $I_C = -1$ mA	40	135		
		$V_{CE} = -1$ V, $I_C = -10$ mA, See Note 1	50	150	300	
		$V_{CE} = -5$ V, $I_C = -100$ mA, See Note 1	20	85		
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 1		−0.75	−0.85	V
		$I_B = -5$ mA, $I_C = -50$ mA, See Note 1		−0.85	−0.95	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 1		−0.06	−0.25	V
		$I_B = -5$ mA, $I_C = -50$ mA, See Note 1		−0.12	−0.40	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	1.3	5.4	12	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	50	200	400	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz		1.3×10^{-4}	10×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz		25	60	µmho
f_T	Transition Frequency	$V_{CE} = -5$ V, $I_C = -10$ mA, f = 100 MHz	200	440		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		2.75	4.5	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 1 MHz, See Notes 2 and 3		5	10	pF
C_{cb}	Collector-Base Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		2.25		pF
$\overline{F}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -100\ \mu A$, $R_G = 1\ k\Omega$, Noise Bandwidth = 15.7 kHz, See Note 4		2	5	dB
t_d	Delay Time	$V_{CC} = -3$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $V_{BE(off)} \approx 0.5$ V, 2N3905 Data Sheet Circuit		13		ns
t_r	Rise Time			13		ns
t_s	Storage Time	$V_{CC} = -3$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $I_{B(2)} \approx 1$ mA, 2N3905 Data Sheet Circuit		60		ns
t_f	Fall Time			22		ns
t_d	Delay Time	$V_{CC} = -3$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $I_{B(2)} \approx 1$ mA, $V_{BE(off)} \approx 4.1$ V, See Figure 1		30		ns
t_r	Rise Time			13		ns
t_s	Storage Time			60		ns
t_f	Fall Time			22		ns

†Trademark of Texas Instruments

◆These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES:
1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in *Silect* packages.
3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

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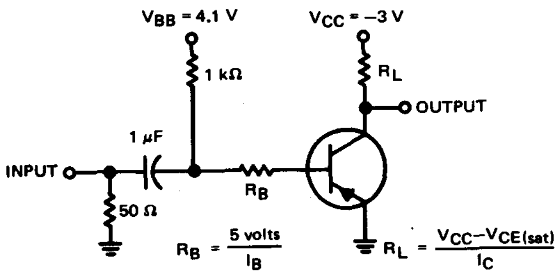
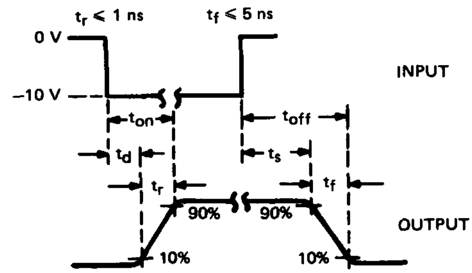
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω; for measuring t_d and t_r, $t_w \approx 200$ ns, duty cycle ≤ 2%; for measuring t_s and t_f, $t_w \approx 10\ \mu s$, duty cycle ≤ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \approx 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

$V_{(BR)CER}$ vs R_{BE}

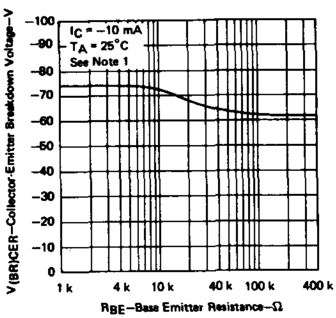


FIGURE 2

I_{CBO} vs T_A

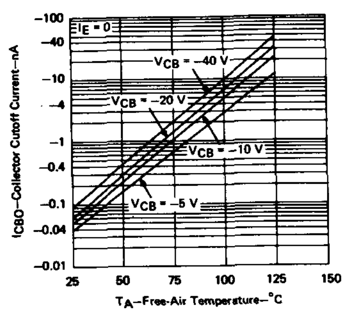


FIGURE 3

h_{FE} vs I_C

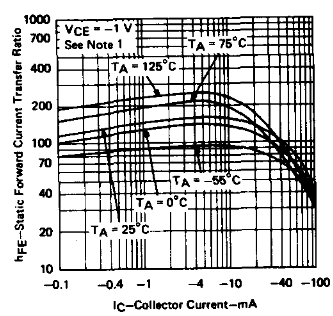


FIGURE 4

h_{FE} vs I_C

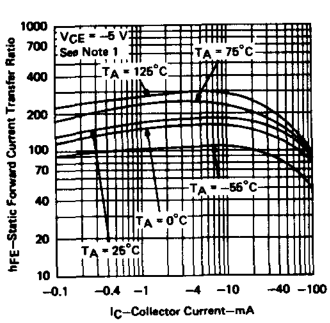


FIGURE 5

V_{BE} vs I_C

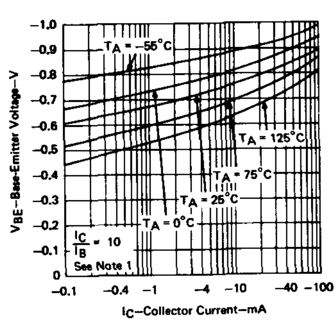


FIGURE 6

$V_{CE(sat)}$ vs I_C

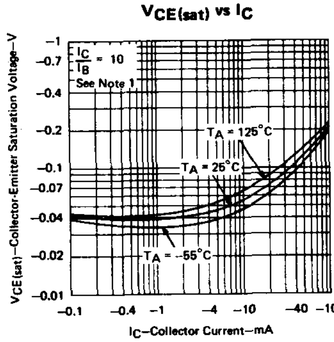


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

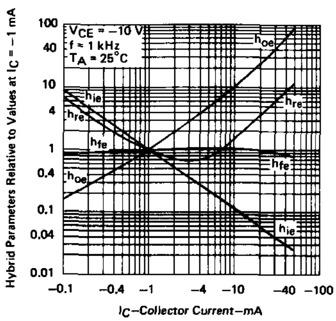


FIGURE 8

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs V_{CE}

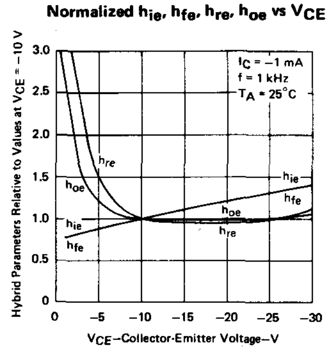


FIGURE 9

f_T vs I_C

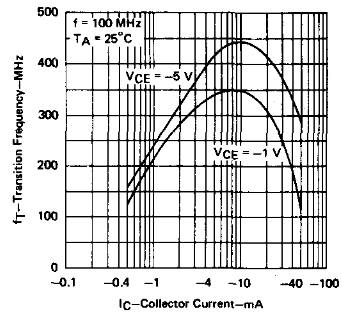


FIGURE 10

C_{cb}, C_{obo} vs V_{CB}

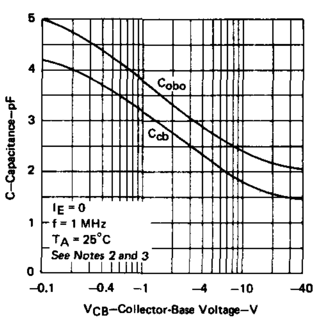


FIGURE 11

C_{ibo} vs V_{EB}

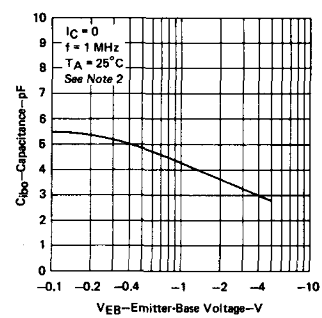


FIGURE 12

F vs f

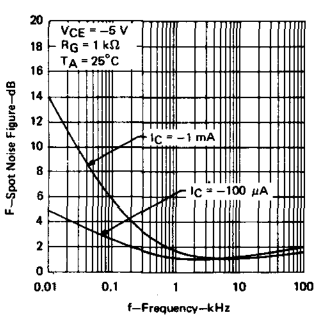


FIGURE 13

$\bar{F}$ vs R_G

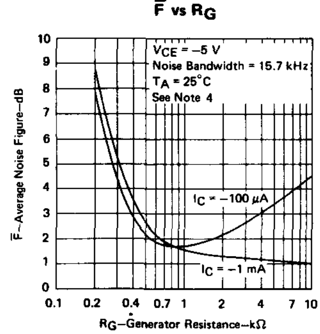


FIGURE 14

NOTES:
2. Capacitance measurements were made using chips mounted in *Silect* packages.
3. C_{cb} measurement employs a three-terminal capacitance bridge incorporating a guard circuit. The emitter is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

TYPICAL CHARACTERISTICS

t_d vs I_C

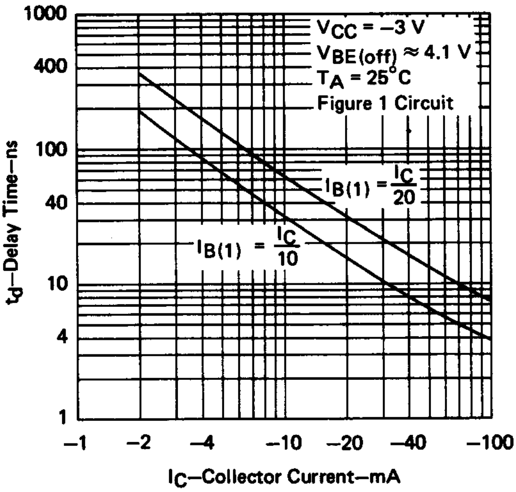


FIGURE 15

t_r vs I_C

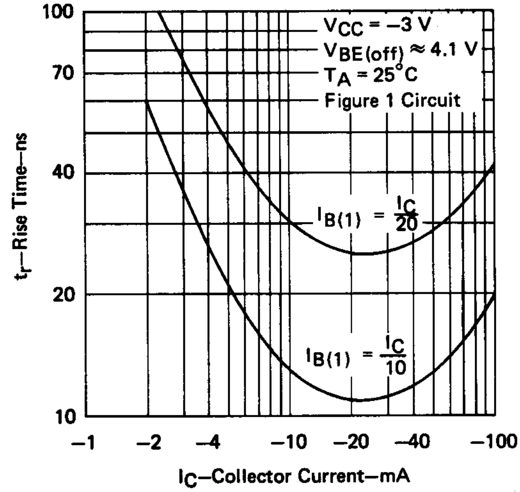


FIGURE 16

t_s vs I_C

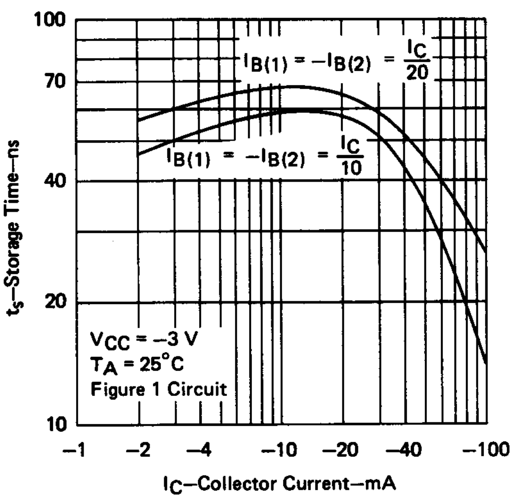


FIGURE 17

t_f vs I_C

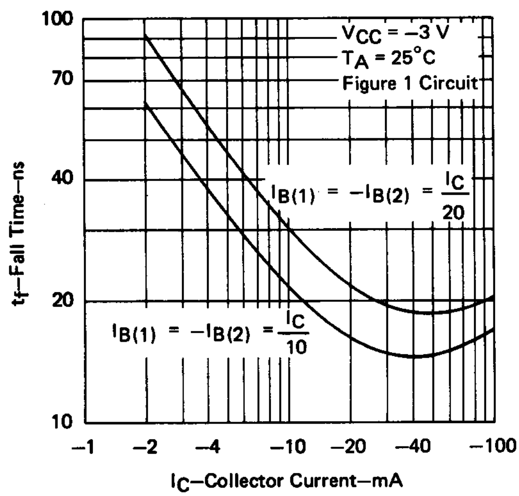
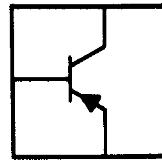


FIGURE 18

CHIP TYPE P16
P-N-P SILICON TRANSISTORS

- P16 is a 28 X 28-mil, epitaxial, planar, direct-contact chip
- Available in TO-18, TO-39, and *Silect*† packages
- For use in general purpose amplifier and switching circuits

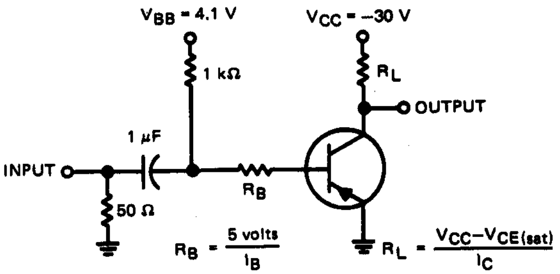


electrical and operating characteristics at 25°C free-air temperature

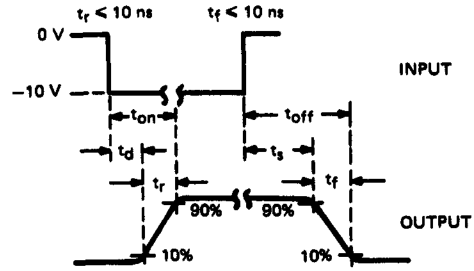
	PARAMETER	CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−80♦	−95		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 1	−60♦	−70		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−6♦	−8		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V, $I_E = 0$		−<1	−50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$		−<0.2	−10	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -100\ \mu A$	30	65		
		$V_{CE} = -5$ V, $I_C = -100$ mA, See Note 1	40	80		
		$V_{CE} = -5$ V, $I_C = -500$ mA, See Note 1	25	70		
		$V_{CE} = -5$ V, $I_C = -1$ A, See Note 1	15	50		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -100$ mA, See Note 1		−0.75	−1.0	V
		$I_B = -15$ mA, $I_C = -150$ mA, See Note 1		−0.85	−1.2	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA, $I_C = -150$ mA, See Note 1		0.15		V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -10$ mA, f = 1 kHz	90	280		Ω
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA, f = 1 kHz	35	90		
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -10$ mA, f = 1 kHz		0.4×10^{-4}		
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -10$ mA, f = 1 kHz		60		μmho
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -50$ mA, f = 20 MHz	100	260		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 1 MHz, See Note 2		9	20	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 1 MHz, See Note 2		60		pF
t_d	Delay Time	$V_{CC} = -30$ V, $I_C \approx -500$ mA, $I_{B(1)} \approx -50$ mA, $V_{BE(off)} \approx 3.8$ V; 2N4026 Data Sheet Circuit		7		ns
t_r	Rise Time			35		ns
t_s	Storage Time	$V_{CC} = -30$ V, $I_C \approx -500$ mA, $I_{B(1)} \approx -50$ mA, $I_{B(2)} \approx 50$ mA; 2N4026 Data Sheet Circuit		17		ns
t_f	Fall Time			22		ns
t_d	Delay Time	$V_{CC} = -30$ V, $I_C \approx -500$ mA, $I_{B(1)} \approx -50$ mA, $I_{B(2)} \approx 50$ mA, $V_{BE(off)} \approx 4.1$ V, See Figure 1		8		ns
t_r	Rise Time			35		ns
t_s	Storage Time			17		ns
t_f	Fall Time			22		ns

†Trademark of Texas Instruments
♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.
NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in *Silect* packages.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_w \approx 10\ \mu s$, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

$V_{(BR)CER}$ vs R_{BE}

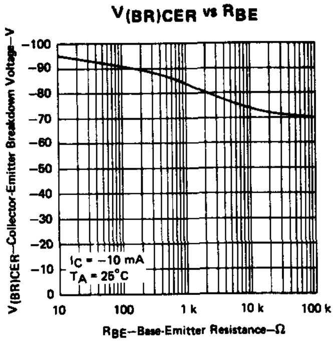


FIGURE 2

I_{CBO} vs T_A

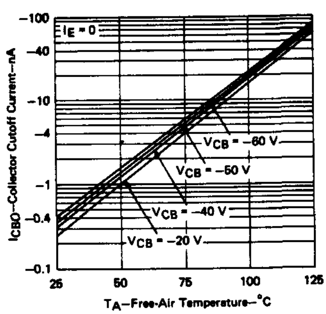


FIGURE 3

h_{FE} vs I_C

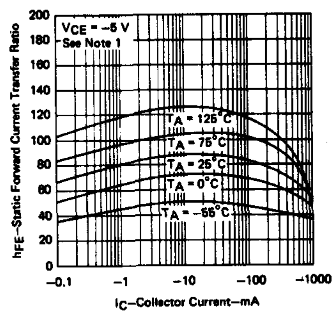


FIGURE 4

V_{BE} vs I_C

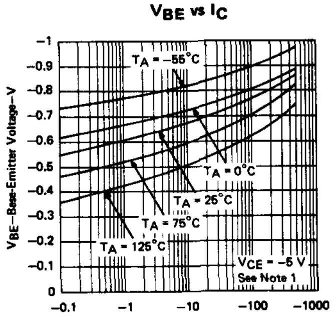


FIGURE 5

V_{BE} vs I_C

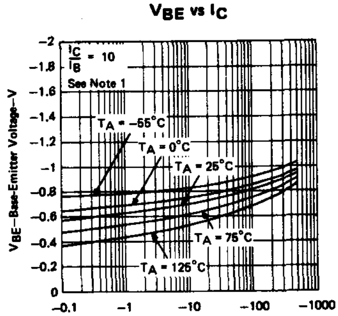


FIGURE 6

$V_{CE(sat)}$ vs I_C

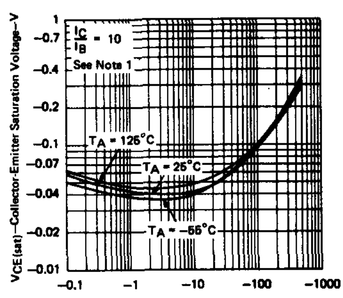


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

TYPICAL CHARACTERISTICS

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

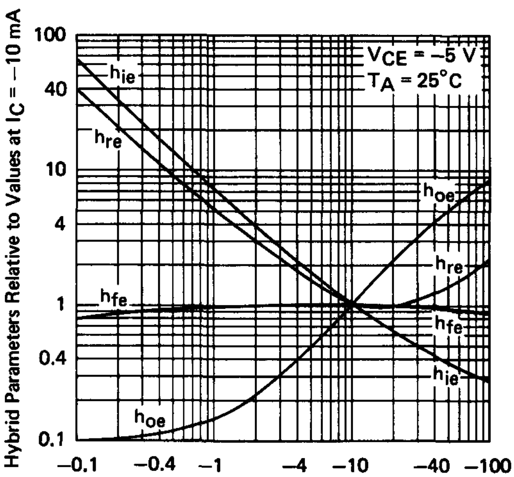


FIGURE 8

f_T vs I_C

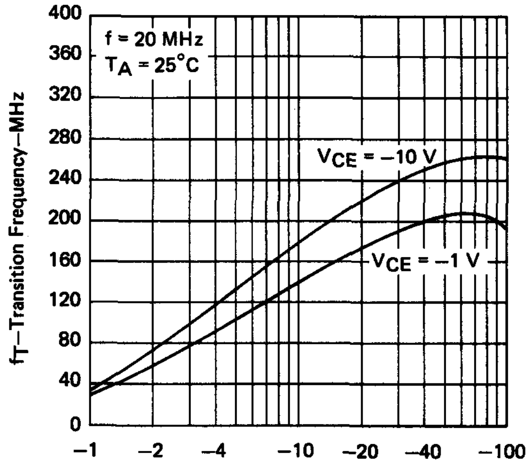


FIGURE 9

C_{obo} vs V_{CB}

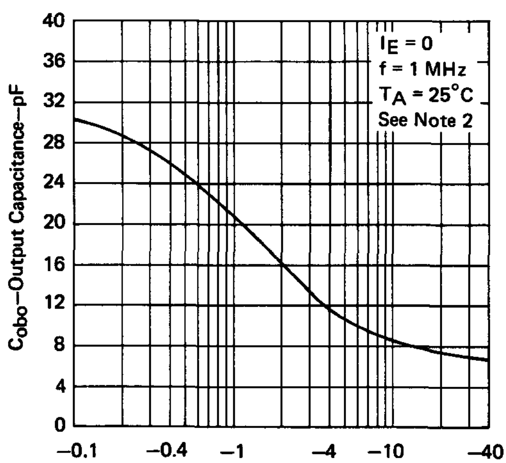


FIGURE 10

C_{ibo} vs V_{EB}

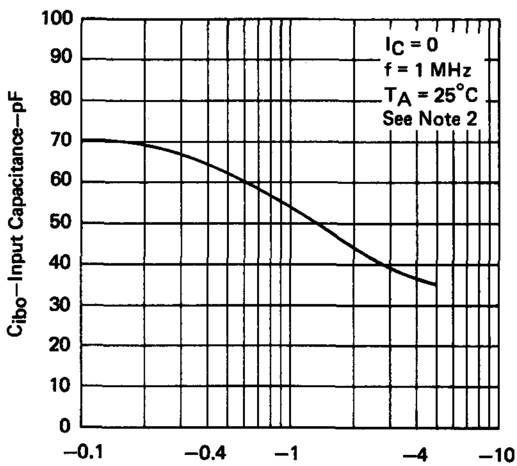


FIGURE 11

NOTE 2: Capacitance measurements were made using chips mounted in *Silect* packages.

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TYPICAL CHARACTERISTICS

t_d vs I_C

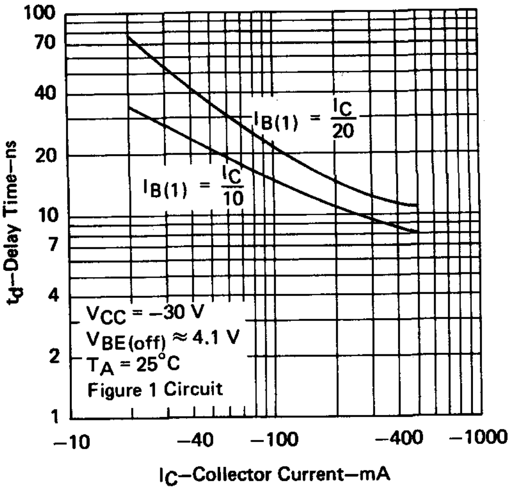


FIGURE 12

t_r vs I_C

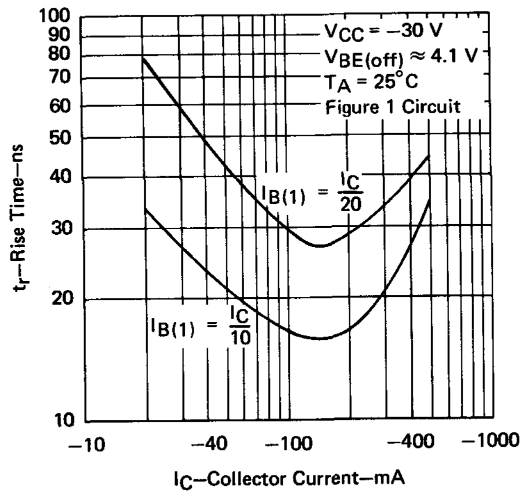


FIGURE 13

t_s vs I_C

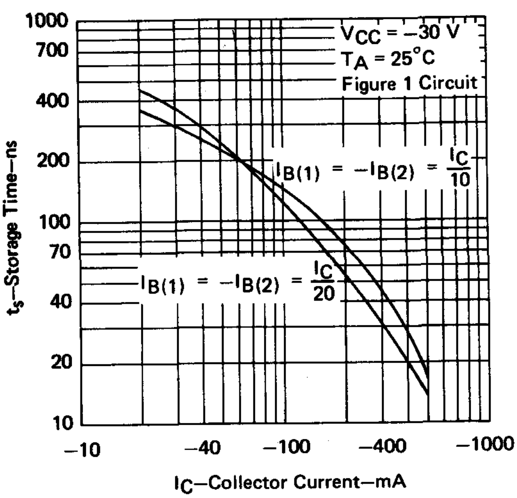


FIGURE 14

t_f vs I_C

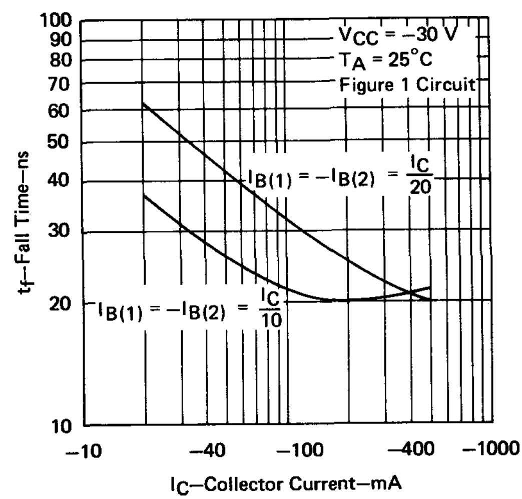
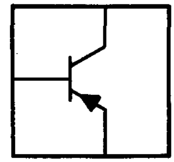


FIGURE 15

CHIP TYPE P17
P-N-P SILICON TRANSISTORS

- P17 is a 20 X 20-mil, epitaxial, planar, direct-contact chip
- Available in TO-5, TO-18, and *Silect*† packages
- For use in high-voltage amplifier and low-current switching circuits



electrical and operating characteristics at 25°C free-air temperature

	PARAMETER	CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−180♦	−220		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 1	−150♦	−180		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−7♦	−8		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -50$ V, $I_E = 0$		−<0.1	−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$		−<0.1	−25	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -100\ \mu A$	35	70	280	
		$V_{CE} = -10$ V, $I_C = -1$ mA	40	80	300	
		$V_{CE} = -10$ V, $I_C = -10$ mA, See Note 1	40	90	300	
		$V_{CE} = -10$ V, $I_C = -50$ mA, See Note 1	40	70	300	
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 1	−0.6	−0.7	−1.0	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 1		−0.1	−0.5	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -10$ mA, f = 1 kHz	0.1	0.34	1.2	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		40	90	300	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			1×10^{-4}	2×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance			40	300	µmho
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -20$ mA, f = 100 MHz	150	220		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 1 MHz, See Note 2		4		pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 1 MHz, See Note 2		22		pF
t_d	Delay Time	$V_{CC} = -30$ V, $I_C = -10$ mA, 2N3494		35		ns
t_r	Rise Time	$I_{B(1)} \approx -1$ mA, $V_{BE(off)} \approx 0$, Data		85		
t_s	Storage Time	$V_{CC} = -30$ V, $I_C \approx -10$ mA, Sheet		820		
t_f	Fall Time	$I_{B(1)} \approx -1$ mA, $I_{B(2)} \approx 1$ mA, Circuit		120		
t_d	Delay Time	$V_{CC} = -30$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $I_{B(2)} \approx 1$ mA, $V_{BE(off)} \approx 4.1$ V, See Figure 1		120		ns
t_r	Rise Time			90		
t_s	Storage Time			820		
t_f	Fall Time			120		

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse tehniques. t_w = 300 µs, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-18 packages.

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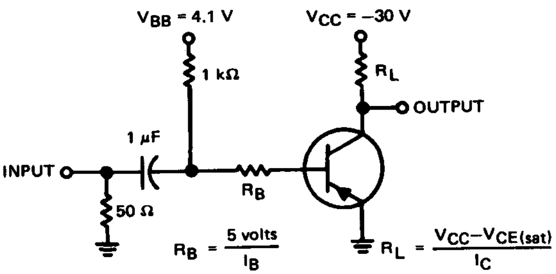
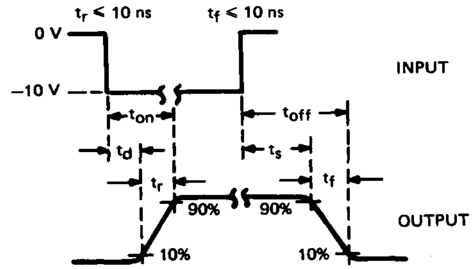
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$; for measuring t_d and t_r, $t_w \approx 100$ ns, duty cycle $\leq 2\%$; for measuring t_s and t_f, $t_w \approx 10\ \mu s$, duty cycle $\leq 2\%$.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100\ k\Omega$, $C_{in} \leq 7$ pF.

FIGURE 1–SWITCHING TIMES

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

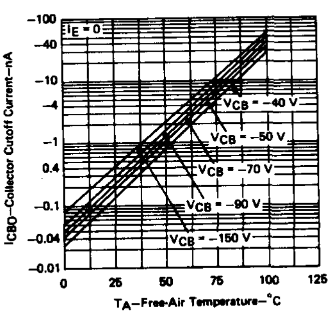


FIGURE 2

h_{FE} vs I_C

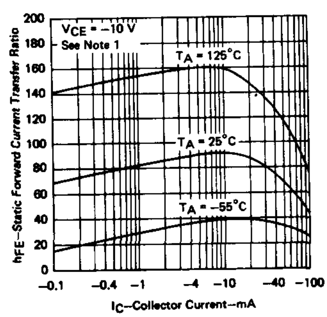


FIGURE 3

V_{BE} vs I_C

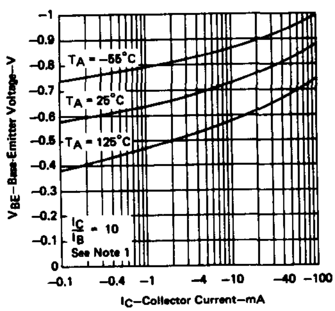


FIGURE 4

$V_{CE(sat)}$ vs I_C

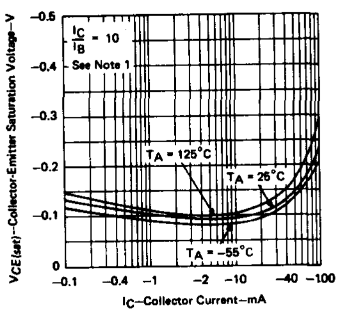


FIGURE 5

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

TYPICAL CHARACTERISTICS

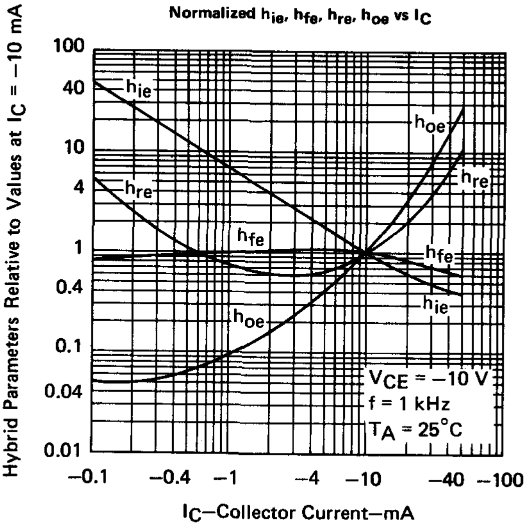


FIGURE 6

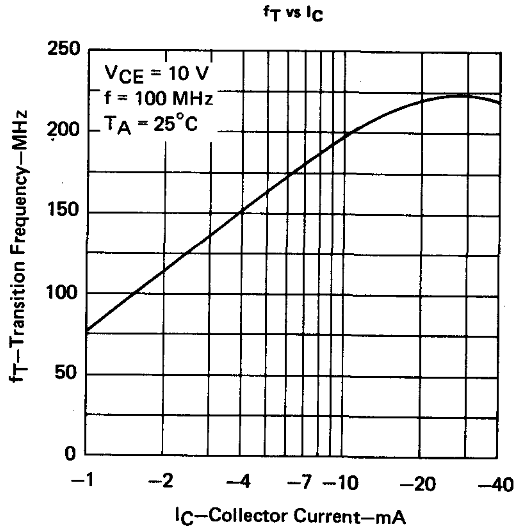


FIGURE 7

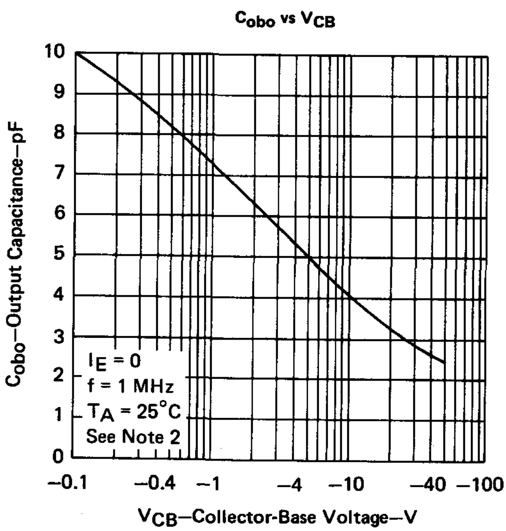


FIGURE 8

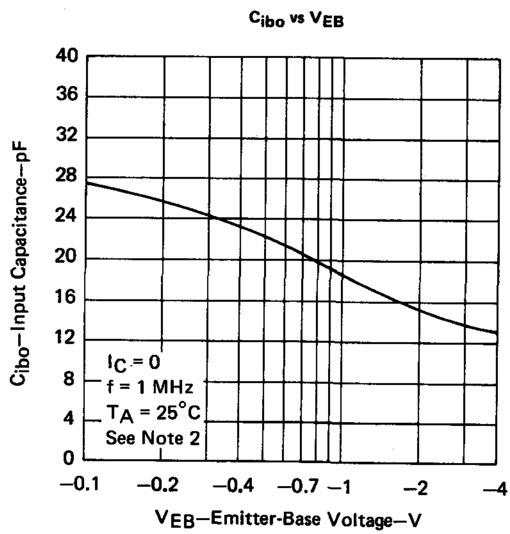


FIGURE 9

NOTE 2: Capacitance measurements were made using chips mounted in TO-18 packages.

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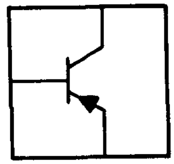
- **P18 is a 20 X 20-mil, epitaxial, planar, direct-contact chip**
- **Available in TO-18 or *Silect*† packages**
- **For use in low-current, low-noise amplifier circuits**



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	OBSERVED VALUES TYP	OBSERVED VALUES HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−50♦	−70		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 1	−50♦	−70		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−7♦	−8		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -30$ V, $I_E = 0$		−<0.1	−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$		−<0.1	−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1\ \mu A$	30	160		
		$V_{CE} = -5$ V, $I_C = -10\ \mu A$	40	220		
		$V_{CE} = -5$ V, $I_C = -100\ \mu A$	45	260		
		$V_{CE} = -5$ V, $I_C = -1$ mA	50	280	600	
		$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 1	50	260		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -1$ mA		−0.6	−1.0	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.5$ mA, $I_C = -10$ mA, See Note 1		−0.08	−0.25	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz		7.5		kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz		280		
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz		1.6×10^{-4}		
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz		15		μmho
f_T	Transition Frequency	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 20 MHz		200		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$, f = 1 MHz, See Note 2		3	6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, f = 1 MHz, See Note 2		7	15	pF
F	Spot Noise Figure	$V_{CE} = -5$ V, $I_C = -100\ \mu A$, $R_G = 10$ kΩ, f = 1 kHz		1	3	dB

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-92 packages.

TYPICAL CHARACTERISTICS

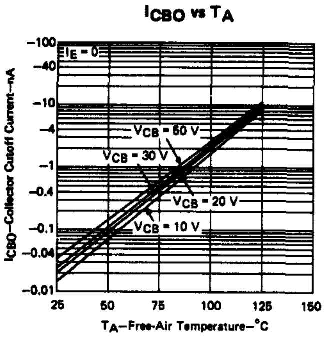


FIGURE 1

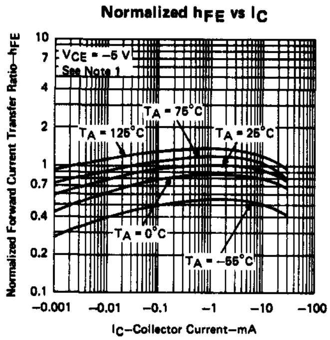


FIGURE 2

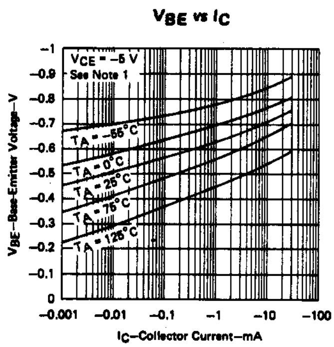


FIGURE 3

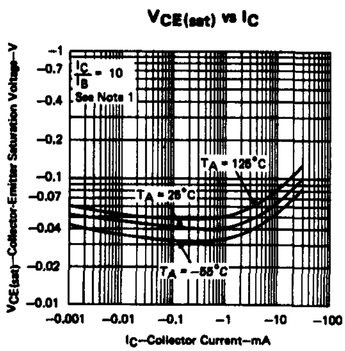


FIGURE 4

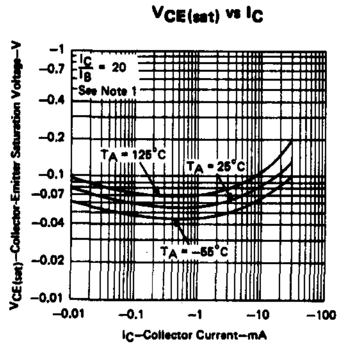


FIGURE 5

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

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TYPICAL CHARACTERISTICS

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs V_{CE}

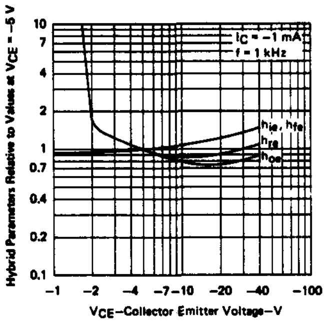


FIGURE 6

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

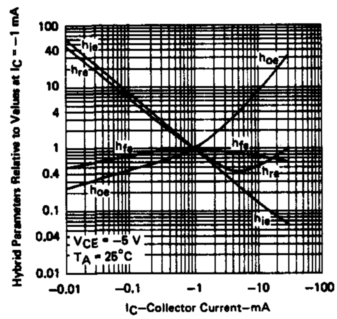


FIGURE 7

f_T vs I_C

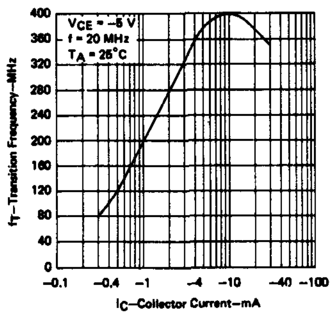


FIGURE 8

F vs f

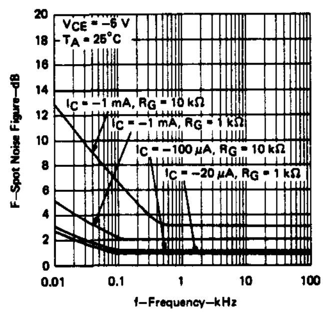


FIGURE 9

C_{obo} vs V_{CB}

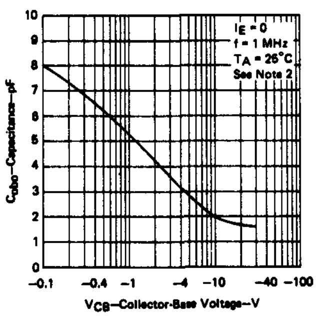


FIGURE 10

C_{ibo} vs V_{EB}

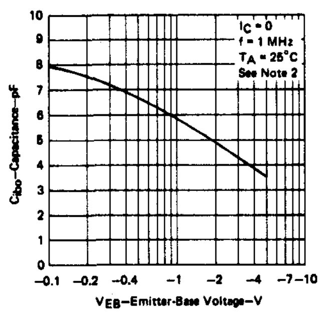
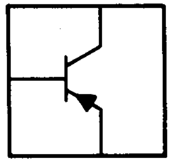


FIGURE 11

NOTE 2. Capacitance measurements were made using chips mounted in TO-92 packages.

CHIP TYPE P19
P-N-P SILICON TRANSISTORS



- P19 is a 20 X 20-mil, epitaxial, planar, direct-contact chip
- Available in TO-18, TO-46, and a short-can version of TO-78 packages
- For use in low-level, low-noise, high-gain amplifier circuits

electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−80♦	−100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 1	−60♦	−80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−8♦	−10		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -45$ V, $I_E = 0$		−<0.1	−10	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V, $I_C = 0$		−<0.1	−20	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1\ \mu A$	30	180		
		$V_{CE} = -5$ V, $I_C = -10\ \mu A$	40	200		
		$V_{CE} = -5$ V, $I_C = -1$ mA	60	220	900	
		$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 1	35	150		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -100\ \mu A$		−0.6	−0.75	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -100\ \mu A$, $I_C = -1$ mA		−0.08	−0.3	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz	2.0	5.5		kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio		50	210	900	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio			1×10^{-4}	50×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance			15	75	μmho
f_T	Transition Frequency	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 30 MHz	90	150		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -5$ V, $I_E = 0$; f = 1 MHz, See Notes 2 and 3		3.1	4	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$		2.9	4	pF
C_{cb}	Collector-Base Capacitance	$V_{CB} = -5$ V, $I_E = 0$		2.3		pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$		2.5		pF
F	Spot Noise Figure	$V_{CE} = -10$ V, $I_C = -100\ \mu A$, $R_G = 3$ kΩ; f = 100 Hz		1.5	4	dB
		f = 1 kHz		0.5	3	
$\overline{F}$	Average Noise Figure	$V_{CE} = -10$ V, $I_C = -100\ \mu A$, Noise Bandwidth = 15.7 kHz, $R_G = 10$ kΩ, See Note 4		0.5	4	dB

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES:
1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in TO-18 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

TYPICAL CHARACTERISTICS

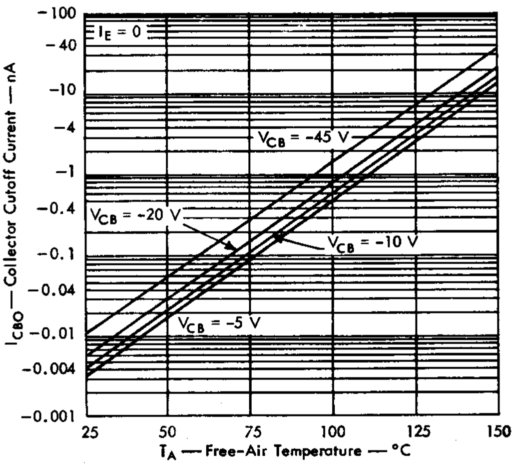


FIGURE 1

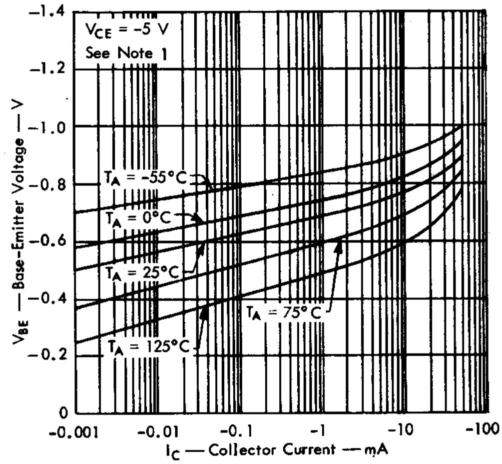


FIGURE 2

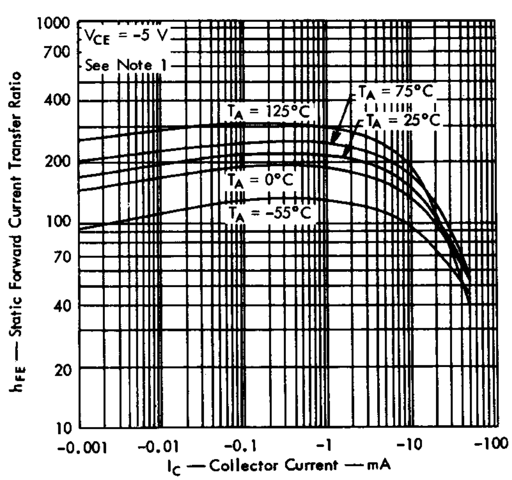


FIGURE 3

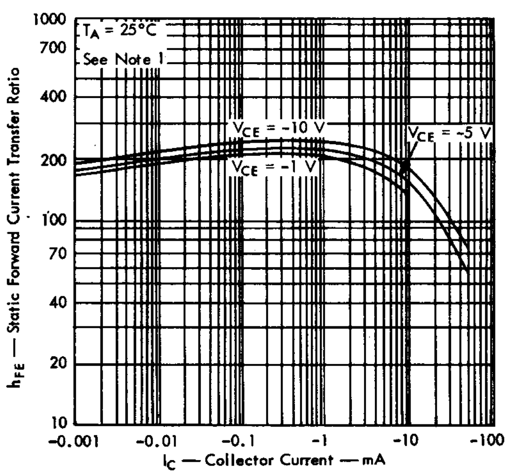


FIGURE 4

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

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TYPICAL CHARACTERISTICS

h_{ie} vs I_C

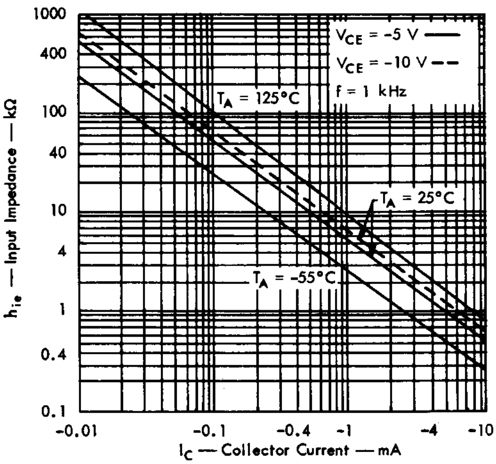

FIGURE 5

h_{fe} vs I_C

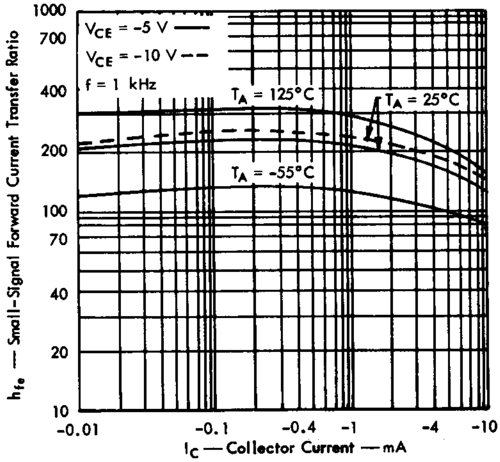

FIGURE 6

5

h_{re} vs I_C

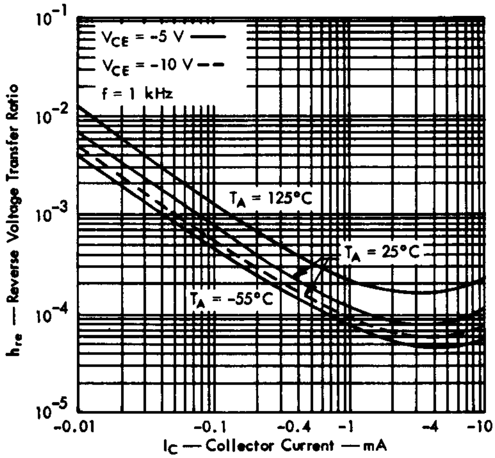

FIGURE 7

h_{oe} vs I_C

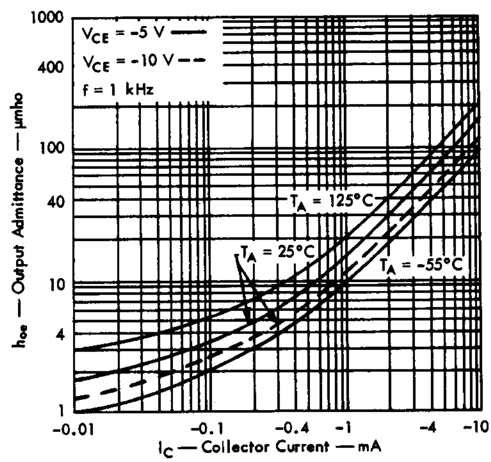

FIGURE 8

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TYPICAL CHARACTERISTICS

f_T vs I_C

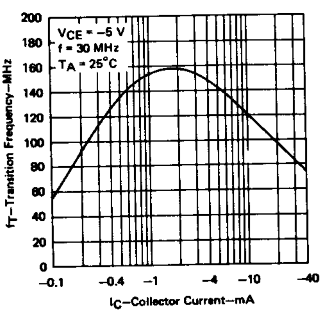


FIGURE 9

C_{obo}, C_{cb} vs V_{CB}

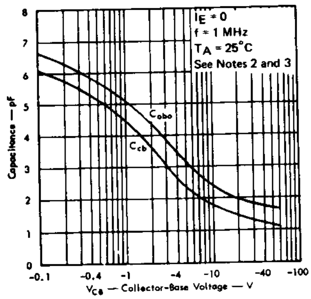


FIGURE 10

C_{ibo}, C_{eb} vs V_{EB}

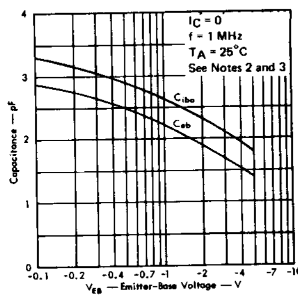


FIGURE 11

$\overline{F}$ vs R_G

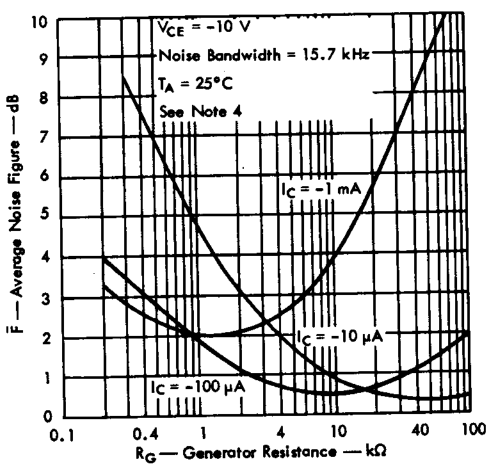


FIGURE 12

F vs f

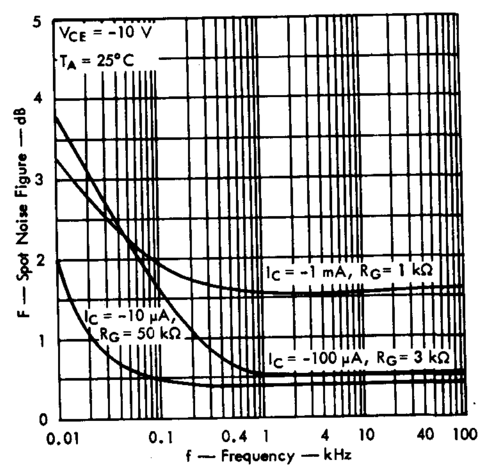
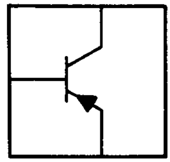


FIGURE 13

NOTES:
2. Capacitance measurements were made using chips mounted in TO-18 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector respectively) is connected to the guard terminal of the bridge. C_{obo} and C_{ibo} measurements are made with the third terminal floating.
4. Average Noise Figure is measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

CHIP TYPE P20
P-N-P SILICON TRANSISTORS

- P20 is a 20 X 20-mil, epitaxial, planar, direct-contact chip
- Available in TO-5, TO-18, TO-39, TO-46, a short-can version of TO-78, plastic dual-in-line quad, and *Silect*† packages
- For use in general purpose amplifier and medium-current switching circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS			OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$,	$I_E = 0$		−80♦	−100		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA,	$I_B = 0$,	See Note 1	−65♦	−80		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$,	$I_C = 0$		−6♦	−7.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -40$ V,	$I_E = 0$			−<0.1	−100	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -4$ V,	$I_C = 0$			−<0.1	−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V,	$I_C = -1$ mA		25	180		
		$V_{CE} = -10$ V,	$I_C = -10$ mA	See Note 1	50	190		
		$V_{CE} = -10$ V,	$I_C = -150$ mA		50	120	500	
		$V_{CE} = -10$ V,	$I_C = -500$ mA		20	55		
V_{BE}	Base-Emitter Voltage	$I_B = -15$ mA,	$I_C = -150$ mA	See Note 1		−0.9	−1.0	V
		$I_B = -50$ mA,	$I_C = -500$ mA			−1.0		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -15$ mA,	$I_C = -150$ mA	See Note 1		−0.25	−0.5	V
		$I_B = -50$ mA,	$I_C = -500$ mA			−0.65		
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V,	$I_C = -10$ mA,	f = 1 kHz	150	600		Ω
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio				50	190	600	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio					1×10^{-4}	15×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance					100	800	μmho
f_T	Transition Frequency	$V_{CE} = -10$ V,	$I_C = -50$ mA,	f = 100 MHz	100	360		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, See Note 2	$I_E = 0$,	f = 1 MHz,		5	12	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -0.5$ V, See Note 2	$I_C = 0$,	f = 1 MHz,		16	30	pF
t_d	Delay Time	$V_{CC} = -30$ V,	$I_C \approx -150$ mA,	2N2904		4		ns
t_r	Rise Time	$I_{B(1)} \approx -15$ mA,	$V_{BE(off)} \approx 0$	Data		13		
t_s	Storage Time	$V_{CC} = -30$ V,	$I_C \approx -150$ mA,	Sheet		60		
t_f	Fall Time	$I_{B(1)} \approx -15$ mA,	$I_{B(2)} \approx 15$ mA	Circuit		20		
t_d	Delay Time	$V_{CC} = -30$ V,	$I_C \approx -150$ mA,	$I_{B(1)} \approx -15$ mA,		6		ns
t_r	Rise Time	$I_{B(2)} \approx 15$ mA,	$V_{BE(off)} \approx 4.1$ V,	See Figure 1		13		
t_s	Storage Time					60		
t_f	Fall Time					20		

†Trademark of Texas Instruments
♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.
NOTES: 1. These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. Capacitance measurements were made using chips mounted in TO-5 packages.

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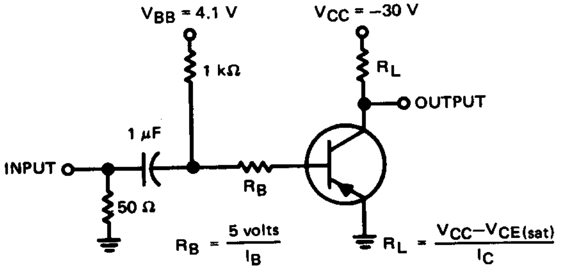
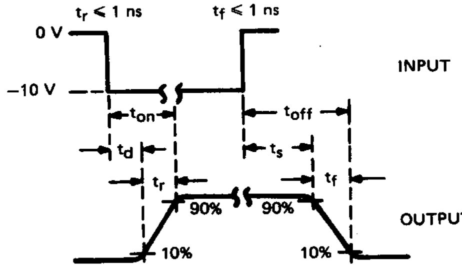
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_w \approx 200$ ns, duty cycle ≤ 2%.
b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

FIGURE 1–SWITCHING TIMES

TYPICAL CHARACTERISTICS

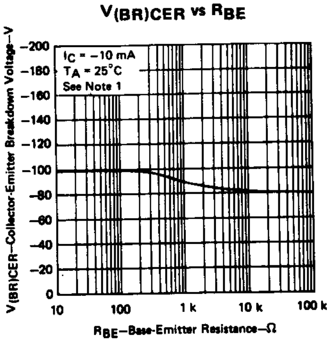


FIGURE 2

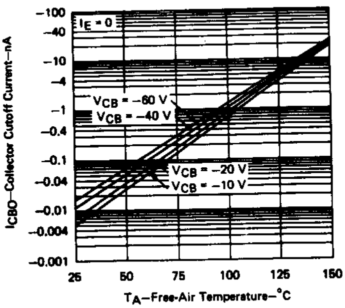


FIGURE 3

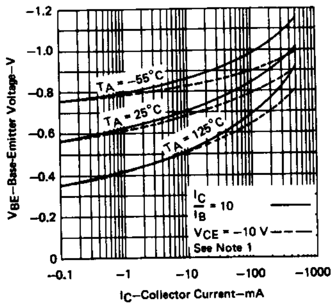


FIGURE 4

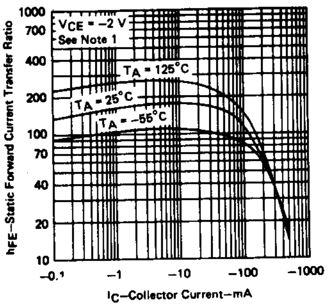


FIGURE 5

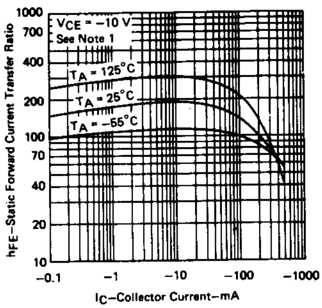


FIGURE 6

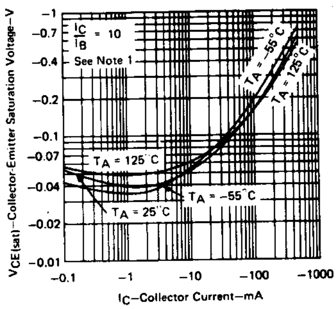


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

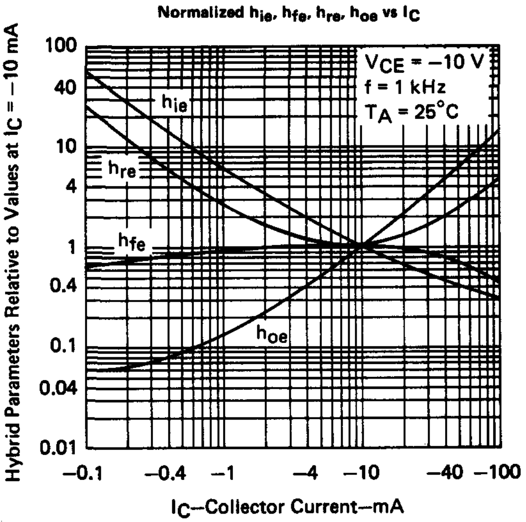


FIGURE 8

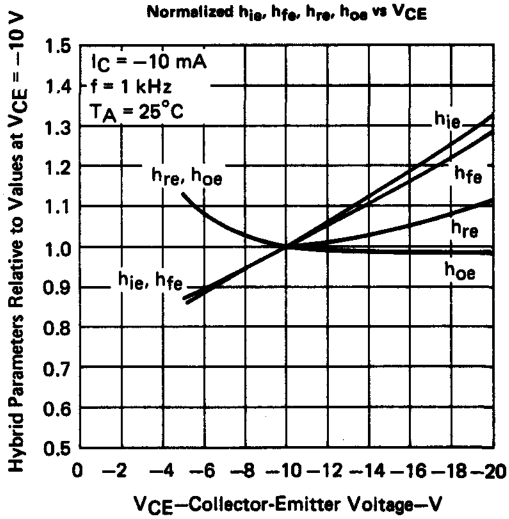


FIGURE 9

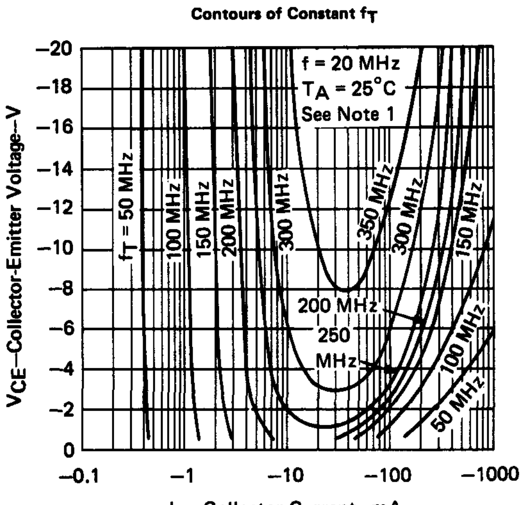


FIGURE 10

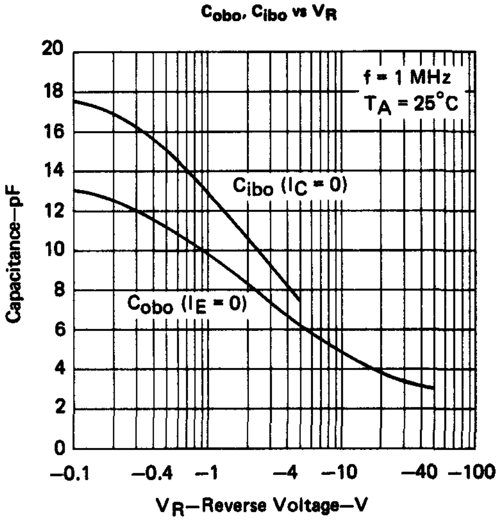


FIGURE 11

NOTES: 1. These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle < 2%.
2. Capacitance measurements were made using chips mounted in TO-5 packages.

TYPICAL CHARACTERISTICS

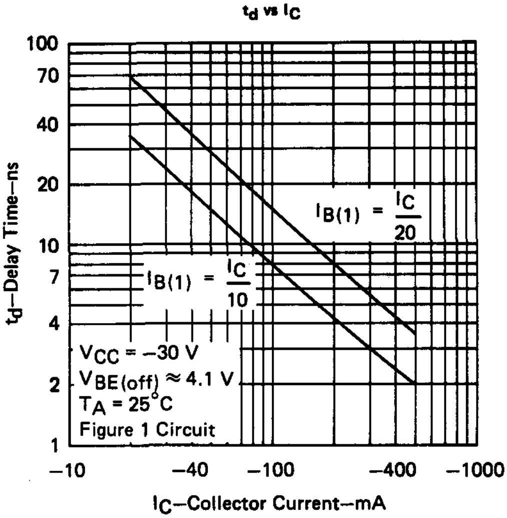


FIGURE 12

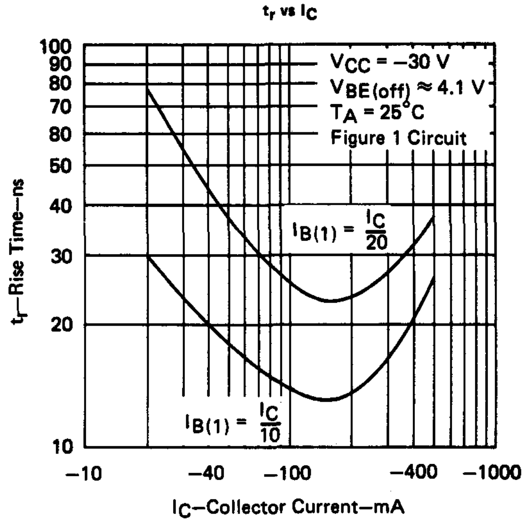


FIGURE 13

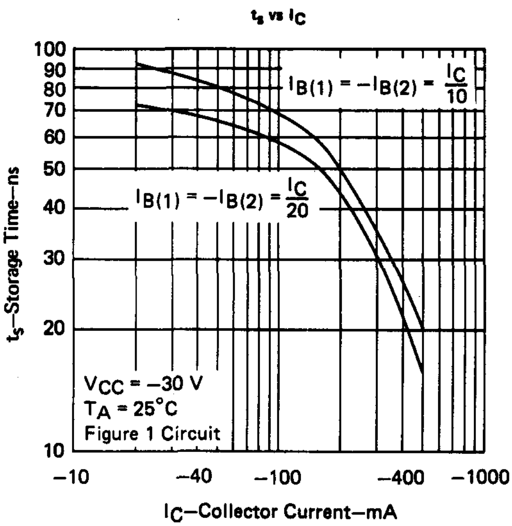


FIGURE 14

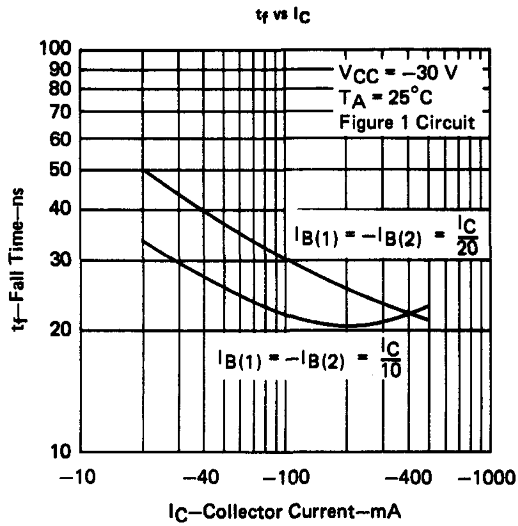
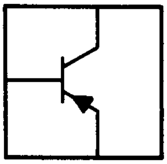


FIGURE 15

CHIP TYPE P22
P-N-P SILICON TRANSISTORS

- P22 is a 20 X 20-mil, epitaxial, planar, direct-contact chip
- Available in *Silect*† packages
- For use in high-voltage amplifier circuits



electrical and operating characteristics at 25°C free-air temperature

	PARAMETER	CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−150♦	−175		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 1	−140♦	−165		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−5.5♦	−7		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -100$ V, $I_E = 0$		−<0.1	−50	nA
I_{EBO}	Emitter Cutoff Current	$V_{EB} = -3$ V, $I_C = 0$		−<0.1	−50	nA
h_{FE}	Static Forward Voltage Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA	30	140		
		$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 1	40	160	240	
		$V_{CE} = -5$ V, $I_C = -50$ mA, See Note 1	40	150		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 1		−0.65	−1.0	V
		$I_B = -1$ mA, $I_C = -10$ mA, See Note 1		−0.7	−1.0	V
		$I_B = -5$ mA, $I_C = -50$ mA, See Note 1		−0.8	−1.0	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 1		−0.06	−0.2	V
		$I_B = -5$ mA, $I_C = -50$ mA, See Note 1		−0.1	−0.5	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz		4.6		kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz	30	170	200	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz		2.7×10^{-4}		
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -10$ V, $I_C = -1$ mA, f = 1 kHz		13.4		μmho
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -10$ mA, f = 20 MHz	100	190		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 1 MHz, See Note 2		4	6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -1$ V, $I_C = 0$, f = 1 MHz, See Note 2		45	60	pF
F	Spot Noise Figure	$V_{CE} = -5$ V, $I_C = -1$ mA, $R_G = 10$ kΩ, f = 1 kHz		3		dB
$\bar{F}$	Average Noise Figure	$V_{CE} = -5$ V, $I_C = -250\ \mu A$, $R_G = 1$ kΩ, Noise Bandwidth = 15.7 kHz, See Note 3		2	8	dB

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance measurements were made using chips mounted in TO-92 packages.

3. Average Noise Figure was measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

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TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

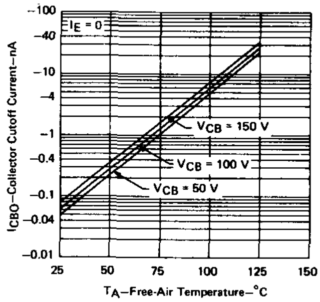

FIGURE 1

h_{FE} vs I_C

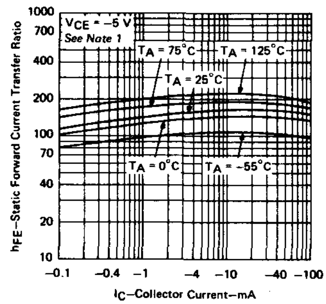

FIGURE 2

V_{BE} vs I_C

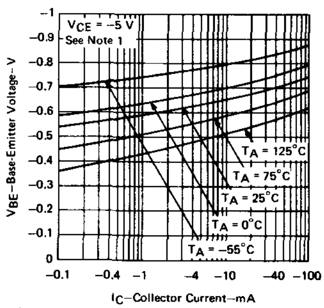

FIGURE 3

$V_{CE(sat)}$ vs I_C

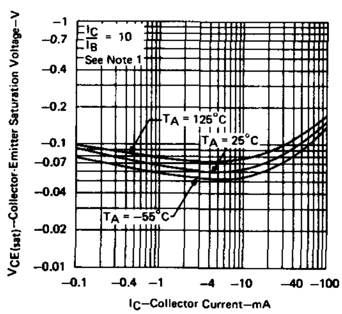

FIGURE 4

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs V_{CE}

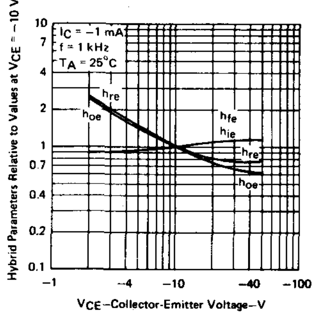

FIGURE 5

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

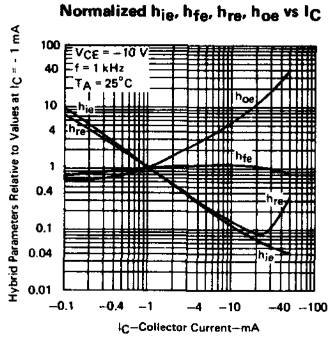

FIGURE 6

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle $\leqslant$ 2%.

5

TYPICAL CHARACTERISTICS

f_T vs I_C

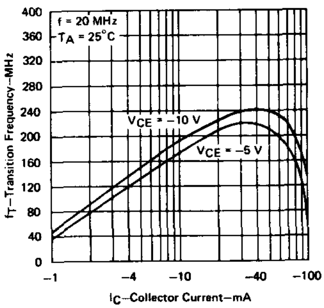

FIGURE 7

C_{obo} vs V_{CB}

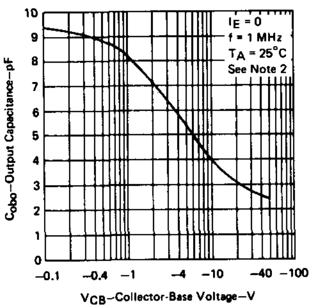

FIGURE 8

C_{ibo} vs V_{EB}

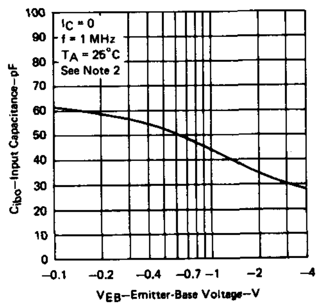

FIGURE 9

F vs f

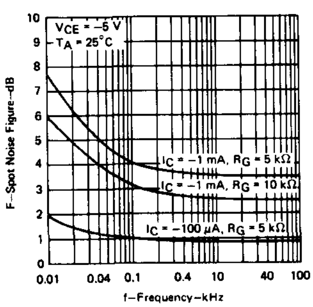

FIGURE 10

$\overline{F}$ vs R_G

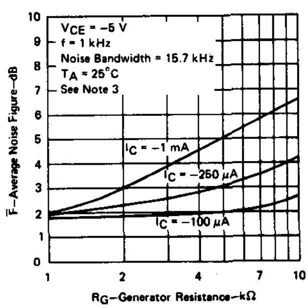

FIGURE 11

NOTES: 2. Capacitance measurements were made using chips mounted in TO-92 packages.
3. Average Noise Figure was measured in an amplifier with response down 3 dB at 10 Hz and 10 kHz and a high-frequency roll-off of 6 dB/octave.

TEXAS INSTRUMENTS
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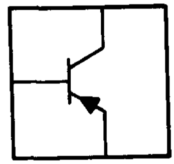
- **P23 is a 20 X 20-mil, epitaxial, planar, expanded-contact chip**
- **Available in TO-18 packages**
- **For use in low-power, general purpose saturated switching and amplifier circuits**



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	$-40^{\blacklozenge}$	−75		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 1	$-30^{\blacklozenge}$	−65		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	$-5^{\blacklozenge}$	−8.5		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -40$ V, $I_E = 0$		−2	−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -100\ \mu A$	40	155		
		$V_{CE} = -1$ V, $I_C = -1$ mA	40	170		
		$V_{CE} = -1$ V, $I_C = -10$ mA, See Note 1	40	150	300	
		$V_{CE} = -1$ V, $I_C = -50$ mA, See Note 1	15	85		
		$V_{CE} = -5$ V, $I_C = -10$ mA, See Note 1	45	175	400	
V_{BE}	Base-Emitter Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 1	−0.6	−0.8	−1.0	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 1		−0.05	−0.35	V
		$I_B = -5$ mA, $I_C = -50$ mA, See Note 1		−0.13	−0.55	V
h_{ie}	Small-Signal Common-Emitter Input Impedance	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz	1	5	12	kΩ
h_{fe}	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz	50	190	400	
h_{re}	Small-Signal Common-Emitter Reverse Voltage Transfer Ratio	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz		1×10^{-4}	20×10^{-4}	
h_{oe}	Small-Signal Common-Emitter Output Admittance	$V_{CE} = -5$ V, $I_C = -1$ mA, f = 1 kHz	4	30	60	μmho
f_T	Transition Frequency	$V_{CE} = -1$ V, $I_C = -10$ mA, f = 100 MHz		340		MHz
		$V_{CE} = -5$ V, $I_C = -10$ mA, f = 100 MHz	200	500		MHz
		$V_{CE} = -20$ V, $I_C = -10$ mA, f = 100 MHz	250	730		MHz
C_{obo}	Common-Base Open-Circuit Output Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 1 MHz, See Note 2		3	6	pF
C_{ibo}	Common-Base Open-Circuit Input Capacitance	$V_{EB} = -1$ V, $I_C = 0$, f = 1 MHz, See Note 2		4	8	pF
F	Spot Noise Figure	$V_{CE} = -5$ V, $I_C = -100\ \mu A$, $R_G = 1$ kΩ, f = 100 Hz		2.5	6	dB
t_d	Delay Time	$V_{CC} = -3$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $V_{BE(off)} \approx 0.5$ V, 2N3250 Data Sheet Circuit		8		ns
t_r	Rise Time	$V_{CC} = -3$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $V_{BE(off)} \approx 0.5$ V, 2N3250 Data Sheet Circuit		13		ns
t_s	Storage Time	$V_{CC} = -3$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $I_{B(2)} \approx 1$ mA, 2N3250 Data Sheet Circuit		130		ns
t_f	Fall Time	$V_{CC} = -3$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $I_{B(2)} \approx 1$ mA, 2N3250 Data Sheet Circuit		25		ns
t_d	Delay Time	$V_{CC} = -3$ V, $I_C \approx -10$ mA, $I_{B(1)} \approx -1$ mA, $I_{B(2)} \approx 1$ mA, $V_{BE(off)} \approx 4.1$ V, See Figure 1		30		ns
t_r	Rise Time	(same)		12		ns
t_s	Storage Delay	(same)		130		ns
t_f	Fall Time	(same)		25		ns

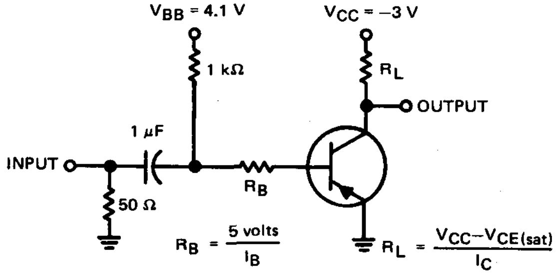
♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

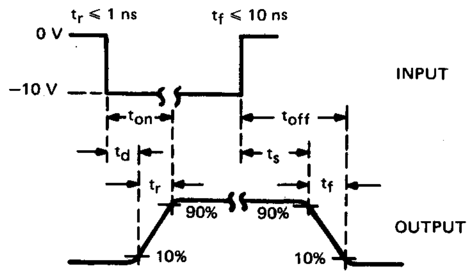
2. Capacitance measurements were made using chips mounted in TO-18 packages.

CHIP TYPE P23
P-N-P SILICON TRANSISTORS

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



(See Notes a and b)
VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics: Z_{out} = 50 Ω; for measuring t_d and t_r, $t_w \approx 200$ ns, duty cycle ≤ 2%; for measuring t_s and t_f, $t_w \approx 10$ μs, duty cycle ≤ 2%.

b. Waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 1$ ns, $R_{in} \geq 100$ kΩ, $C_{in} \leq 7$ pF.

FIGURE 1—SWITCHING TIMES

TYPICAL CHARACTERISTICS

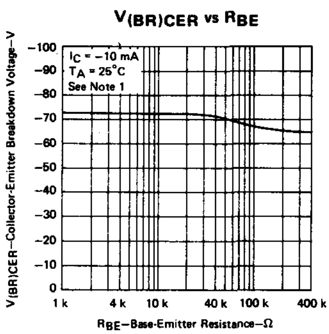


FIGURE 2

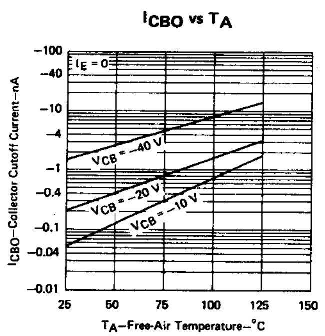


FIGURE 3

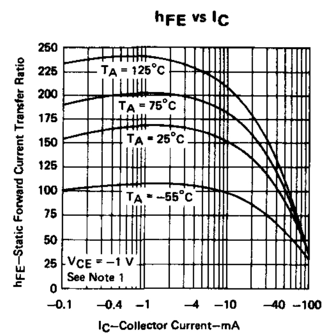


FIGURE 4

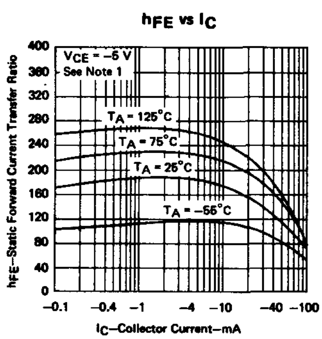


FIGURE 5

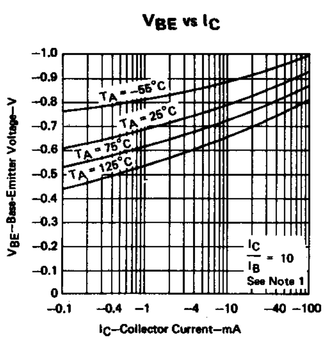


FIGURE 6

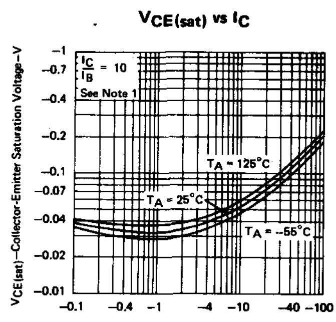


FIGURE 7

NOTE 1: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

TYPICAL CHARACTERISTICS

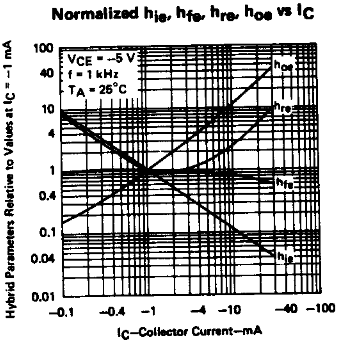


FIGURE 8

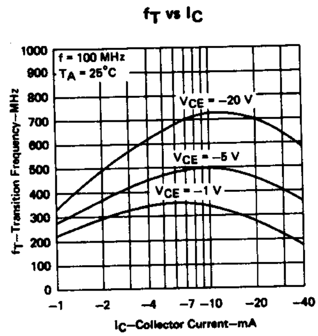


FIGURE 9

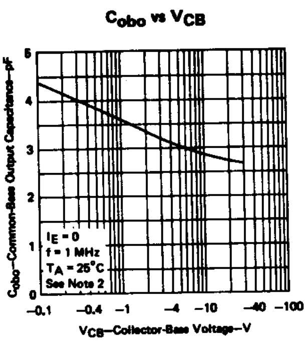


FIGURE 10

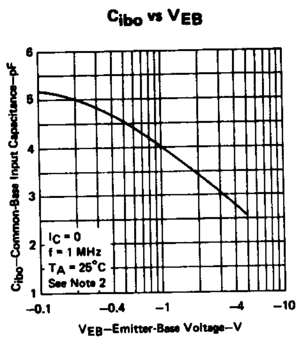


FIGURE 11

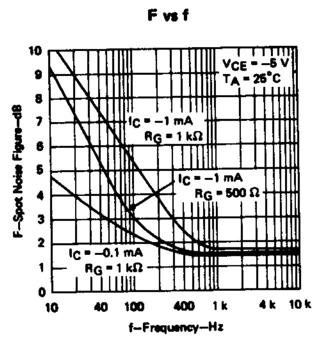


FIGURE 12

NOTE 2: Capacitance measurements were made using chips mounted in TO-18 packages.

TYPICAL CHARACTERISTICS

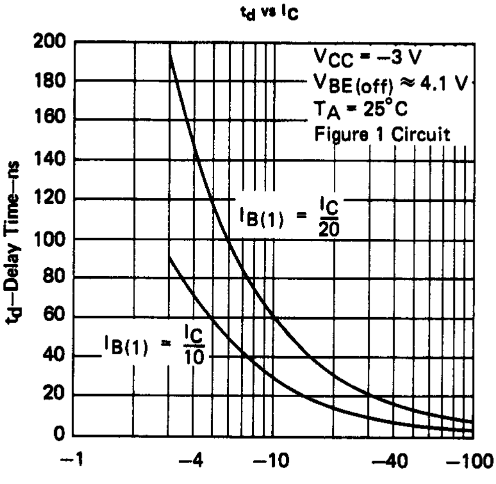


FIGURE 13

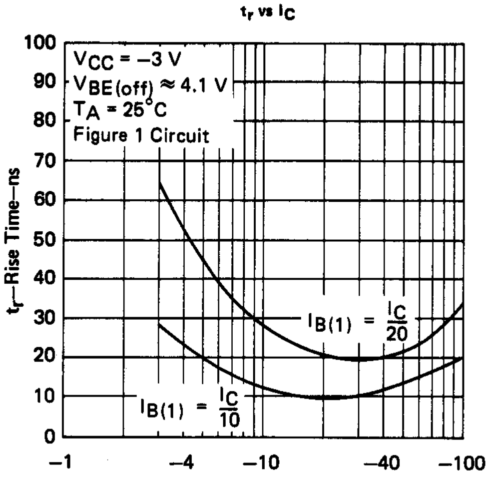


FIGURE 14

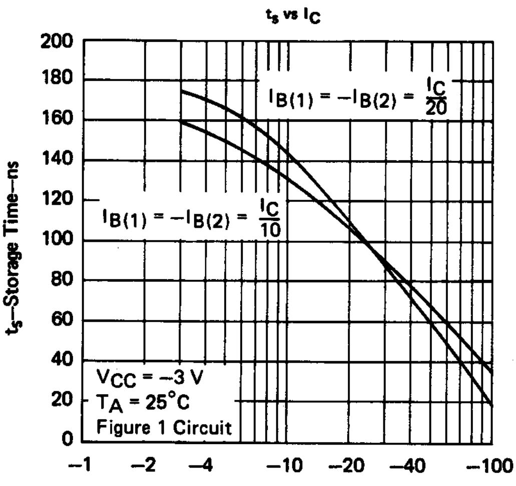


FIGURE 15

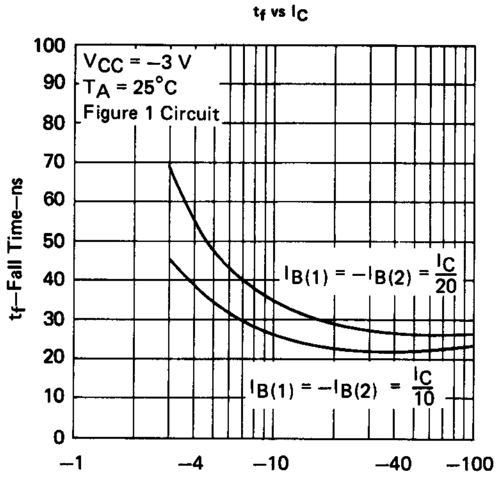


FIGURE 16

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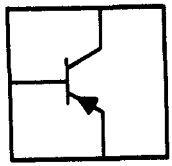
- **P24 is a 20 X 20-mil, epitaxial, planar, direct-contact chip**
- **Available in *Silect*† packages**
- **For use in AM/FM/TV RF/IF converter and amplifier circuits to 300 MHz**



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−70♦	−110		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -2\ mA$, $I_B = 0$, See Note 1	−70♦	−110		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−4♦	−6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -20\ V$, $I_E = 0$		−<0.1	100	nA
		$V_{CB} = -60\ V$, $I_E = 0$		−<1		
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -9\ V$, $I_C = -0.1\ mA$		55		
		$V_{CE} = -9\ V$, $I_C = -1\ mA$	25	90		
		$V_{CE} = -9\ V$, $I_C = -10\ mA$, See Note 1		120		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -9\ V$, $I_C = -1\ mA$	−0.5	−0.65	−0.85	V
		$V_{CE} = -9\ V$, $I_C = -10\ mA$, See Note 1		−0.75		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.1\ mA$, $I_C = -1\ mA$		−0.07	−0.5	V
		$I_B = -1\ mA$, $I_C = -10\ mA$, See Note 1		−0.09		
$\lvert h_{fe} \rvert$	Small-Signal Common-Emitter Forward Current Transfer Ratio	$V_{CE} = -9\ V$, $I_C = -1\ mA$, $f = 455\ kHz$	30	39		dB
		$V_{CE} = -9\ V$, $I_C = -1\ mA$, $f = 10\ MHz$	14	25		
f_T	Transition Frequency	$V_{CE} = -10\ V$, $I_C = -10\ mA$, $f = 100\ MHz$		320		MHz
$\lvert y_{fe} \rvert$	Small-Signal Common-Emitter Forward Transfer Admittance	$V_{CE} = -9\ V$, $I_C = -1\ mA$, $f = 455\ kHz$	32	35		mmho
C_{cb}	Collector-Base Capacitance	$V_{CB} = -9\ V$, $I_E = 0$, $f = 1\ MHz$, See Notes 2 and 3		1.1		pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5\ V$, $I_C = 0$, $f = 1\ MHz$, See Notes 2 and 3		2.8		pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CB} = -9\ V$, $I_E = 1\ mA$, $f = 79.8\ MHz$		30	70	ps
F	Spot Noise Figure	$V_{CE} = -9\ V$, $I_C = -50\ \mu A$, $R_G = 1\ k\Omega$, $f = 10\ Hz$		3.5		dB
		$V_{CE} = -9\ V$, $I_C = -50\ \mu A$, $R_G = 1\ k\Omega$, $f = 1\ kHz$		1.5		
		$V_{CE} = -9\ V$, $I_C = -1\ mA$, $R_G = 1\ k\Omega$, $f = 1\ MHz$		1		

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
2. Capacitance measurements were made using chips mounted in TO-92 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

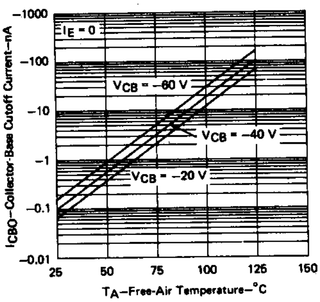


FIGURE 1

h_{FE} vs I_C

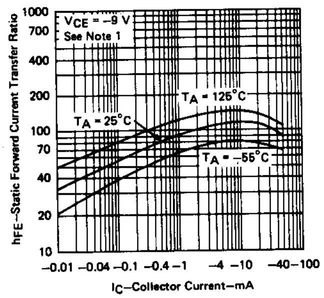


FIGURE 2

V_{BE} vs I_C

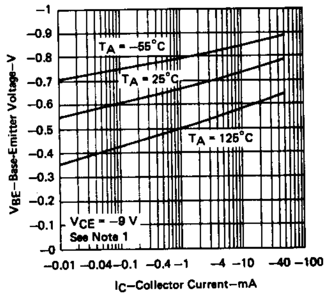


FIGURE 3

V_{BE} vs I_C

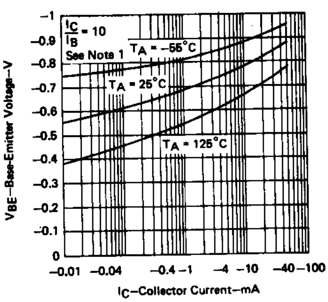


FIGURE 4

$V_{CE(sat)}$ vs I_C

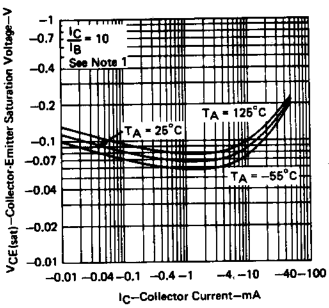


FIGURE 5

Normalized h_{ie}, h_{fe}, h_{re}, h_{oe} vs I_C

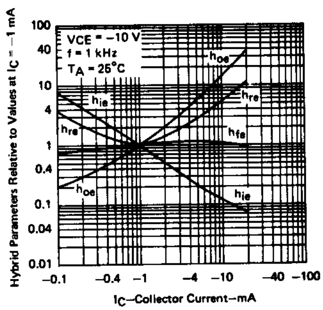


FIGURE 6

$|h_{fe}|$ vs I_C

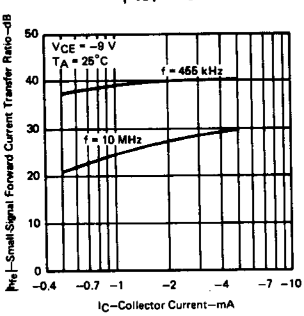


FIGURE 7

f_T vs I_C

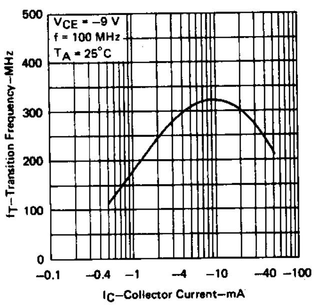


FIGURE 8

$|y_{fe}|$ vs I_C

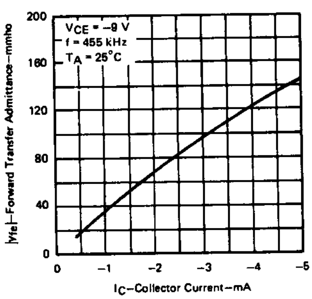


FIGURE 9

NOTE 1: These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leqslant 2\%$.

TYPICAL CHARACTERISTICS

r_{iep} vs I_C

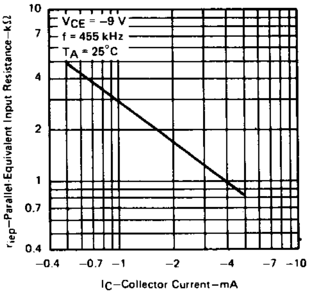


FIGURE10

r_{oep} vs I_C

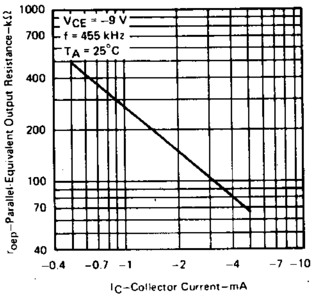


FIGURE 11

C_{cb} vs V_{CB}

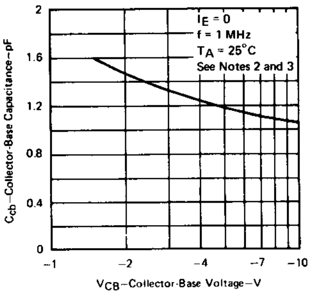


FIGURE 12

C_{eb} vs V_{EB}

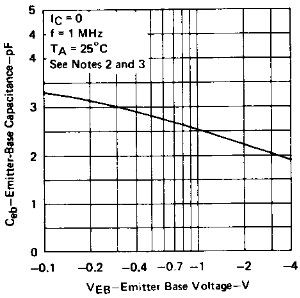


FIGURE 13

$r_b'C_c$ vs I_E

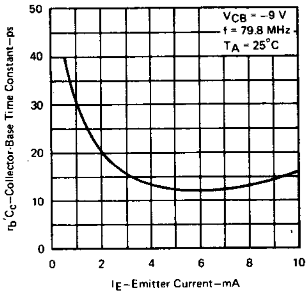


FIGURE 14

F vs f

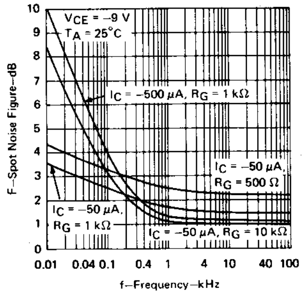


FIGURE 15

F vs I_C

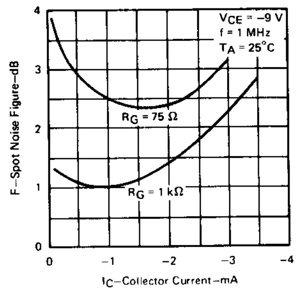


FIGURE 16

F vs R_G

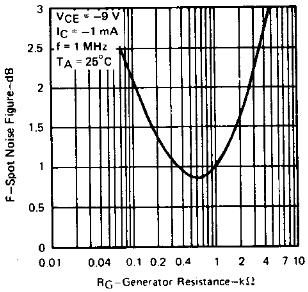


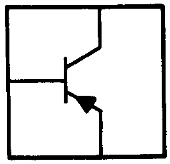
FIGURE 17

NOTES 2. Capacitance measurements were made using chips mounted in TO-92 packages.

3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

CHIP TYPE P25
P-N-P SILICON TRANSISTORS

- P25 is a 10 X 12-mil, epitaxial, planar, expanded-contact chip
- Available in *Silect*† packages
- For use in VHF/UHF common-base amplifier circuits requiring forward-AGC characteristics



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -100\ \mu A$, $I_E = 0$	−60♦	−110		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -1$ mA, $I_B = 0$, See Note 1	−45♦	−100		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -100\ \mu A$, $I_C = 0$	−4♦	−6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -25$ V, $I_E = 0$		−<0.1	−100	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -10$ V, $I_C = -2$ mA	30	50		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -10$ V, $I_C = -2$ mA		−0.8	−1.1	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -0.25$ mA, $I_C = -2.5$ mA		−0.3	−1.0	V
f_T	Transition Frequency	$V_{CE} = -10$ V, $I_C = -2$ mA, f = 100 MHz	650	900		MHz
$\lvert s_{fb}\rvert^2$	Square of Common-Base Forward Transmission Coefficient‡	$V_{CB} = -10$ V, $I_E = 2$ mA, f = 400 MHz, $Z_G = Z_L = 50\ \Omega + j0$, See Note 2		3		dB
C_{cb}	Collector-Base Capacitance	$V_{CB} = -10$ V, $I_E = 0$, f = 1 MHz, See Notes 2 and 3		0.5		pF
C_{ce}	Collector-Emitter Capacitance	$V_{CE} = -10$ V, $I_B = 0$, f = 1 MHz, See Notes 2 and 3		0.25	0.30	pF
F	Spot Noise Figure	$V_{CB} = -10$ V, $I_E = 2$ mA, $R_G = 50\ \Omega$, f = 850 MHz		5	6.5	dB

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

‡ $\lvert s_{fb}\rvert^2$ is equal to the insertion power gain of the transistor alone.

NOTES:
1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.
2. Capacitance and s-parameter measurements were made using chips mounted in *Silect* packages.
3. C_{cb} and C_{ce} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or base, respectively) is connected to the guard terminal of the bridge.

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TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

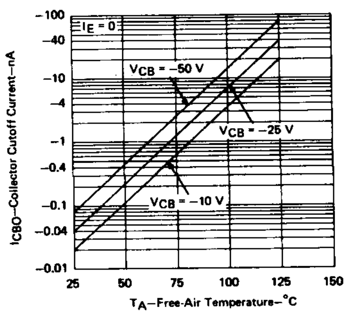


FIGURE 1

h_{FE} vs I_C

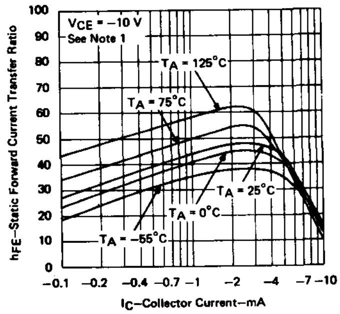


FIGURE 2

V_{BE} vs I_C

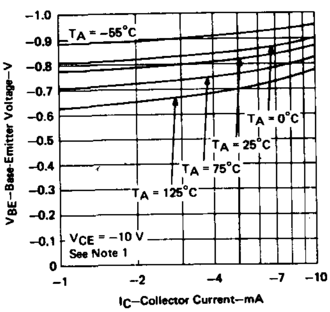


FIGURE 3

$V_{CE(sat)}$ vs I_C

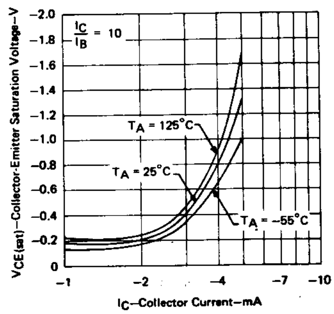


FIGURE 4

f_T vs I_C

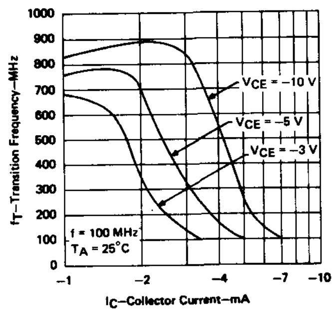


FIGURE 5

C_{cb}, C_{ce} vs V_R

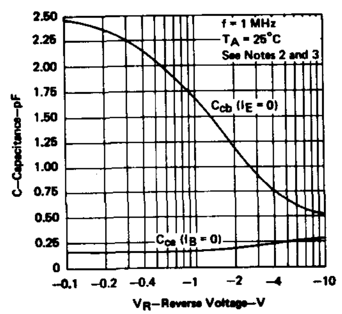


FIGURE 6

$|s_{fb}|^2$ vs f

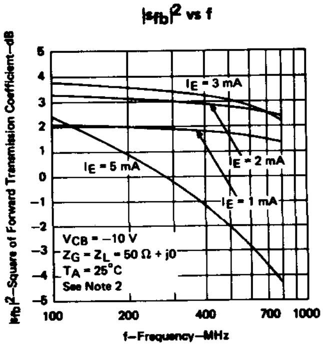


FIGURE 7

$|s_{rb}|^2$ vs f

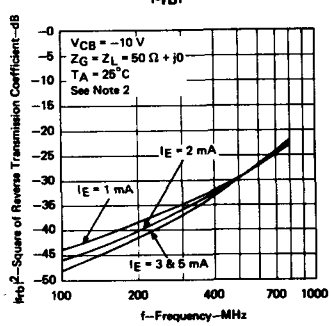
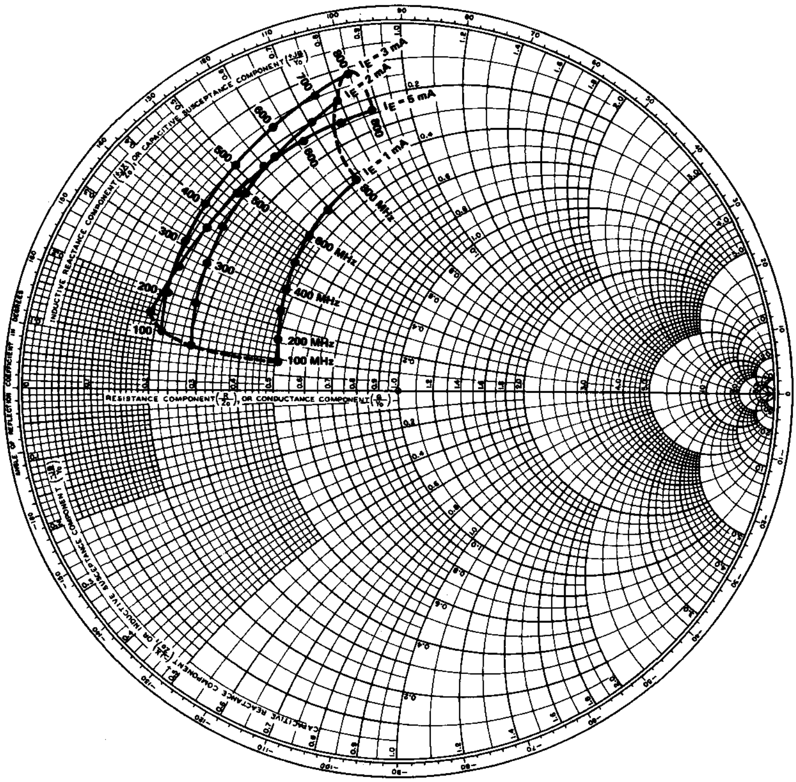


FIGURE 8

NOTES.
1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.
2. Capacitance and s-parameter measurements were made using chips mounted in *Silect* packages.
3. C_{cb} and C_{ce} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or base, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

COMMON-BASE INPUT REFLECTION COEFFICIENT, s_{ib}
and
NORMALIZED INPUT IMPEDANCE
$V_{CB} = -10$ V, $Z_G = Z_L = 50\ \Omega + j0$, $T_A = 25°C$



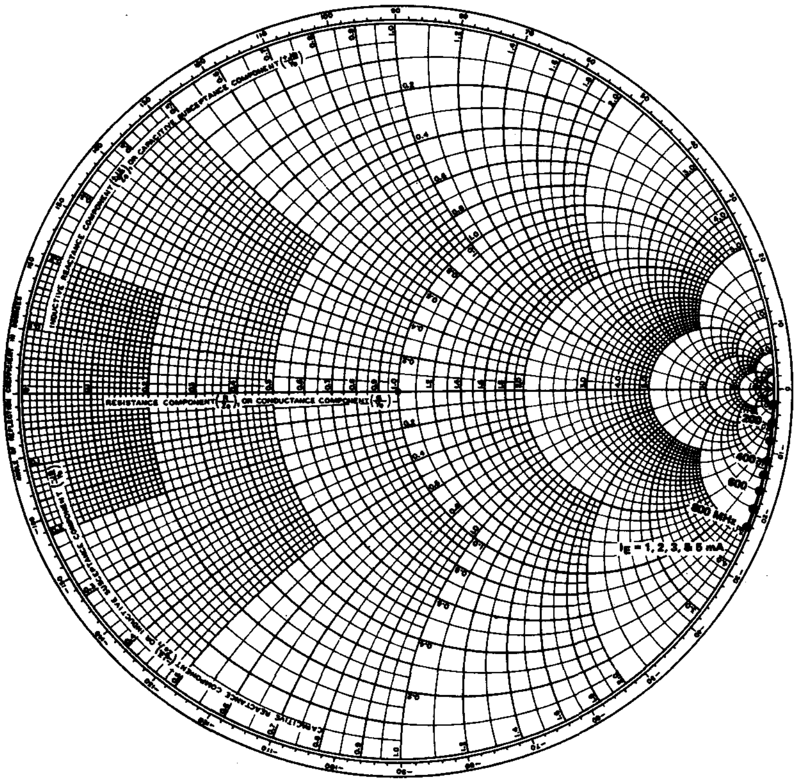
Frequency	$I_E = 1$ mA		$I_E = 2$ mA		$I_E = 3$ mA		$I_E = 5$ mA	
	$\|s_{ib}\|$	ϕ_{sib}	$\|s_{ib}\|$	ϕ_{sib}	$\|s_{ib}\|$	ϕ_{sib}	$\|s_{ib}\|$	ϕ_{sib}
100 MHz	0.33	167°	0.57	167°	0.65	166°	0.70	162°
200 MHz	0.35	157°	0.59	157°	0.67	157°	0.68	150°
300 MHz	0.38	145°	0.62	146°	0.70	145°	0.68	139°
400 MHz	0.41	138°	0.65	137°	0.73	135°	0.70	129°
500 MHz	0.45	129°	0.69	129°	0.76	125°	0.71	121°
600 MHz	0.49	119°	0.72	118°	0.79	115°	0.73	111°
700 MHz	0.53	111°	0.77	108°	0.84	105°	0.74	102°
800 MHz	0.59	102°	0.81	102°	0.88	99°	0.77	95°

These measurements were made using chips mounted in *Silect* packages.

FIGURE 9

TYPICAL CHARACTERISTICS

COMMON-BASE OUTPUT REFLECTION COEFFICIENT, s_{ob}
and
NORMALIZED OUTPUT IMPEDANCE
$V_{CB} = -10$ V, $Z_G = Z_L = 50\ \Omega + j0$, $T_A = 25°C$



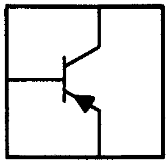
Frequency	I_E = 1 mA		I_E = 2 mA		I_E = 3 mA		I_E = 5 mA	
	$\lvert s_{ob}\rvert$	ϕ_{sob}	$\lvert s_{ob}\rvert$	ϕ_{sob}	$\lvert s_{ob}\rvert$	ϕ_{sob}	$\lvert s_{ob}\rvert$	ϕ_{sob}
100 MHz	0.998	−2°	0.998	−2°	0.998	−2°	0.998	−2°
200 MHz	0.998	−5°	0.998	−5°	0.998	−5°	0.998	−5°
300 MHz	0.998	−8°	0.998	−8°	0.998	−8°	0.998	−8°
400 MHz	0.998	−11°	0.998	−11°	0.998	−11°	0.998	−11°
500 MHz	0.998	−14°	0.998	−14°	0.998	−14°	0.998	−14°
600 MHz	0.998	−16°	0.998	−16°	0.998	−16°	0.998	−16°
700 MHz	0.998	−19°	0.998	−19°	0.998	−19°	0.998	−19°
800 MHz	0.998	−22°	0.998	−22°	0.998	−22°	0.998	−22°

These measurements were made using chips mounted in *Silect* packages.

FIGURE 10

CHIP TYPE P27
P-N-P SILICON TRANSISTORS

- P27 is a 15 X 15-mil, epitaxial, planar, expanded-contact chip
- Available in TO-72 and *Silect*† packages
- For high-speed switching or high-frequency (to 2 GHz) amplifier circuits



electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = -10\ \mu A$, $I_E = 0$	−15♦	−30		V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = -10$ mA, $I_B = 0$, See Note 1	−15♦	−20		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = -10\ \mu A$, $I_C = 0$	−4.5♦	−6		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = -15$ V, $I_E = 0$		−<0.1	−50	nA
h_{FE}	Static Forward Current Transfer Ratio	$V_{CE} = -1$ V, $I_C = -1$ mA	25	35		
		$V_{CE} = -6$ V, $I_C = -10$ mA, See Note 1	30	50		
V_{BE}	Base-Emitter Voltage	$V_{CE} = -1$ V, $I_C = -1$ mA		−0.7	−0.8	V
		$V_{CE} = -6$ V, $I_C = -10$ mA, See Note 1		−0.8	−1	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_B = -1$ mA, $I_C = -10$ mA, See Note 1		−0.11	−0.35	V
f_T	Transition Frequency	$V_{CE} = -6$ V, $I_C = -20$ mA, f = 400 MHz	1.6	2.8		GHz
$\|s_{fe}\|^2$	Square of Common-Emitter Forward Transmission Coefficient‡	$V_{CE} = -6$ V, $Z_G = Z_L = 50\ \Omega + j0$, f = 450 MHz, See Note 2, $I_C = -2$ mA		8		dB
		$V_{CE} = -6$ V, $Z_G = Z_L = 50\ \Omega + j0$, f = 450 MHz, See Note 2, $I_C = -10$ mA		11		
C_{cb}	Collector-Base Capacitance	$V_{CB} = -6$ V, $I_E = 0$, f = 1 MHz		0.75	1.5	pF
C_{eb}	Emitter-Base Capacitance	$V_{EB} = -0.5$ V, $I_C = 0$, See Notes 2 and 3		2.25	3.0	pF
$r_b'C_c$	Collector-Base Time Constant	$V_{CE} = -6$ V, $I_C = -5$ mA, f = 79.8 MHz, See Note 2		11	30	ps
F	Spot Noise Figure	$V_{CE} = -6$ V, $I_C = -2$ mA, $R_G = 50\ \Omega$, f = 450 MHz		3.3	4	dB

†Trademark of Texas Instruments

♦These values do not modify guaranteed limits for specific devices and do not justify operation in excess of absolute maximum ratings.

‡ $|s_{fe}|^2$ is equal to the insertion power gain of the transistor alone.

NOTES: 1. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%.

2. Capacitance, $r_b'C_c$, and s-parameter measurements were made using chips mounted in TO-72 packages.

3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

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TYPICAL CHARACTERISTICS

I_{CBO} vs T_A

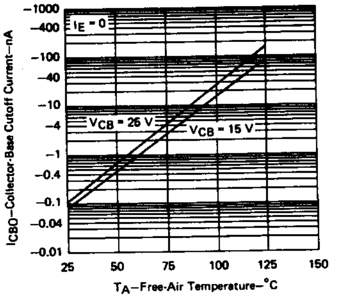


FIGURE 1

h_{FE} vs I_C

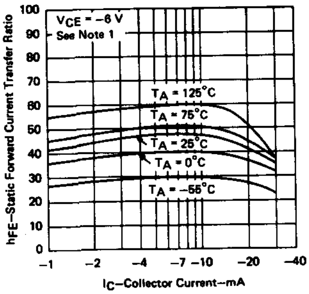


FIGURE 2

h_{FE} vs I_C

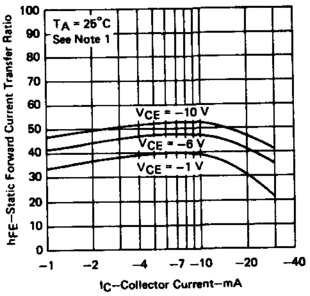


FIGURE 3

V_{BE} vs I_C

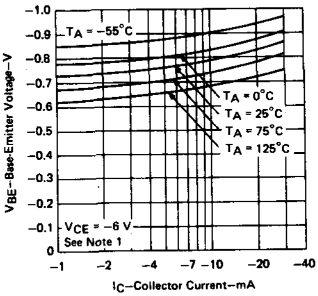


FIGURE 4

$V_{CE(sat)}$ vs I_C

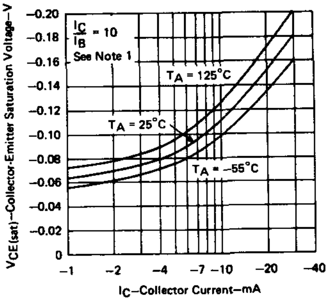


FIGURE 5

NOTE 1: This parameter was measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

TYPICAL CHARACTERISTICS

f_T vs I_C

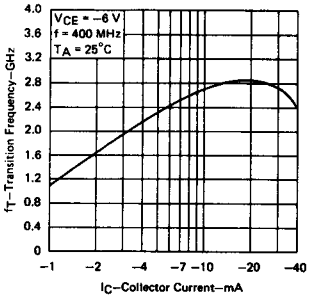


FIGURE 6

C_{cb} vs V_{CB}

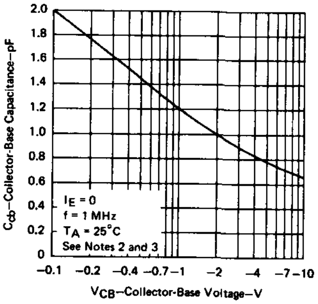


FIGURE 7

C_{eb} vs V_{EB}

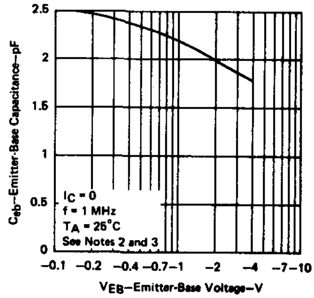


FIGURE 8

$|s_{fe}|^2$ vs f

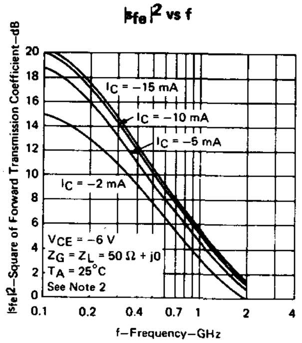


FIGURE 9

$|s_{re}|^2$ vs f

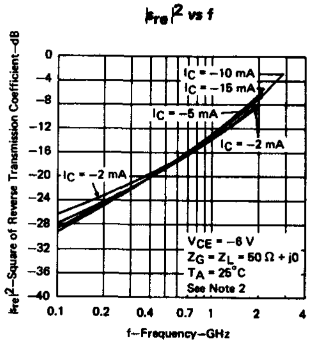
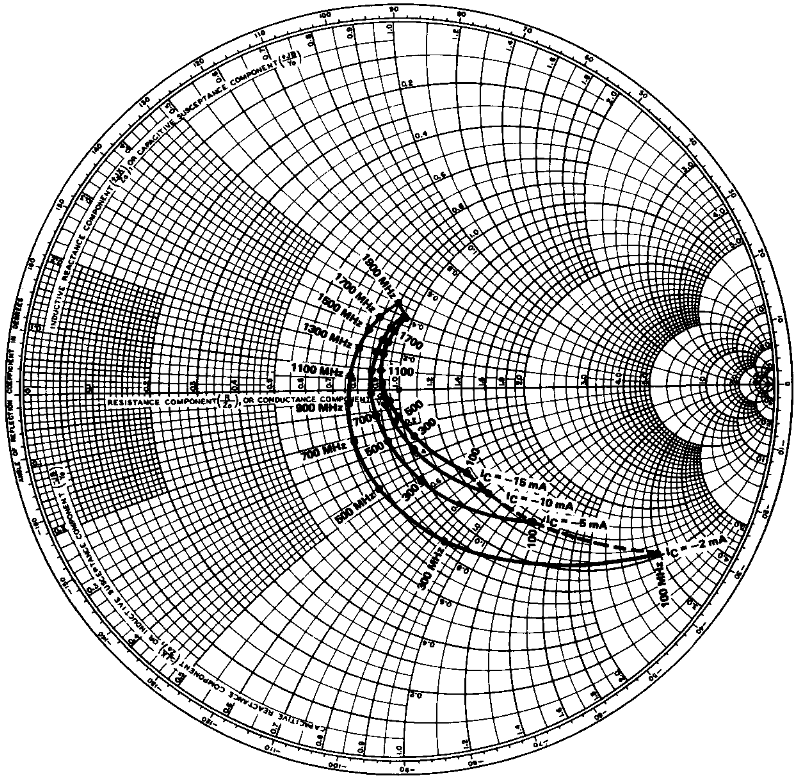


FIGURE 10

NOTES: 1. This parameter was measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.
2. Capacitance, $r_b'C_c$, and s-parameter measurements were made using chips mounted in TO-72 packages.
3. C_{cb} and C_{eb} measurements employ a three-terminal capacitance bridge incorporating a guard circuit. The third electrode (emitter or collector, respectively) is connected to the guard terminal of the bridge.

TYPICAL CHARACTERISTICS

COMMON-EMITTER INPUT REFELCTION COEFFICIENT, s_{ie}
and
NORMALIZED INPUT IMPEDANCE
V_{CE} = −6 V, Z_G = Z_L = 50 Ω + j0, T_A = 25°C



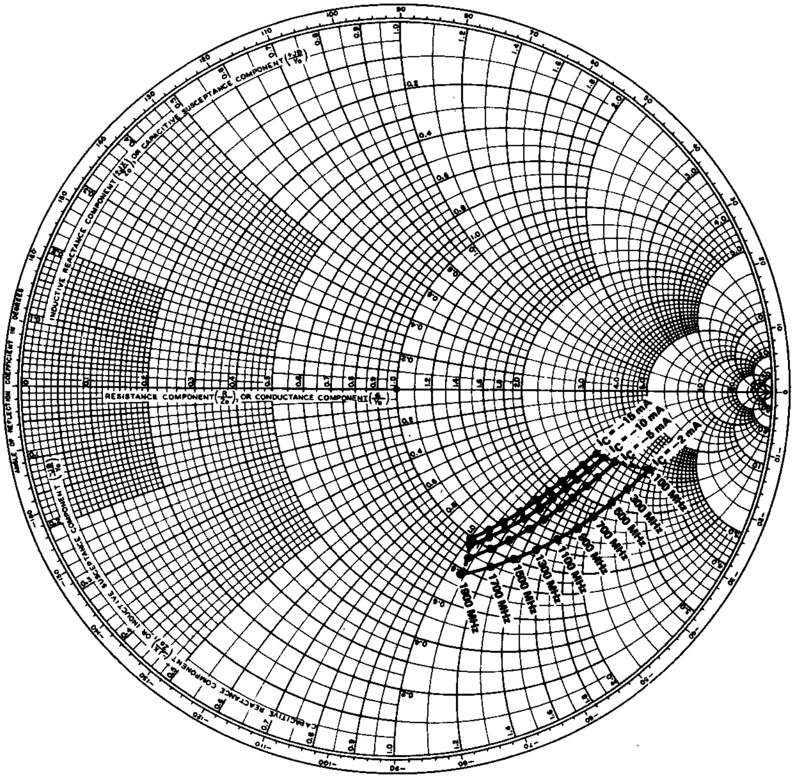
Frequency	I_C = −2 mA		I_C = −5 mA		I_C = −10 mA		I_C = −15 mA	
	$\|s_{ie}\|$	ϕ_{sie}	$\|s_{ie}\|$	ϕ_{sie}	$\|s_{ie}\|$	ϕ_{sie}	$\|s_{ie}\|$	ϕ_{sie}
100 MHz	0.82	−34°	0.51	−46°	0.37	−51°	0.29	−53°
300 MHz	0.43	−75°	0.25	−78°	0.17	−78°	0.13	−75°
500 MHz	0.28	−102°	0.14	−102°	0.09	−99°	0.07	−93°
700 MHz	0.18	−131°	0.09	−131°	0.05	−131°	0.04	−133°
900 MHz	0.14	−165°	0.08	−176°	0.05	170°	0.05	156°
1100 MHz	0.14	164°	0.09	143°	0.07	130°	0.07	130°
1300 MHz	0.16	133°	0.12	118°	0.11	112°	0.11	112°
1500 MHz	0.18	115°	0.15	107°	0.14	103°	0.14	103°
1700 MHz	0.20	103°	0.17	95°	0.18	93°	0.16	93°
1900 MHz	0.24	90°	0.20	85°	0.19	84°	0.19	84°

These measurements were made using chips mounted in TO-72 packages.

FIGURE 11

TYPICAL CHARACTERISTICS

COMMON-EMITTER OUTPUT REFLECTION COEFFICIENT, s_{oe}
and
NORMALIZED OUTPUT IMPEDANCE
$V_{CE} = -6\ V$, $Z_G = Z_L = 50\ \Omega + j0$, $T_A = 25°C$



Frequency	$I_C = -2$ mA		$I_C = -5$ mA		$I_C = -10$ mA		$I_C = -15$ mA	
	$\lvert s_{oe} \rvert$	ϕ_{soe}	$\lvert s_{oe} \rvert$	ϕ_{soe}	$\lvert s_{oe} \rvert$	ϕ_{soe}	$\lvert s_{oe} \rvert$	ϕ_{soe}
100 MHz	0.71	−17°	0.62	−18°	0.59	−18°	0.56	−18°
300 MHz	0.68	−24°	0.59	−24°	0.56	−23°	0.54	−22°
500 MHz	0.66	−28°	0.57	−27°	0.54	−27°	0.52	−26°
700 MHz	0.64	−33°	0.56	−32°	0.52	−31°	0.51	−30°
900 MHz	0.62	−38°	0.55	−36°	0.51	−35°	0.49	−34°
1100 MHz	0.60	−44°	0.54	−42°	0.50	−40°	0.48	−39°
1300 MHz	0.58	−50°	0.52	−47°	0.49	−45°	0.47	−45°
1500 MHz	0.56	−56°	0.51	−54°	0.48	−53°	0.46	−52°
1700 MHz	0.55	−62°	0.50	−60°	0.48	−58°	0.46	−57°
1900 MHz	0.53	−72°	0.50	−67°	0.47	−65°	0.45	−64°

These measurements were made using chips mounted in TO-72 packages.

FIGURE 12

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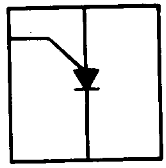
- U41 is a 20 X 20-mil, epitaxial, planar, direct-contact, p-n-p-n thyristor chip with an n-gate
- Available in TO-18 and *Silect*† packages
- For unijunction applications requiring programmable η, r_{BB}, I_V, and I_P

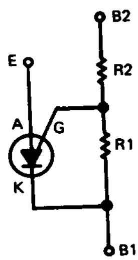


electrical and operating characteristics at 25°C free-air temperature

PARAMETER		CONDITIONS	OBSERVED VALUES LOW	TYP	HIGH	UNIT
I_{GAO}	Gate Reverse Current	$V_{GA} = 40$ V, $I_K = 0$		<0.1	5	nA
I_{GKS}	Gate Reverse Current	$V_{GK} = 40$ V, $V_{AK} = 0$		<0.1	50	nA
V_P-V_S	Offset Voltage	$V_S = 10$ V, $R_G = 10$ kΩ	0.2	0.35	0.6	V
		$V_S = 10$ V, $R_G = 10$ MΩ	0.2	0.33	1.6	
I_P	Peak-Point Current	$V_S = 10$ V, $R_G = 10$ kΩ		1.0	5	μA
		$V_S = 10$ V, $R_G = 1$ MΩ		0.1	2	
I_V	Valley-Point Current	$V_S = 10$ V, $R_G = 10$ kΩ	25	200		μA
		$V_S = 10$ V, $R_G = 1$ MΩ		15	50	
V_F	Anode-Cathode On-State Voltage	$V_S = 10$ V, $R_G = 10$ kΩ, $I_F = 50$ mA		1	1.5	V
V_{OM}	Peak Output Voltage	$V_{AA} = 20$ V, C1 = 0.2 μF, See Figure 3	6	10		V
t_r	Output Pulse Rise Time			60	80	ns

5

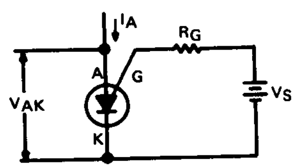
PARAMETER MEASUREMENT INFORMATION



Interbase Resistance $r_{BB} \approx R1+R2$

Intrinsic Standoff Ratio $\eta \approx \frac{R1}{R1 \cdot R2}$

FIGURE 1–PROGRAMMABLE UNIJUNCTION CIRCUIT



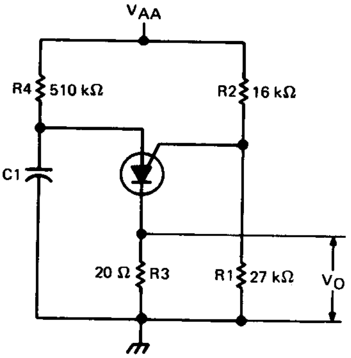
$V_S = \frac{R1 \cdot V_{B2B1}}{R1+R2}$

$R_G = \frac{R1 \cdot R2}{R1+R2}$

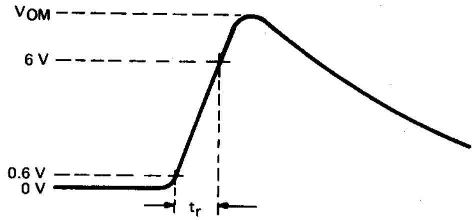
FIGURE 2–EQUIVALENT CIRCUIT USED FOR TESTING

†Trademark of Texas Instruments

PARAMETER MEASUREMENTS



TEST CIRCUIT



OUTPUT VOLTAGE WAVEFORM

FIGURE 3—TESTING OPERATING CHARACTERISTICS

TYPICAL CHARACTERISTICS

I_{GKS} vs T_A

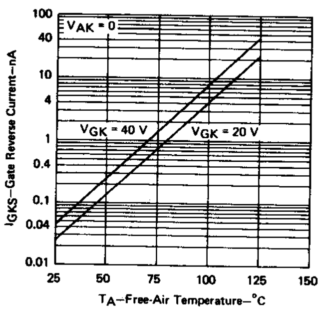


FIGURE 4

I_P vs T_A

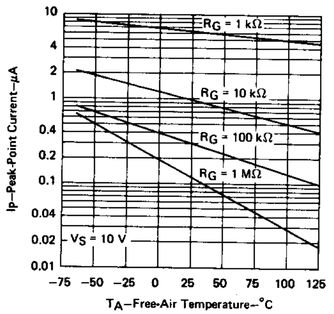


FIGURE 5

I_P vs V_S

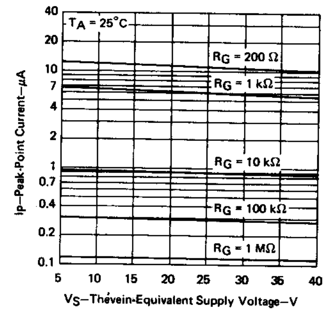


FIGURE 6

V_P-V_S vs T_A

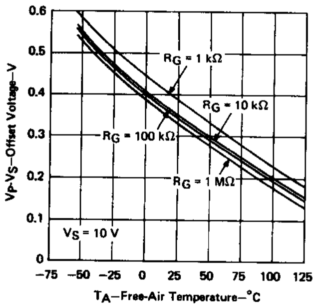


FIGURE 7

I_V vs T_A

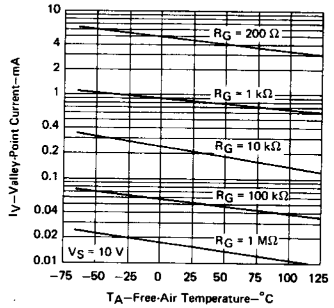


FIGURE 8

I_V vs V_S

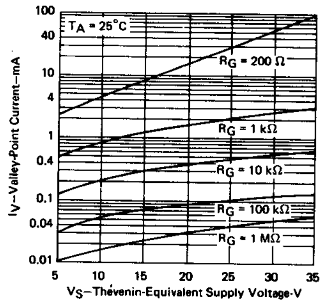


FIGURE 9

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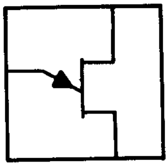
CHIP TYPE U42
P-N PLANAR UNIJUNCTION TRANSISTORS

- U42 is a 15 X 15-mil, P-N, direct-contact chip
- Available in modified TO-18 and *Silect*† packages
- For use in simple relaxation oscillator circuits as SCR drivers, timers, motor-speed controls, waveform generators, multivibrators, ring counters, electronic organs, and ordnance fuzes



electrical and operating characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		CONDITIONS	OBSERVED VALUES			UNIT
			LOW	TYP	HIGH	
r_{BB}	Static Interbase Resistance	$V_{B2B1} = 3$ V, $I_E = 0$	4	6	12	kΩ
α_{rBB}	Interbase Resistance Temperature Coefficient	$V_{B2B1} = 3$ V, $I_E = 0$, $T_A = -65°C$ to $100°C$, See Note 1	0.1		0.9	%/°C
η	Intrinsic Standoff Ratio	$V_{B2B1} = 10$ V	0.50		0.86	
$I_{B2(mod)}$	Modulated Interbase Current	$V_{B2B1} = 10$ V, $I_E = 50$ mA, See Note 2	12	28		mA
I_{EB2O}	Emitter Reverse Current	$V_{EB2} = -30$ V, $I_{B1} = 0$		−2.5	−10	nA
I_P	Peak-Point Emitter Current	$V_{B2B1} = 25$ V		0.4	2	μA
$V_{EB1(sat)}$	Emitter Saturation Voltage	$V_{B2B1} = 20$ V, $I_E = 50$ mA, See Note 2		1.8	3	V
I_V	Valley-Point Emitter Current	$V_{B2B1} = 20$ V	1	5	20	mA
V_{OB1}	Base-One Peak Pulse Voltage	See Figure 1		7.5		V

†Trademark of Texas Instruments

NOTES: 1. Temperature coefficient α_{rBB} is determined by the following formula:

$$\alpha_{rBB} = \left[\frac{(r_{BB} @ 100°C) - (r_{BB} @ -65°C)}{(r_{BB} @ 25°C)}\right] \frac{100\%}{165°C}$$

To obtain r_{BB} for a given temperature $T_{A(2)}$, use the following formula:

$$r_{BB(2)} = [r_{BB} @ 25°C]\ [1 + (\alpha_{rBB}/100\%)\ (T_{A(2)} - 25°C)]$$

2. These parameters were measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

CHIP TYPE U42
P-N PLANAR UNIJUNCTION TRANSISTORS

PARAMETER MEASUREMENT INFORMATION

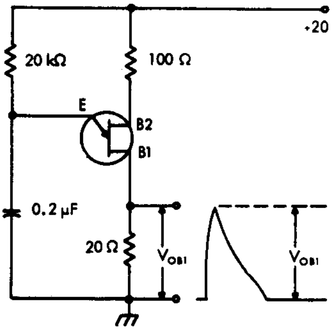


FIGURE 1—V_{OB1} TEST CIRCUIT

TYPICAL CHARACTERISTICS

r_{BB} vs T_A

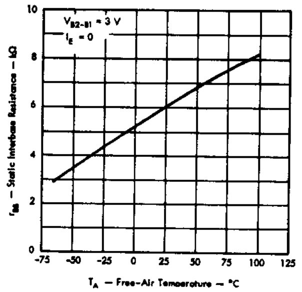


FIGURE 2

I_{EB2O} vs T_A

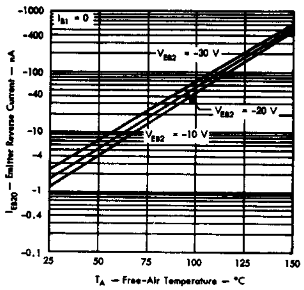


FIGURE 3

$I_{B2(mod)}$ vs V_{B2B1}

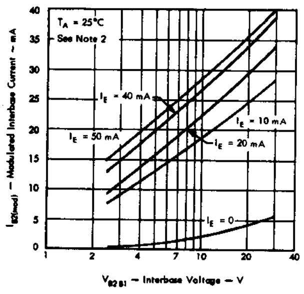


FIGURE 4

$I_{B2(mod)}$ vs T_A

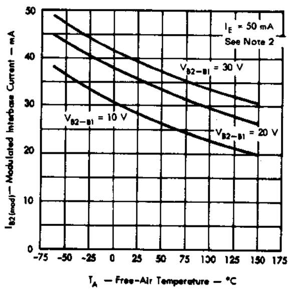


FIGURE 5

NOTE 2: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

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TYPICAL CHARACTERISTICS

I_P vs T_A

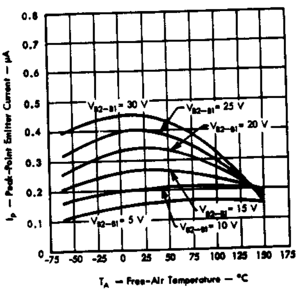

FIGURE 6

V_{EB1} vs I_E

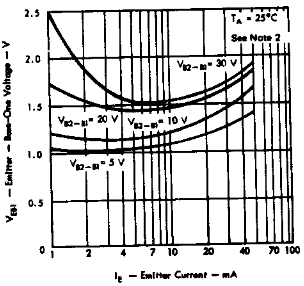

FIGURE 7

$V_{EB1(sat)}$ vs T_A

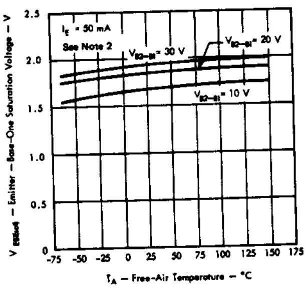

FIGURE 8

I_V vs T_A

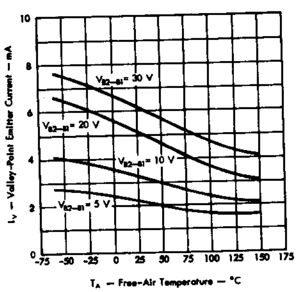

FIGURE 9

V_{OB1} vs T_A

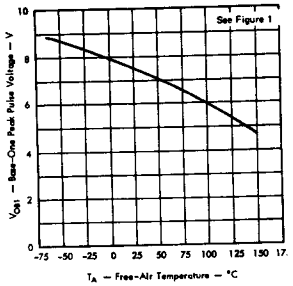

FIGURE 10

NOTE 2: These parameters were measured using pulse techniques. t_w = 300 μs, duty cycle ≤ 2%.

Transistor Quality and Reliability Information

All transistor types listed in this catalog are subject to electrical and mechanical sampling inspection performed by the Quality and Reliability Group to the following AQLs (Acceptance Quality Levels):

PARAMETER SUBGROUP	AQL, PARTIAL	AQL, CUMULATIVE
Static Parameters at 25°C	–	0.65
Static Parameters at other than 25°C	1.5	4.0
Dynamic Parameters (≤1 kHz)	1.5	4.0
Dynamic Parameters (>1 kHz)	1.5	4.0
Capacitances	1.5	4.0
Operating Characteristics	1.5	4.0
Switching Characteristics	1.5	4.0
All Other Parameters	1.5	4.0
Inoperatives	–	0.25

RELIABILITY OF SILICON TRANSISTORS

The technology for epitaxial planar silicon transistor chips with aluminum metallization has been established for several years. This technology, for the most part, is well understood. Processes for fabricating epitaxial planar silicon transistors are mature, and failure modes for transistors fabricated in a controlled process are defined. The failure-mode distribution for this process is shown in Figure 1. The primary failure modes are related to wire-bond-to-chip (contact) integrity and certain surface phenomena.

Understanding of the epitaxial planar silicon chip technology, maturity of the process, and knowledge of the failure-mode distribution make possible the definition of the reliability of these transistors. The reliability to be expected for transistors manufactured by the standard process is shown in the plot of average failure rate as a function of junction temperature in Figure 1. Data for Figure 2 are derived from life-tests at maximum-rated conditions—some as long as 35,000 hours (4 years, continuous). Specifically, the reliability of transistors from the standard process is defined by the curve labeled "Hermetically Packaged, Commercial".

Improvement in the reliability of these transistors can be achieved only by *additional* process requirements such as special selection of chips, more stringent pre-encapsulation criteria, or special screens such as active burn-in or high-temperature reverse-bias screening of encapsulated transistors. These measures are effective in removing devices with manufacturing anomalies which might cause failure of the parts during use. Column B of Figure 2 shows the relative improvement in failure rate and occurrence of failures which result from imposing special process requirements and subsequent screens.

The degree of reliability improvement obtained by the imposition of special process requirements and screens depends upon their efficacy. For example, Texas Instruments, experience shows that 100% pre-encapsulation inspection to the requirements of MIL-STD-750, Method 2072, is effective in removing visual defects which may ultimately be related to device reliability. On the other hand, inspection to more stringent criteria may very well result in the costly rejection of devices for reasons which in all probability are not related to ultimate reliability of failure-rate improvement.

The types and levels of stress used in screening transistors to improve reliability vary by device series. Some devices, for example, general purpose N-P-N transistors, are more effectively screened by active burn-in; others, for example, general purpose P-N-P transistors, by high-temperature reverse bias. In some cases, such as in attaining stabilization for a very low-level h_{FE}, a combination of both stresses is more desirable. If the types and levels of stress are properly specfied for the particular transistor series involved, no more than 168 hours of stress screening should be required. In some cases as little as 48 to 72 hours is sufficient. In general, stress screening longer than 168 hours does not significantly improve transistor reliability.

Figure 2 shows a plot of average failure rates as a function of virtual junction temperatures for different chip technologies, package configurations, and stress-screening requirements.

Figure 2 may also be interpreted as a rough thermal-derating guide for design purposes.

PLASTIC-ENCAPSULATED TRANSISTORS

Plastic-encapsulated transistors are fabricated with the same epitaxial planar silicon chips as used in hermetically packaged transistors. Processes for these plastic-encapsulated transistors are still changing because of improvements in the technology and packaging techniques of plastic compounds.

Packaging defects in conventional metal-case transistors are primarily related to hermeticity, whereas encapsulation with plastics introduces several additional variables including glass-transition temperature (a temperature at which certain plastic compounds suffer irreversible chemical changes), impurity levels, and coefficient of expansion of the plastic.

The failure-rate curve for plastic-encapsulated transistors in Figure 1 will be subject to significant improvements as plastic technology is further developed.

HERMETICALLY PACKAGED TRANSISTORS

The failure-rate curve in Figure 1 labeled "Hermetically Packaged, Commercial" reflects the expected average reliability of conventional transistors with standard process controls and with no special stress screening to remove potential failures. The curve in Figure 1 labeled "Hermetically Packaged, JAN" reflects an improvement in failure rate reliability through lot screening of devices for manufacturing anomalies and by lot-acceptance testing which includes both environmental and life-test requirements.

The failure-rate curve labeled "Hermetically Packaged, Special Screens" shows still further improvement in reliability as a result of additional process and stress-screening requirements. The absolute location of this curve is determined by the efficiency of special processing and screening, with a maximum improvement in failure rate of approximately one order of magnitude in comparison with transistors which do not receive this special processing. The failure rates shown on this particular curve correspond to the level of processing employed in the fabrication of transistors ranging from JANTX to high-reliability military and space applications.

SUMMARY

The process capability and reliability of epitaxial planar silicon transistors are well established. Several levels of reliability of these transistors can be attained by specific process and stress-screening requirements. Further improvements in reliability are attainable only by the introduction of different technologies. The reliability of plastic-encapsulated transistors is expected to improve significantly as plastic technology is further developed.

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AVERAGE FAILURE RATES (AND ESTIMATED FIELD FAILURE RATES) OF SILICON TRANSISTORS vs TEMPERATURE

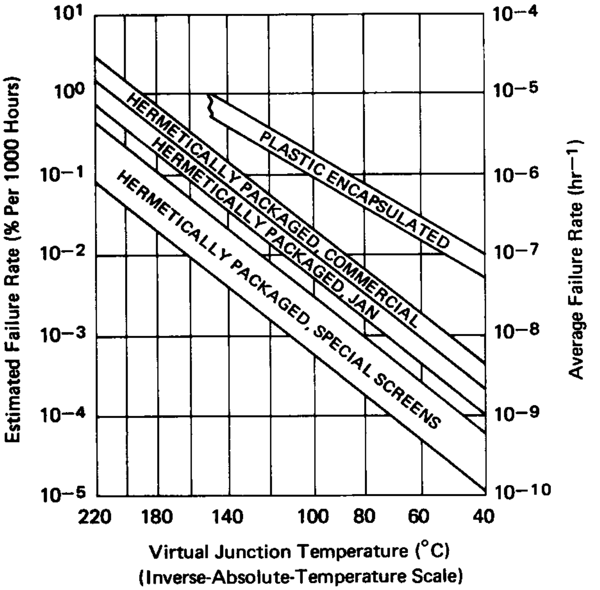

FIGURE 1

FAILURE-MODE DISTRIBUTION OF SILICON TRANSISTORS

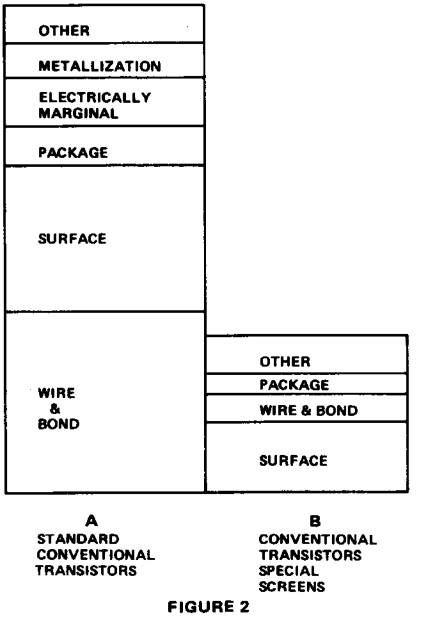

FIGURE 2

FACILITIES AND EQUIPMENT

A. LIFE-TEST AND BURN-IN FACILITIES

1. Texas Instruments Incorporated is equipped with extensive facilities to provide life-test and burn-in capabilities for silicon transistors and diodes.

2. Facilities are available for a wide range of tests including:

   a. Storage life testing up to 300°C.

   b. Voltage-temperature stress testing at both ambient and elevated temperature conditions.

   c. Free-air operating for transistors and diodes.

   d. Intermittent operating at various cycle times and power levels.

B. ENVIRONMENTAL FACILITIES

1. Test capabilities of the Environmental Laboratory are shown in two different ways. First, Military Standard Test Capability which lists capability per MIL-STD-202, MIL-STD-750, and MIL-STD-883 for each test category; and second, Overall Test Capability which lists capability limits and, where applicable, combined environment capability for each test category.

2. Laboratory capabilities required for performance of tests per MIL-STD-202, MIL-STD-750, and MIL-STD-883 are listed in Table I. Those tests which are noted as exceptions are beyond the capability of the Environmental Laboratory.

3. Laboratory capability limits, including limits of combined environments, are shown in Table II for each test category.

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TABLE I—MILITARY STANDARD TEST CAPABILITY

TEST CATEGORY	MIL-STD-202	MIL-STD-750	MIL-STD-883
Altitude	All Conditions	All Conditions	All Conditions
Dew Point		All Conditions	All Conditions
Flammability	All Conditions		
Moisture Resistance	All Conditions	All Conditions	All Conditions
Resistance to Solvents (Symbolization)	All Conditions		
Salt Atmosphere		All Conditions	All Conditions
Salt Spray	All Conditions	All Conditions	
Seal, Gross Leak	All Gross Leak Conditions (Method 112A, Conditions A, B, and Procedure IV of Condition C. Method 104A, Conditions A, B & C)†	All Gross Leak Conditions (Method 1071, Conditions C, D, E & F)†	All Gross Leak Conditions (Method 1014, Conditions C & D)†
Solderability	All Conditions	All Conditions	All Conditions
Soldering Heat		All Conditions	
Temperature Cycling	All Conditions EXCEPT: Method 107, Conditions D & F	All Conditions EXCEPT: Method 1051, Conditions D & E	All Conditions EXCEPT: Method 1010, Conditions E & F
Terminal Strength (Lead Integrity)	All Conditions	All Conditions	All Conditions
Thermal Shock (Glass Strain)		All Conditions	All Conditions
Acceleration, Sustained (Centrifuge)	All Conditions	All Conditions	All Conditions EXCEPT: Method 2001, Condition J NOTE: ¶Method 2001, Condition G and H, may require special fixturing. Limited capability for these conditions is available for special package types.
‡Shock (Mechanical)	All Conditions EXCEPT: Method 213, Conditions B, C, G, J, and K	All Conditions	All Conditions NOTE: ¶Method 2002, Condition F and G, may require special fixturing. Capability for these conditions is available for special package types.
Vibration, Fatigue		All Conditions	All Conditions
Vibration, Noise		All Conditions	All Conditions
▲Vibration, Random	All Conditions		
▲Vibration, Variable-Frequency	All Conditions	All Conditions	All Conditions
Seal, Fine Leak (Radioactive Tracer Gas)	ONLY Method 112A, Condition C, Procedure III.B	ONLY Method 1071, Condition G	ONLY Method 1014, Condition B
♦X-Ray, Film	All Conditions	All Conditions	All Conditions
♦X-Ray, Real Time (TV X-Ray)	All Conditions	All Conditions	All Conditions

†Items in parentheses are the gross-leak test conditions performed by Environmental Laboratory.
‡Also can perform mechanical shock per MIL-STD-810B, Method 516, Procedures I, III and IV.
▲Also can perform random vibration and vibration variable frequency per MIL-STD-810B, Method 514.1, Procedures I, II, III, IV, and VII. Omit paragraph 4.5.1.1, Resonant Search, and paragraph 4.5.1.2, Resonant Dwell for Electronic Components.
¶Capability for testing approximately 15 major microelectric package types per MIL-STD-883, Method 2001, Conditions G and H (sustained acceleration) and for testing approximately 30 major microelectronic packages per MIL-STD-883, Method 2002, Conditions F and G (mechanical shock) are presently available. These high "G" level conditions are used primarily for evaluation tests on small packages such as C-DIP, P-DIP, TO-5, TO-18, etc.
♦Radiographic inspection is performed in accordance with many other goverment and customer specifications. Before any new radiographic specification is acceptance for use as a test standard with Components Group, it must be approved by Environmental Laboratory.

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TABLE II—OVERALL TEST CAPABILITY

TEST	CAPABILITY
Acceleration, Sustained (Centrifuge)	50-50,000 g (Standard) 50,000-100,000 g (Nonstandard)
Altitude (Barometric Pressure, Reduced)	450,000 ft. Simulated Altitude with −125°C to 125°C Capability
Cryogenic Exposure	−75°C to −196°C
Dew Point	−65°C to 150°C
Flammability	900°C to 1100°C
Moisture Resistance	2°C to 96°C, 40% to 100% RH
Radiographic Inspection (X-Ray)	
Film	Resolution to 0.001 Inch, 150 kV-5 mA
Real Time	360° Rotation—Resolution to 0.001 Inch
Salt Atmosphere/Spray	25°C to 71°C, Up to 20% Salt Solution by Weight
Seal	
Gross Leak	$>5 \times 10^{-6}$, 150°C, Fluorocarbons, Mineral Oils, Ethylene Glycol Hydrostatic Pressure—0-300 psig
Radioactive Tracer Gas	$> 1 \times 10^{-11}$
Symbolization (Resistance to Solvents)	
Shock (Mechanical)	**PULSE SHAPE—APPROXIMATELY HALF-SINE** 1,500-30,000 g @ 0.2 ms ± 0.1 ms 1,000-6,000 g @ 0.3 ms ± 0.1 ms 500-10,000 g @ 0.5 ms ± 0.15 ms 500-4,000 g @ 1 ms ± 0.3 ms 500 & 1,000 g @ 1.5 ms ± 0.45 ms 1,800 g @ 3 ms ± 0.6 ms 50-100 g @ 6 ms ± 0.9 ms 50-200 g @ 7 ms ± 1.05 ms 15-150 g @ 11 ms ± 1.65 ms **PULSE SHAPE—SAWTOOTH** 100 g @ 6 ms
Solderability/Soldering	Up to 280°C
Temperature Cycling	−185°C to 300°C
Terminal Strength (Lead Integrity)	Lead Fatigue, Tension, Stud Torque, Terminal Torque
Thermal Shock	−196°C to 200°C
Ultrasonics	0-100 psi at 25 kHz or 40 kHz
Ultraviolet Exposure	To 12.5 mW/cm^2
Vibration, Fatigue	10-100 Hz, 5-70 g
Vibration, Random	20-200 Hz, Power Density 1.3 g^2/Hz
Vibration, Variable	5-2,000 Hz as Limited by 1 Inch DA and 60 Inches/Second Velocity. 0-70 g (Standard), 70-100 g (Nonstandard)

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Diode Product Spectrum

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DIODE PRODUCTS

TI manufactures one of the broadest lines of discrete axial-lead diodes and multiple-diode arrays available to the electronic industry. These product families are divided into the following categories:

Discrete Diodes

1. Switching diodes . . . logic, core driver and high-voltage
2. Pico-second diodes . . . fast switching
3. Radiation-tolerant diodes
4. Tuning diodes . . . AFC, UHF, VHF
5. General purpose diodes . . . 20 V thru 720 V
6. Rectifiers . . . 50 V thru 1000 V
7. Voltage regulators . . . 3.3 V thru 33 V, 400 mW thru 1 W

Diode Arrays

1. Dual diodes (TO-18)
2. Diode arrays (plastic dual-in-line, metal and ceramic flat packages)
3. Programmable matrices (ceramic dual-in-line and metal flat packages)

DISCRETE DIODES

TI manufactures discrete diodes featuring double-plug construction, which results in a proven, highly reliable product. TI has recently completed a program to utilize this package concept on all axial-lead diodes. This double-plug package, proven by years of volume production, ensures the best in mechanical integrity and the lowest possible junction temperature when compared to the thermal characteristics of whisker packages. The individual piece parts used have closely matched coefficients of thermal expansion to ensure superior reliability over extended temperature excursions. This double-plug construction affords integral positive contact by means of a thermal-compression bond. Moisture-free stability is achieved through hermetic sealing. The chips used in these products feature diffused mesa and planar construction utilizing true glass passivation.

DIODE ARRAYS

In addition to discrete diodes, TI also manufactures a very broad spectrum of diode arrays and diode matrices in integrated-circuit packages. These arrays feature multiple diode junctions fabricated by a planar process and assembled by a hybrid technique. They are ideal for logic and core-driver applications in computer, consumer, and other switching applications. Diode arrays offer many of the same advantages as integrated circuits, such as high density packaging and improved reliability. The high degree of reliability results from fewer connections, more uniform device parameters, smaller size, less weight, fewer glass-to-metal seals, and elimination of pressure contacts and whiskers. Dual-in-line packages facilitate use of wire-wrap techniques in the assembly of electronic equipment. To meet this requirement TI offers a broad selection of planar silicon diode-array products, both in the popular 14-pin dual-in-line packages and in the 10- or 14-pin flat packages.

HIGH-REL SPECIAL CAPABILITY

In addition to the above standard product line, TI also has extensive capabilities to manufacture special discrete diodes such as high-reliability diodes. This high-rel capability is based on the philosophy that reliability must be built into a product and not tested into it. Consequently, TI established a high-rel manufacturing facility with a Class-100 clean-room atmosphere that is virtually particle-free with a manufacturing flow designed to meet or exceed the most stringent specifications. Individual piece parts are cleaned and inspected prior to assembly which results in the ultra-high-rel features of these products.

DIODE PRODUCT SPECTRUM

In addition to assembly capability, TI has available extensive environmental and electrical-test facilities for performing environmental tests such as temperature cycling, mechanical shock, vibration, centrifuge, radiographic inspection, visual inspection, high-temperature reverse blocking, d-c operation, liquid bath for parameter matching, and other environmental tests.

Upon request, TI will supply customers with quotations for hi-rel diode products.

DISCRETE DIODE SHIPPING CONTAINERS

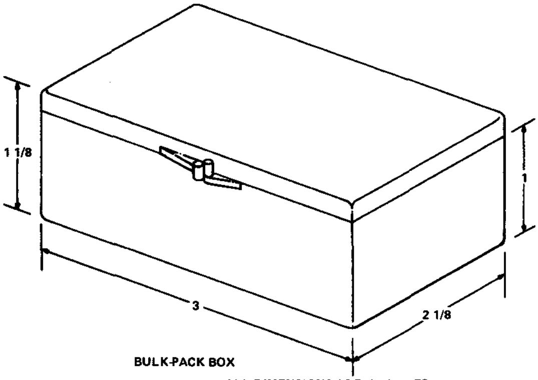
Texas Instruments ships axial-lead diode products using several methods including bulk, bag, and reel packaging.

1. Bulk Pack

   Bulk pack is TI's standard method of shipment. Diodes are packed in plastic boxes measuring 3 by 2 1/8 by 1 1/8 inches. (See illustration). The quantity of parts per box varies according to the package outline as shown below:

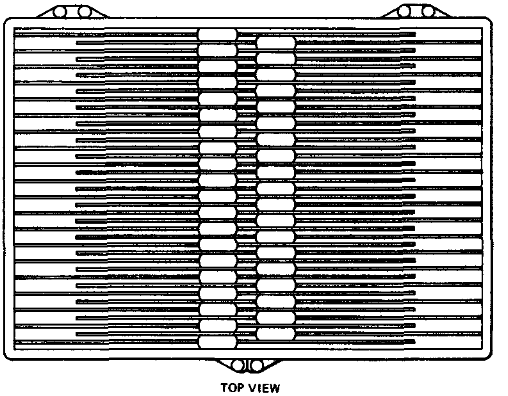
	DO-41	DO-7	PP†	DO-35	DO-34
Maximum Quantity	250	250	500	500	500

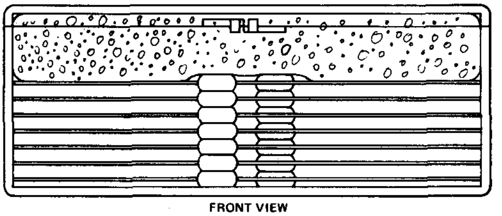
   Up to 10 plastic boxes are packed in cardboard containers for ease of handling.



BULK-PACK BOX

ALL DIMENSIONS ARE IN INCHES


TOP VIEW


FRONT VIEW

2. Bag Pack

   Upon request, diodes can be placed in plastic bags. The average quantity is 5,000 per bag. This method is most commonly used for clipped-lead diodes and offers maximum economy to the customer.

†See package drawing on page 8-14.

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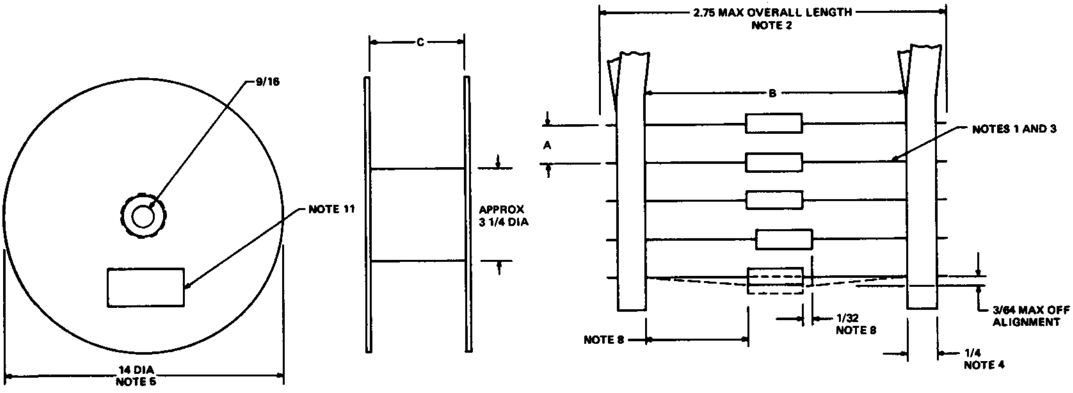
3. Reel Pack

Texas Instruments will supply, upon request, reel-packed diodes. These reel packages meet industry accepted standards for component spacing when used with automatic insertion equipment.

Reel-packed diodes are shipped on standard 14-inch reels with the following quantity per reel:

	DO-41	DO-7	PP†	DO-35	DO-34
Maximum Quantity‡	5,000	5,000	8,000	10,000	10,000



BODY DIA	DIODE SPACING "A"	TAPE SPACING "B"	REEL WIDTH "C"
Up to 0.200	0.200 ± 0.015	2 to $2\frac{3}{32}$	$3 \pm \frac{1}{32}$

ALL DIMENSIONS ARE IN INCHES

REEL PACK DIMENSIONS

NOTES:
1. Any kink or bend that projects outside of the lead position is less than 3/64 inch radius.
2. Overall length of devices is 1/8 to 1/4 inch shorter than the "C" dimension of the reel.
3. All diodes are oriented in one direction. The cathode lead tape is red and the anode lead tape is white.
4. Lead tape is 1/4-inch Minnesota Mining and Manufacturing Company # 267 tape or equivalent.
5. Reels are disposable metal, chipboard, plastic, or equivalent.
6. A minimum 36-inch leader tape is provided before the first and after the last diode on the reel.
7. 50- or 60-lb. kraft paper is wound between layers of diodes. Width of this paper is 1/16 inch to 3/4 inch less than the "C" dimension of the reel.
8. Rows of diodes are centered ±3/64 inch between tapes. Individual diodes may deviate ±1/32 inch from the center of the diode row.
9. No staples or other mechanical devices are used for splicing. Up to four layers of tape may be used in one splice area. No tape is offset from another by more than 1/32 inch. Tape splices overlap at least six inches and are as strong as the unspliced tape.
10. A maximum of 10 diodes may be missing from any 10-foot section. A maximum of three consecutive diodes may be missing provided this gap is followed by six consecutive diodes.
11. Reels and cartons are marked as follows:
    TI Part No.
    Purchase Order No.
    Quantity
    Date Code or Codes

†See package drawing on page 8-14.
‡Quantities less than 100 are shipped in bulk pack.

Diode Selection Guides

DIODE SELECTION GUIDES

These guides are arranged into application families. These families are:

Switching Diodes 8-1

Picosecond Diodes 8-2

Radiation-Tolerant Diodes 8-2

Tuning Diodes 8-3

General Purpose Diodes 8-3

Rectifiers 8-4

Voltage Regulators 8-5

Dual Diodes 8-12

Diode Arrays 8-12

Diode Matrices 8-13

The tabular entries within these families are not made in the usual manner of increasing type number, which would have little inherent utility, but rather are ranked by the most-significant electrical characteristic of that family. Where there is more than one diode type having the identical primary characteristic, the types within that group are further ranked by a secondary characteristic, and so on.

This form of organization works most efficiently when the user's selection criteria coincides with the organizational layout but should not present undue difficulties if it does not.

SWITCHING DIODES

DEVICE TYPE	FORWARD CURRENT		V_{BR} (V)	MAXIMUM I_R				C_T (pF)	t_{rr} (ns)	PACKAGE*
				25°C		150°C				
	I_F (mA)	V_F (V)		(V)	(μA)	(V)	(μA)			
1N625	4.0	1.5	30	20	1.0				1000	PP
1N626	4.0	1.5	50	35	1.0				1000	PP
1N627	4.0	1.5	100	75	1.0				1000	PP
1N628	4.0	1.5	150	125	1.0				1000	PP
1N629	4.0	1.5	200	175	1.0				1000	PP
1N251	5.0	1.0	40	10	0.1				150	PP
TI71	6.0	1.0	40	20	1.0				10	PP
1N659	6.0	1.0	60	50	5.0				300	PP
1N660	6.0	1.0	120	100	5.0				300	PP
1N661	6.0	1.0	240	200	5.0				300	PP
1N4727	10	0.85	30	20	0.1			4.0		DO-35
1N4305	10	0.85	75	50	0.1	50	100	2.0	4.0	DO-35
1N917	10	1.0	40	10	0.05			2.5	6.0	PP
TI72	10	1.0	40	20	1.0				20	PP
1N4532	10	1.0	75	50	0.1	50	100	2.0	4.0	DO-34
1N4454	10	1.0	75	50	0.1	50	100	2.0	4.0	DO-35
1N3064	10	1.0	75	50	0.1	50	100	2.0	4.0	PP
1N662	10	1.0	100	10	1.0				500	PP
1N916	10	1.0	100	20	0.025	20	50	2.0	8.0	PP
1N914	10	1.0	100	20	0.025	20	50	4.0	8.0	PP
1N4149	10	1.0	100	20	0.025	20	50	2.0	4.0	DO-35
1N4531	10	1.0	100	20	0.025	20	50	4.0	8.0	DO-34
1N4148	10	1.0	100	20	0.025	20	50	4.0	4.0	DO-35
1N643	10	1.0	200	100	1.0	30	50		300	PP
1N4533	20	0.88	40	30	0.05	30	50	2.0	4.0	DO-34
1N4152	20	0.88	40	30	0.05	30	50	2.0	4.0	DO-35
1N4534	20	0.88	75	50	0.05	50	50	2.0	4.0	DO-34
1N4153	20	0.88	75	50	0.05	50	50	2.0	4.0	DO-35
TI73	20	1.0	40	20	1.0				20	PP
1N916A	20	1.0	100	20	0.025	20	50	2.0	8.0	PP
1N4446	20	1.0	100	20	0.025	20	50	2.0	4.0	DO-35
1N914A	20	1.0	100	20	0.025	20	50	4.0	8.0	PP
1N4447	20	1.0	100	20	0.025	20	50	4.0	4.0	DO-35
1N4536	30	1.0	35	20	0.1	20	100	4.0	4.0	DO-34
1N4154	30	1.0	35	25	0.1	25	100	4.0	4.0	DO-35
TI74	30	1.0	40	15	1.0				30	PP
1N4449	30	1.0	100	20	0.025	20	50	2.0	4.0	DO-35
1N916B	30	1.0	100	20	0.025	20	50	2.0	8.0	PP
1N915	50	1.0	65	10	0.025			4.0	10	PP
1N4151	50	1.0	75	50	0.05	50	50	2.0	4.0	DO-35
TID40	50	1.0	250	100	0.1	20	50	5.0	30	PP
TID45	50	1.0	250	200	2.0			1.5	50	PP
TI75	75	1.0	40	35	5.0				50	PP
1N4444	100	1.0	70	50	0.05	50	50	2.0	4.0	DO-35
TID38	100	1.0	75	50	0.1			3.0	5.0	DO-35
TID37	100	1.0	75	50	0.1	50	100	4.0	6.0	DO-35

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*See package drawings on page 8-14.

SWITCHING DIODES (Continued)

DEVICE TYPE	FORWARD CURRENT		V_{BR} (V)	MAXIMUM I_R				C_T (pF)	t_{rr} (ns)	PACKAGE*
				25°C		150°C				
	I_F (mA)	V_F (V)		(V)	(μA)	(V)	(μA)			
TID39	100	1.0	75	50	0.1			5.0	20	DO-35
1N914B	100	1.0	100	20	0.025	20	50	4.0	8.0	PP
1N4448	100	1.0	100	20	0.025	20	50	4.0	4.0	DO-35
TID36	100	1.0	100	50	0.1	50	100	4.0	10	DO-35
1N663	100	1.0	100	75	5.0				500	PP
TID42	100	1.0	150	100	0.1	20	50	5.0	30	PP
TID41	100	1.0	200	100	0.1	20	50	5.0	30	PP
1N4938	100	1.0	250	175	0.1	175	100	5.0	50	DO-35
1N3070	100	1.0	250	175	0.1	175	100	5.0	50	PP
TID35	150	1.0	75	50	0.1	50	100	4.0	10	DO-35
TID34	150	1.0	100	50	0.1	50	100	4.0	10	DO-35
TID43	150	1.0	150	100	0.1	20	50	5.0	30	PP
1N4150	200	1.0	50	50	0.1	50	100	2.5	4.0	DO-35
TID31	200	1.0	75	50	0.1	50	100	2.5	6.0	DO-35
TID33	200	1.0	75	50	0.1	50	100	4.0	10	DO-35
TID32	200	1.0	100	50	0.1	50	100	4.0	10	DO-35
TID44	200	1.0	100	100	0.1	20	50	5.0	30	PP
1N4606	250	1.1	85	50	0.1			2.5	6.0	DO-35
1N4607	400	1.1	85	50	0.1			4.0	10	DO-35
1N4608	500	1.1	85	50	0.1			4.0	10	DO-35

PICO-SECOND DIODES

DEVICE TYPE	FORWARD CURRENT		V_{BR} (V)	MAXIMUM I_R				C_T (pF)	t_{rr} (ps)	PACKAGE*
				25°C		150°C				
	I_F (mA)	V_F (V)		(V)	(μA)	(V)	(μA)			
TID778	50	1.35	30	20	0.1	20	100	1.0	750	DO-35
TID777	50	1.35	20	20	0.1	20	100	1.3	750	DO-35

RADIATION TOLERANT DIODES

DEVICE TYPE	FORWARD CURRENT		V_{BR} (V)		MAXIMUM I_R				C_T (pF)	t_{rr} (ns)	PACKAGE*
					25°C		125°C				
	I_F (mA)	V_F (V)	MIN	MAX	(V)	(μA)	(V)	(μA)			
TI550	100	1.0	200	300	175	0.1	175	10	20	0.7	PP
TI551	100	1.0	290	400	225	0.1	225	10	20	0.7	PP

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*See package drawings on page 8-14.

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TUNING DIODES

DEVICE TYPE	pF CAPACITANCE V_R MIN	MAX	V	CAP RATIO MIN	MAX	FIGURE OF MERIT Q	V_{BR} (V)	FUNCTION	PACKAGE*
TIV306	5	9	4	1.5		200	20	AFC	DO-35
TIV307	7	11	4	1.5		200	20	AFC	DO-35
TIV22	9	14	3	4.0	5.0	150	30	UHF	DO-34
TIV23	9	14	3	4.0	6.0	100	30	UHF	DO-34
TIV21	9	14	3	4.5	6.0	150	30	UHF	DO-34
TIV308	9	14	4	1.5		200	20	AFC	DO-35
TIV24	22	34	3	3.5	6.0	80	30	VHF	DO-34
TIV25	23	34	3	4.5	6.0	80	30	VHF	DO-34

GENERAL PURPOSE DIODES

DEVICE TYPE	FORWARD CURRENT		V_{BR} (V)	MAXIMUM I_R				PACKAGE*
				25°C		150°C		
	I_F (mA)	V_F (V)		(V)	(μA)	(V)	(μA)	
1N463	1.0	1.0	200	175	0.5	175	30	DO-7
1N464	3.0	1.0	150	125	0.5	125	30	DO-7
1N459	3.0	1.0	200	175	0.025	175	5	DO-7
1N462	5.0	1.0	70	60	0.5	60	30	DO-7
1N458	7.0	1.0	150	125	0.025	125	5	DO-7
1N461	15.0	1.0	30	25	0.5	25	30	DO-7
1N457	20.0	1.0	70	60	0.025	60	5	DO-7
1N456	40.0	1.0	30	25	0.025	25	5	DO-7
G129	100	1.0	6	2	0.1			DO-7
G130	100	1.0	6	2	0.1			DO-7
1N456A	100	1.0	30	25	0.025	25	5	DO-7
1N461A	100	1.0	30	25	0.5	25	30	DO-7
1N482A	100	1.0	40	30	0.025	30	15	DO-7
1N482B	100	1.0	40	30	0.025	30	5	DO-7
1N457A	100	1.0	70	60	0.025	60	5	DO-7
1N462A	100	1.0	70	60	0.5	60	30	DO-7
1N483A	100	1.0	80	60	0.025	60	15	DO-7
1N483B	100	1.0	80	60	0.025	60	5	DO-7
1N458A	100	1.0	150	125	0.025	125	5	DO-7
1N464A	100	1.0	150	125	0.5	125	30	DO-7
1N484A	100	1.0	150	125	0.025	125	15	DO-7
1N484B	100	1.0	150	125	0.025	125	5	DO-7
1N459A	100	1.0	200	175	0.025	175	5	DO-7
1N463A	100	1.0	200	175	0.5	175	30	DO-7
1N485A	100	1.0	200	175	0.025	175	15	DO-7
1N485B	100	1.0	200	175	0.025	175	5	DO-7
1N482	100	1.1	40	30	0.250	30	30	DO-7
1N483	100	1.1	80	70	0.250	70	30	DO-7
1N484	100	1.1	150	125	0.250	125	30	DO-7
1N485	100	1.1	200	175	0.250	175	30	DO-7
TI51	200	1.0	20	10	1.0			DO-7
TI52	200	1.0	30	20	1.0			DO-7

*See package drawings on page 8-14.

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GENERAL PURPOSE DIODES (Continued)

DEVICE TYPE	FORWARD CURRENT I_F (mA)	FORWARD CURRENT V_F (V)	V_{BR} (V)	MAXIMUM I_R 25°C (V)	MAXIMUM I_R 25°C (μA)	MAXIMUM I_R 150°C (V)	MAXIMUM I_R 150°C (μA)	PACKAGE*
TI53	200	1.0	40	30	1.0			DO-7
TI54	200	1.0	50	40	1.0			DO-7
TI55	200	1.0	80	60	1.0			DO-7
TI56	400	1.0	120	100	1.0			DO-7
TI57	400	1.0	200	150	1.0			DO-7
TI58	400	1.0	270	175	1.0			DO-7
1N645	400	1.0	275	225	0.2			DO-7
1N645A	400	1.0	275	225	0.2			DO-7
TI59	400	1.0	320	200	1.0			DO-7
1N646	400	1.0	360	300	0.2			DO-7
TI60	400	1.0	400	300	1.0			DO-7
1N647	400	1.0	480	400	0.2			DO-7
1N648	400	1.0	600	500	0.2			DO-7
1N649	400	1.0	720	600	0.2			DO-7

RECTIFIERS

DEVICE TYPE	I_O (A)	SURGE (A)	FORWARD CURRENT I_F (A)	FORWARD CURRENT V_F (V)	V_{BR} (V)	MAXIMUM I_R 25°C V	MAXIMUM I_R 25°C μA	MAXIMUM I_R 100°C V	MAXIMUM I_R 100°C μA	PACKAGE*
1N645	0.400	3	0.400	1.0	275	225	0.2	225	15	DO-7
1N645A	0.400	3	0.400	1.0	275	225	0.2	225	15	DO-7
1N646	0.400	3	0.400	1.0	360	300	0.2	300	15	DO-7
1N647	0.400	3	0.400	1.0	480	400	0.2	400	20	DO-7
1N648	0.400	3	0.400	1.0	600	500	0.2	500	20	DO-7
1N649	0.400	3	0.400	1.0	720	600	0.2	600	25	DO-7
1N2069A	0.750	6	0.500	1.0	200	200	5			DO-41
1N2069	0.750	6	0.500	1.2	200	200	10			DO-41
1N2070A	0.750	6	0.500	1.0	400	400	5			DO-41
1N2070	0.750	6	0.500	1.2	400	400	10			DO-41
1N2071A	0.750	6	0.500	1.0	600	600	5			DO-41
1N2071	0.750	6	0.500	1.2	600	600	10			DO-41
1N4001	1.0	30	1.0	1.1	50	50	10	50	50	DO-41
1N4002	1.0	30	1.0	1.1	100	100	10	100	50	DO-41
1N4003	1.0	30	1.0	1.1	200	200	10	200	50	DO-41
1N4004	1.0	30	1.0	1.1	400	400	10	400	50	DO-41
1N4005	1.0	30	1.0	1.1	600	600	10	600	50	DO-41
1N4006	1.0	30	1.0	1.1	800	800	10	800	50	DO-41
1N4007	1.0	30	1.0	1.1	1000	1000	10	1000	50	DO-41
TID381	1.0	50	1.0	1.1	50	50	10	50	250	DO-41
TID382	1.0	50	1.0	1.1	100	100	10	100	250	DO-41
TID383	1.0	50	1.0	1.1	200	200	10	200	250	DO-41
TID384	1.0	50	1.0	1.1	400	400	10	400	250	DO-41
TID385	1.0	50	1.0	1.1	600	600	10	600	250	DO-41

*See package drawings on page 8-14.

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VOLTAGE REGULATORS

DEVICE TYPE	P_D @ 25°C (mW)	V_Z @ I_{ZT}		TOL	I_R @ V_R		Z_Z @ I_{ZT}	PACKAGE*
		(V)	(mA)	%	(V)	(µA)	MAX Ω	
1N702	400	2.6	5	20	1	75	60	DO-7
1N702A	400	2.6	5	5	1	75	60	DO-7
1N746	400	3.3	20	10	1	10	28	DO-7
1N746A	400	3.3	20	5	1	10	28	DO-7
1N3506	400	3.3	20	5	1	4	24	DO-7
1N703	400	3.45	5	20	1	50	55	DO-7
1N703A	400	3.45	5	5	1	50	55	DO-7
1N747	400	3.6	20	10	1	10	24	DO-7
1N747A	400	3.6	20	5	1	10	24	DO-7
1N3507	400	3.6	20	5	1	2	22	DO-7
1N748	400	3.9	20	10	1	10	23	DO-7
1N748A	400	3.9	20	5	1	10	23	DO-7
1N3508	400	3.9	20	5	1	0.4	20	DO-7
1N704	400	4.1	5	20	1	5	45	DO-7
1N704A	400	4.1	5	5	1	5	45	DO-7
1N749	400	4.3	20	10	1	2	22	DO-7
1N749A	400	4.3	20	5	1	2	22	DO-7
1N3509	400	4.3	20	5	1	0.1	18	DO-7
1N750	400	4.7	20	10	1	2	19	DO-7
1N750A	400	4.7	20	5	1	2	19	DO-7
1N3510	400	4.7	20	5	2	5	16	DO-7
1N705	400	4.85	5	20	1.5	5	35	DO-7
1N705A	400	4.85	5	5	1.5	5	35	DO-7
1N761	400	4.85	10	10			40	DO-7
1N751	400	5.1	20	10	1	1	17	DO-7
1N751A	400	5.1	20	5	1	1	17	DO-7
1N3511	400	5.1	20	5	2	2	14	DO-7
1N752	400	5.6	20	10	1	1	11	DO-7
1N752A	400	5.6	20	5	1	1	11	DO-7
1N3512	400	5.6	20	5	3	5	8	DO-7
1N708	400	5.6	25	10			3.6	DO-7
1N708A	400	5.6	25	5			3.6	DO-7
1N706	400	5.8	5	20	1.5	5	20	DO-7
1N706A	400	5.8	5	5	1.5	5	20	DO-7
1N762	400	5.8	10	10			18	DO-7
1N753	400	6.2	20	10	1	0.1	7	DO-7
1N753A	400	6.2	20	5	1	0.1	7	DO-7
1N3513	400	6.2	20	5	4	5	3	DO-7
1N709	400	6.2	25	10			4.1	DO-7
1N709A	400	6.2	25	5			4.1	DO-7
1N957	400	6.8	18.5	20			4.5	DO-7
1N957A	400	6.8	18.5	10	5.2	150	4.5	DO-7
1N957B	400	6.8	18.5	5	5.2	150	4.5	DO-7
1N754	400	6.8	20	10	1	0.1	5	DO-7
1N754A	400	6.8	20	5	1	0.1	5	DO-7
1N3514	400	6.8	20	5	5	1	3	DO-7

*See package drawings on page 8-14.

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VOLTAGE REGULATORS (Continued)

DEVICE TYPE	P_D @ 25°C (mW)	V_Z @ I_{ZT} (V)	(mA)	TOL %	I_R @ V_R (V)	(μA)	Z_Z @ I_{ZT} MAX Ω	PACKAGE*
1N710	400	6.8	25	10			4.7	DO-7
1N710A	400	6.8	25	5			4.7	DO-7
1N707	400	7.1	5	20	3.5	5	10	DO-7
1N707A	400	7.1	5	5	3.5	5	10	DO-7
1N763	400	7.1	10	10			7	DO-7
1N3515	400	7.5	10	5	6	0.5	4	DO-7
1N958	400	7.5	16.5	20			5.5	DO-7
1N958A	400	7.5	16.5	10	5.7	75	5.5	DO-7
1N958B	400	7.5	16.5	5	5.7	75	5.5	DO-7
1N755	400	7.5	20	10	1	0.1	6	DO-7
1N755A	400	7.5	20	5	1	0.1	6	DO-7
1N711	400	7.5	25	10			5.3	DO-7
1N711A	400	7.5	25	5			5.3	DO-7
1N3516	400	8.2	10	5	7	0.25	5	DO-7
1N959	400	8.2	15	20			6.5	DO-7
1N959A	400	8.2	15	10	6.2	50	6.5	DO-7
1N959B	400	8.2	15	5	6.2	50	6.5	DO-7
1N756	400	8.2	20	10	1	0.1	8	DO-7
1N756A	400	8.2	20	5	1	0.1	8	DO-7
1N712	400	8.2	25	10			6	DO-7
1N712A	400	8.2	25	5			6	DO-7
1N764	400	8.75	10	10			12	DO-7
1N3517	400	9.1	10	5	7	0.025	6	DO-7
1N713	400	9.1	12	10			7	DO-7
1N713A	400	9.1	12	5			7	DO-7
1N960	400	9.1	14	20			7.5	DO-7
1N960A	400	9.1	14	10	6.9	25	7.5	DO-7
1N960B	400	9.1	14	5	6.9	25	7.5	DO-7
1N757	400	9.1	20	10	1	0.1	10	DO-7
1N757A	400	9.1	20	5	1	0.1	10	DO-7
1N3518	400	10	10	5	8	0.010	7	DO-7
1N714	400	10	12	10			8	DO-7
1N714A	400	10	12	5			8	DO-7
1N961	400	10	12.5	20			8.5	DO-7
1N961A	400	10	12.5	10	7.6	10	8.5	DO-7
1N961B	400	10	12.5	5	7.6	10	8.5	DO-7
1N758	400	10	20	10	1	0.1	17	DO-7
1N758A	400	10	20	5	1	0.1	17	DO-7
1N765	400	10.5	5	10			45	DO-7
1N3519	400	11	10	5	9	0.010	8	DO-7
1N962	400	11	11.5	20			9.5	DO-7
1N962A	400	11	11.5	10	8	5	9.5	DO-7
1N962B	400	11	11.5	5	8.4	5	9.5	DO-7
1N715	400	11	12	10			9	DO-7
1N715A	400	11	12	5			9	DO-7
1N3520	400	12	10	5	10	0.010	10	DO-7
1N963	400	12	10.5	20			11.5	DO-7
1N963A	400	12	10.5	10	8.6	5	11.5	DO-7

*See package drawings on page 8-14.

TEXAS INSTRUMENTS
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VOLTAGE REGULATORS (Continued)

DEVICE TYPE	P_D @ 25°C (mW)	V_Z @ I_{ZT} (V)	(mA)	TOL %	I_R @ V_R (V)	(μA)	Z_Z @ I_{ZT} MAX Ω	PACKAGE*
1N963B	400	12	10.5	5	9.1	5	11.5	DO-7
1N716	400	12	12	10			10	DO-7
1N716A	400	12	12	5			10	DO-7
1N759	400	12	20	10	1	0.1	30	DO-7
1N759A	400	12	20	5	1	0.1	30	DO-7
1N766	400	12.75	5	10			55	DO-7
1N3521	400	13	5	5	11	0.010	12	DO-7
1N964	400	13	9.5	20			13	DO-7
1N964A	400	13	9.5	10	9.4	5	13	DO-7
1N964B	400	13	9.5	5	9.9	5	13	DO-7
1N717	400	13	12	10			11	DO-7
1N717A	400	13	12	5			11	DO-7
1N3522	400	15	5	5	13	0.010	14	DO-7
1N965	400	15	8.5	20			16	DO-7
1N965A	400	15	8.5	10	10.8	5	16	DO-7
1N965B	400	15	8.5	5	11.4	5	16	DO-7
1N718	400	15	12	10			13	DO-7
1N718A	400	15	12	5			13	DO-7
1N767	400	15.75	5	10			70	DO-7
1N3523	400	16	5	5	14	0.010	16	DO-7
1N966	400	16	7.8	20			17	DO-7
1N966A	400	16	7.8	10	11.5	5	17	DO-7
1N966B	400	16	7.8	5	12	5	17	DO-7
1N719	400	16	12	10			15	DO-7
1N719A	400	16	12	5			15	DO-7
1N3524	400	18	5	5	16	0.010	18	DO-7
1N967	400	18	7	20			21	DO-7
1N967A	400	18	7	10	13	5	21	DO-7
1N967B	400	18	7	5	14	5	21	DO-7
1N720	400	18	12	10			17	DO-7
1N720A	400	18	12	5			17	DO-7
1N768	400	19	5	10			100	DO-7
1N721	400	20	4	10			20	DO-7
1N721A	400	20	4	5			20	DO-7
1N3525	400	20	5	5	18	0.010	20	DO-7
1N968	400	20	6.2	20			25	DO-7
1N968A	400	20	6.2	10	14.4	5	25	DO-7
1N968B	400	20	6.2	5	15	5	25	DO-7
1N722	400	22	4	10			24	DO-7
1N722A	400	22	4	5			24	DO-7
1N3526	400	22	5	5	19	0.010	35	DO-7

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*See package drawings on page 8-14.

VOLTAGE REGULATORS (Continued)

DEVICE TYPE	P_D @ 25°C (mW)	V_Z @ I_{ZT} (V)	(mA)	TOL %	I_R @ V_R (V)	(μA)	Z_Z @ I_{ZT} MAX Ω	PACKAGE*
1N969	400	22	5.6	20			29	DO-7
1N969A	400	22	5.6	10	15.8	5	29	DO-7
1N969B	400	22	5.6	5	17	5	29	DO-7
1N769	400	23.5	5	10			150	DO-7
1N723	400	24	4	10			28	DO-7
1N723A	400	24	4	5			28	DO-7
1N3527	400	24	5	5	20	0.010	38	DO-7
1N970	400	24	5.2	20			33	DO-7
1N970A	400	24	5.2	10	17.3	5	33	DO-7
1N970B	400	24	5.2	5	18	5	33	DO-7
1N724	400	27	4	10			35	DO-7
1N724A	400	27	4	5			35	DO-7
1N3528	400	27	4	5	22	0.010	40	DO-7
1N971	400	27	4.6	20			41	DO-7
1N971A	400	27	4.6	10	19.4	5	41	DO-7
1N971B	400	27	4.6	5	21	5	41	DO-7
1N725	400	30	4	10			42	DO-7
1N725A	400	30	4	5			42	DO-7
1N3529	400	30	4	5	24	0.010	48	DO-7
1N972	400	30	4.2	20			49	DO-7
1N972A	400	30	4.2	10	21.6	5	49	DO-7
1N972B	400	30	4.2	5	23	5	49	DO-7
1N3530	400	33	3	5	26	0.010	50	DO-7
1N973	400	33	3.8	20			58	DO-7
1N973A	400	33	3.8	10	23.8	5	58	DO-7
1N973B	400	33	3.8	5	25	5	58	DO-7
1N726	400	33	4	10			50	DO-7
1N726A	400	33	4	5			50	DO-7
1N5226	500	3.3	20	20			28	DO-7
1N5226A	500	3.3	20	10	0.95	25	28	DO-7
1N5226B	500	3.3	20	5	1	25	28	DO-7
1N5227	500	3.6	20	20			24	DO-7
1N5227A	500	3.6	20	10	0.95	15	24	DO-7
1N5227B	500	3.6	20	5	1	15	24	DO-7
1N5228	500	3.9	20	20			23	DO-7
1N5228A	500	3.9	20	10	0.95	10	23	DO-7
1N5228B	500	3.9	20	5	1	10	23	DO-7
1N5229	500	4.3	20	20			22	DO-7
1N5229A	500	4.3	20	10	0.95	5	22	DO-7
1N5229B	500	4.3	20	5	1	5	22	DO-7
1N5230	500	4.7	20	20			19	DO-7
1N5230A	500	4.7	20	10	1.9	5	19	DO-7
1N5230B	500	4.7	20	5	2	5	19	DO-7
1N5231	500	5.1	20	20			17	DO-7
1N5231A	500	5.1	20	10	1.9	5	17	DO-7
1N5231B	500	5.1	20	5	2	5	17	DO-7
1N5232	500	5.6	20	20			11	DO-7

*See package drawings on page 8-14.

TEXAS INSTRUMENTS
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VOLTAGE REGULATORS (Continued)

DEVICE TYPE	P_D @ 25°C (mW)	V_Z @ I_{ZT} (V)	(mA)	TOL %	I_R @ V_R (V)	(μA)	Z_Z @ I_{ZT} MAX Ω	PACKAGE*
1N5232A	500	5.6	20	10	2.9	5	11	DO-7
1N5232B	500	5.6	20	5	3	5	11	DO-7
1N5233	500	6	20	20			7	DO-7
1N5233A	500	6	20	10	3.3	5	7	DO-7
1N5233B	500	6	20	5	3.5	5	7	DO-7
1N5234	500	6.2	20	20			7	DO-7
1N5234A	500	6.2	20	10	3.8	5	7	DO-7
1N5234B	500	6.2	20	5	4	5	7	DO-7
1N5235	500	6.8	20	20			5	DO-7
1N5235A	500	6.8	20	10	4.8	3	5	DO-7
1N5235B	500	6.8	20	5	5	3	5	DO-7
1N5236	500	7.5	20	20			6	DO-7
1N5236A	500	7.5	20	10	5.7	3	6	DO-7
1N5236B	500	7.5	20	5	6	3	6	DO-7
1N5237	500	8.2	20	20			8	DO-7
1N5237A	500	8.2	20	10	6.2	3	8	DO-7
1N5237B	500	8.2	20	5	6.5	3	8	DO-7
1N5238	500	8.7	20	20			8	DO-7
1N5238A	500	8.7	20	10	6.2	3	8	DO-7
1N5238B	500	8.7	20	5	6.5	3	8	DO-7
1N5239	500	9.1	20	20			10	DO-7
1N5239A	500	9.1	20	10	6.7	3	10	DO-7
1N5239B	500	9.1	20	5	7	3	10	DO-7
1N5240	500	10	20	20			17	DO-7
1N5240A	500	10	20	10	7.6	3	17	DO-7
1N5240B	500	10	20	5	8	3	17	DO-7
1N5241	500	11	20	20			22	DO-7
1N5241A	500	11	20	10	8	2	22	DO-7
1N5241B	500	11	20	5	8.4	2	22	DO-7
1N5242	500	12	20	20		1	30	DO-7
1N5242A	500	12	20	10	8.7	1	30	DO-7
1N5242B	500	12	20	5	9.1	1	30	DO-7
1N5243	500	13	9.5	20			13	DO-7
1N5243A	500	13	9.5	10	9.4	0.5	13	DO-7
1N5243B	500	13	9.5	5	9.9	0.5	13	DO-7
1N5244	500	14	9	20			15	DO-7
1N5244A	500	14	9	10	9.5	0.1	15	DO-7
1N5244B	500	14	9	5	10	0.1	15	DO-7
1N5245	500	15	8.5	20			16	DO-7
1N5245A	500	15	8.5	10	10.5	0.1	16	DO-7
1N5245B	500	15	8.5	5	11	0.1	16	DO-7

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*See package drawings on page 8-14.

VOLTAGE REGULATORS (Continued)

DEVICE TYPE	P_D @ 25°C (mW)	V_Z @ I_{ZT} (V)	V_Z @ I_{ZT} (mA)	TOL %	I_R @ V_R (V)	I_R @ V_R (μA)	Z_Z @ I_{ZT} MAX Ω	PACKAGE*
1N5246	500	16	7.8	20			17	DO-7
1N5246A	500	16	7.8	10	11.4	0.1	17	DO-7
1N5246B	500	16	7.8	5	12	0.1	17	DO-7
1N5247	500	17	7.4	20			19	DO-7
1N5247A	500	17	7.4	10	12.4	0.1	19	DO-7
1N5247B	500	17	7.4	5	13	0.1	19	DO-7
1N5248	500	18	7	20			21	DO-7
1N5248A	500	18	7	10	13.3	0.1	21	DO-7
1N5248B	500	18	7	5	14	0.1	21	DO-7
1N5249	500	19	6.6	20			23	DO-7
1N5249A	500	19	6.6	10	13.3	0.1	23	DO-7
1N5249B	500	19	6.6	5	14	0.1	23	DO-7
1N5250	500	20	6.2	20			25	DO-7
1N5250A	500	20	6.2	10	14.3	0.1	25	DO-7
1N5250B	500	20	6.2	5	15	0.1	25	DO-7
1N5251	500	22	5.6	20			29	DO-7
1N5251A	500	22	5.6	10	16.2	0.1	29	DO-7
1N5251B	500	22	5.6	5	17	0.1	29	DO-7
1N5252	500	24	5.2	20			33	DO-7
1N5252A	500	24	5.2	10	17.1	0.1	33	DO-7
1N5252B	500	24	5.2	5	18	0.1	33	DO-7
1N5253	500	25	5	20			35	DO-7
1N5253A	500	25	5	10	18.1	0.1	35	DO-7
1N5253B	500	25	5	5	19	0.1	35	DO-7
1N5254	500	27	4.6	20			41	DO-7
1N5254A	500	27	4.6	10	20	0.1	41	DO-7
1N5254B	500	27	4.6	5	21	0.1	41	DO-7
1N5255	500	28	4.5	20			44	DO-7
1N5255A	500	28	4.5	10	20	0.1	44	DO-7
1N5255B	500	28	4.5	5	21	0.1	44	DO-7
1N5256	500	30	4.2	20			49	DO-7
1N5256A	500	30	4.2	10	22	0.1	49	DO-7
1N5256B	500	30	4.2	5	23	0.1	49	DO-7
1N5257	500	33	3.8	20			58	DO-7
1N5257A	500	33	3.8	10	24	0.1	58	DO-7
1N5257B	500	33	3.8	5	25	0.1	58	DO-7
1N4728	1000	3.3	76	10	1	100	10	DO-41
1N4728A	1000	3.3	76	5	1	100	10	DO-41
1N4729	1000	3.6	69	10	1	100	10	DO-41
1N4729A	1000	3.6	69	5	1	100	10	DO-41
1N4730	1000	3.9	64	10	1	50	9	DO-41
1N4730A	1000	3.9	64	5	1	50	9	DO-41
1N4731	1000	4.3	58	10	1	10	9	DO-41
1N4731A	1000	4.3	58	5	1	10	9	DO-41
1N4732	1000	4.7	53	10	1	10	8	DO-41
1N4732A	1000	4.7	53	5	1	10	8	DO-41
1N4733	1000	5.1	49	10	1	10	7	DO-41

*See package drawings on page 8-14.

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VOLTAGE REGULATORS (Continued)

DEVICE TYPE	P_D @ 25°C (mW)	V_Z @ I_{ZT} (V)	(mA)	TOL %	I_R @ V_R (V)	(μA)	Z_Z @ I_{ZT} MAX Ω	PACKAGE*
1N4733A	1000	5.1	49	5	1	10	7	DO-41
1N4734	1000	5.6	45	10	2	10	5	DO-41
1N4734A	1000	5.6	45	5	2	10	5	DO-41
1N4735	1000	6.2	41	10	3	10	2	DO-41
1N4735A	1000	6.2	41	5	3	10	2	DO-41
1N4736	1000	6.8	37	10	4	10	3.5	DO-41
1N4736A	1000	6.8	37	5	4	10	3.5	DO-41
1N4737	1000	7.5	34	10	5	10	4	DO-41
1N4737A	1000	7.5	34	5	5	10	4	DO-41
1N4738	1000	8.2	31	10	6	10	4.5	DO-41
1N4738A	1000	8.2	31	5	6	10	4.5	DO-41
1N4739	1000	9.1	28	10	7	10	5	DO-41
1N4739A	1000	9.1	28	5	7	10	5	DO-41
1N4740	1000	10	25	10	7.6	10	7	DO-41
1N4740A	1000	10	25	5	7.6	10	7	DO-41
1N4741	1000	11	23	10	8.4	5	8	DO-41
1N4741A	1000	11	23	5	8.4	5	8	DO-41
1N4742	1000	12	21	10	9.1	5	9	DO-41
1N4742A	1000	12	21	5	9.1	5	9	DO-41
1N4743	1000	13	19	10	9.9	5	10	DO-41
1N4743A	1000	13	19	5	9.9	5	10	DO-41
1N4744	1000	15	17	10	11.4	5	14	DO-41
1N4744A	1000	15	17	5	11.4	5	14	DO-41
1N4745	1000	16	15.5	10	12.2	5	16	DO-41
1N4745A	1000	16	15.5	5	12.2	5	16	DO-41
1N4746	1000	18	14	10	13.7	5	20	DO-41
1N4746A	1000	18	14	5	13.7	5	20	DO-41
1N4747	1000	20	12.5	10	15.2	5	22	DO-41
1N4747A	1000	20	12.5	5	15.2	5	22	DO-41
1N4748	1000	22	11.5	10	16.7	5	23	DO-41
1N4748A	1000	22	11.5	5	16.7	5	23	DO-41
1N4749	1000	24	10.5	10	18.2	5	25	DO-41
1N4749A	1000	24	10.5	5	18.2	5	25	DO-41
1N4750	1000	27	9.5	10	20.6	5	35	DO-41
1N4750A	1000	27	9.5	5	20.6	5	35	DO-41
1N4751	1000	30	8.5	10	22.8	5	40	DO-41
1N4751A	1000	30	8.5	5	22.8	5	40	DO-41
1N4752	1000	33	7.5	10	25.1	5	45	DO-41
1N4752A	1000	33	7.5	5	25.1	5	45	DO-41

*See package drawings on page 8-14.

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PRODUCT SELECTION GUIDE
DIODE ARRAYS

DUAL DIODES

DEVICE TYPE	CIRCUIT	FORWARD CURRENT		V_{BR}	I_R @ V_R @ 25°C		PACKAGE*
		I_F (mA)	V_F (V)	(V)	V	μA	
TID17	COMMON CATHODE	500	1.5	60	30	0.1	TO-18
TID18	COMMON CATHODE	500	1.7	40	15	0.1	TO-18
TID19	COMMON ANODE	500	1.5	60	30	0.1	TO-18
TID20	COMMON ANODE	500	1.7	40	15	0.1	TO-18

PLASTIC DUAL-IN-LINE PACKAGE

DEVICE TYPE	CIRCUIT	FORWARD CURRENT		V_{BR}	I_R @ V_R @ 25°C		PACKAGE*
		I_F (mA)	V_F(V)	(V)	V	μA	
TID139N	7 INDEPENDENT DIODES	500	1.3	60	40	0.1	14 Lead N
TID140N	7 INDEPENDENT DIODES	100	1.3	40	20	0.05	14 Lead N
TID141N	DUAL 4-DIODE COMMON CATHODE	500	1.3	60	40	0.1	14 Lead N
TID142N	DUAL 4-DIODE COMMON CATHODE	100	1.3	40	20	0.05	14 Lead N
TID143N	DUAL 4-DIODE COMMON ANODE	500	1.3	60	40	0.1	14 Lead N
TID144N	DUAL 4-DIODE COMMON ANODE	100	1.3	40	20	0.05	14 Lead N
TID121	8-DIODE COMMON CATHODE	500	1.3	60	40	0.1	14 Lead N
TID122	8-DIODE COMMON CATHODE	500	1.5	40	25	0.1	14 Lead N
TID123	8-DIODE COMMON ANODE	500	1.3	60	40	0.1	14 Lead N
TID124	8-DIODE COMMON ANODE	500	1.5	40	25	0.1	14 Lead N
TID133	DUAL 8-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	14 Lead N
TID134	DUAL 8-DIODE (C.C. and C.A.)	500	1.5	40	25	0.1	14 Lead N
TID125	16-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	14 Lead N
TID126	16-DIODE (C.C. and C.A.)	500	1.5	40	25	0.1	14 Lead N
TID135N	16-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	14 Lead N
TID136N	16-DIODE (C.C. and C.A.)	100	1.3	40	20	0.05	14 Lead N
TID129	DUAL 10-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	14 Lead N
TID130	DUAL 10-DIODE (C.C. and C.A.)	500	1.5	40	25	0.1	14 Lead N

METAL FLAT PACKAGE, 1/4" X 1/8"

DEVICE TYPE	CIRCUIT	FORWARD CURRENT		V_{BR}	I_R @ V_R @ 25°C		PACKAGE*
		I_F (mA)	V_F (V)	(V)	V	μA	
TID139F	7 INDEPENDENT DIODES	500	1.3	60	40	0.1	14 Lead F
TID140F	7 INDEPENDENT DIODES	100	1.3	40	20	0.05	14 Lead F
TID141F	DUAL 4-DIODE COMMON CATHODE	500	1.3	60	40	0.1	10 Lead F
TID142F	DUAL 4-DIODE COMMON CATHODE	100	1.3	40	20	0.05	10 Lead F
TID143F	DUAL 4-DIODE COMMON ANODE	500	1.3	60	40	0.1	10 Lead F
TID144F	DUAL 4-DIODE COMMON ANODE	100	1.3	40	20	0.05	10 Lead F
TID21A	8-DIODE COMMON CATHODE	500	1.3	60	40	0.1	10 Lead F
TID22A	8-DIODE COMMON CATHODE	500	1.5	40	25	0.1	10 Lead F
TID23A	8-DIODE COMMON ANODE	500	1.3	60	40	0.1	10 Lead F
TID24A	8-DIODE COMMON ANODE	500	1.5	40	25	0.1	10 Lead F
TID131	DUAL 8-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	14 Lead F
TID132	DUAL 8-DIODE (C.C. and C.A.)	500	1.5	40	25	0.1	14 Lead F
TID25A	16-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	10 Lead F
TID26A	16-DIODE (C.C. and C.A.)	500	1.5	40	25	0.1	10 Lead F
TID29A	DUAL 10-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	14 Lead F
TID30A	DUAL 10-DIODE (C.C. and C.A.)	500	1.5	40	25	0.1	14 Lead F

*See package drawings on page 8-14.

TEXAS INSTRUMENTS
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PRODUCT SELECTION GUIDE
DIODE ARRAYS

CERAMIC FLAT PACKAGE, 1/4" X 1/4"

DEVICE TYPE	CIRCUIT	FORWARD CURRENT		V_{BR}	I_R @ V_R @ 25°C		PACKAGE*
		I_F (mA)	V_F (V)	(V)	V	μA	
1N5768	8-DIODE COMMON CATHODE	500	1.3	60	40	0.1	10 Lead
1N5769	8-DIODE COMMON CATHODE	500	1.5	40	25	0.1	10 Lead
1N5770	8-DIODE COMMON ANODE	500	1.3	60	40	0.1	10 Lead
1N5771	8-DIODE COMMON ANODE	500	1.5	40	25	0.1	10 Lead
1N5774	DUAL 8-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	14 Lead
1N5775	DUAL 8-DIODE (C.C. and C.A.)	500	1.5	40	25	0.1	14 Lead
1N5772	16-DIODE (C.C. and C.A.)	500	1.3	60	40	0.1	10 Lead
1N5773	16-DIODE (C.C. and C.A.)	500	1.5	40	25	0.1	10 Lead

MATRICES (PROGRAMMABLE), CERAMIC DUAL-IN-LINE (J) AND METAL FLAT PACKAGE (F)

DEVICE TYPE	MATRIX SIZE	t_{rr} (ns) 10-10-1 mA	FORWARD CURRENT		V_{BR}	I_R @ V_R @ 25°C		PACKAGE*
			I_F (mA)	V_F (V)	(V)	V	μA	
TIDM155J	5 X 5	10	20	1.5	45	25	0.02	14 Lead J
TIDM255J	5 X 5	25	20	1.7	35	25	0.05	14 Lead J
TIDM166J	6 X 6	10	20	1.5	45	25	0.02	14 Lead J
TIDM266J	6 X 6	25	20	1.7	35	25	0.05	14 Lead J
TIDM168J	6 X 8	10	20	1.5	45	25	0.02	14 Lead J
TIDM268J	6 X 8	25	20	1.7	35	25	0.05	14 Lead J
TIDM185J	8 X 5	10	20	1.5	45	25	0.02	14 Lead J
TIDM285J	8 X 5	25	20	1.7	35	25	0.05	14 Lead J
TIDM186J	8 X 6	10	20	1.5	45	25	0.02	14 Lead J
TIDM286J	8 X 6	25	20	1.7	35	25	0.05	14 Lead J
TIDM155F	5 X 5	10	20	1.5	45	25	0.02	14 Lead F
TIDM255F	5 X 5	25	20	1.7	35	25	0.05	14 Lead F
TIDM166F	6 X 6	10	20	1.5	45	25	0.02	14 Lead F
TIDM266F	6 X 6	25	20	1.7	35	25	0.05	14 Lead F
TIDM168F	6 X 8	10	20	1.5	45	25	0.02	14 Lead F
TIDM268F	6 X 8	25	20	1.7	35	25	0.05	14 Lead F
TIDM185F	8 X 5	10	20	1.5	45	25	0.02	14 Lead F
TIDM285F	8 X 5	25	20	1.7	35	25	0.05	14 Lead F
TIDM186F	8 X 6	10	20	1.5	45	25	0.02	14 Lead F
TIDM286F	8 X 6	25	20	1.7	35	25	0.05	14 Lead F

*See package drawings on page 8-14.

PACKAGE DRAWINGS


DO-34

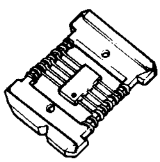

DO-35


PP


DO-41


DO-7

DOUBLE-PLUG DIODES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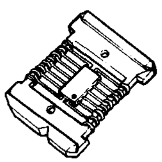
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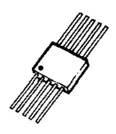
1/4" X 1/8" METAL FLAT PACKAGES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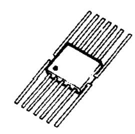
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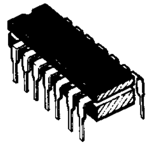
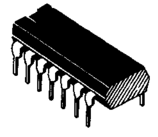
1/4" X 1/4" CERAMIC FLAT PACKAGES


TO-18


J CERAMIC


N PLASTIC

TO-116 DUAL-IN-LINE PACKAGES

Diode Interchangeability

DIODE INTERCHANGEABILITY

This list of low-power (generally two watts or less power dissipation in free-air) diodes is designed to assist the design engineer in determining the recommended TI replacement or equivalent for over 5700 diodes when only the device type number is known. Also included is a summary of the significant ratings and electrical characteristics of the referenced types. This interchangeability guide differs from the corresponding transistor lists in this volume in that only JEDEC registered ("1N") types are covered.

In compiling this list, all registered diodes were considered regardless of the semiconductor material used, the diode function, package type, or rated power dissipation. The result was massive. In order to keep the list within manageable size, it was severely edited down by deleting most of the entries for high-power diodes and specialized diodes not having wide-spread application.

Germanium diodes were retained in the list but it should be remembered that all recommended replacements for referenced germanium diodes are silicon diodes and that the replacement suggestions are based on specifications only.

Every effort has been made to ensure the accuracy of each entry. However, TI makes no warranty as to the information furnished and the user assumes all risk in the use thereof.

KEY TO CLASSIFICATION CODES

RE – RECTIFIER
RD – REFERENCE DIODE
SD – SIGNAL DIODE
ZD – REGULATOR (ZENER) DIODE

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N34	G	SD		1N4454		60		30/10	1/5			
1N34A	G	SD		1N4454		60		30/10	1/5			
1N34AS	G	SD		1N4148		75		30/10	1/5			
1N35	G	SD		1N4454		50		10/10	1/7			
1N36	G	SD		1N4148		36		100/25	1/4			
1N38	G	SD		1N4148		100		500/100	1/7			
1N38A	G	SD		1N4938		115		500/100	1/4			
1N38B	G	SD		1N4938		125		500/100	1/4			
1N39	G	SD		1N4938		210		100/100	1/3			
1N39A	G	SD		1N4938		230		65/100	1/5			
1N39B	G	SD		1N4938		200		100/100	1/4			
1N40	G	SD		1N4148		25		35/10	1.5/12			
1N41	G	SD		1N4454		25		35/10	1.5/12			
1N42	G	SD		1N4938		115			1.5/12			
1N43	G	SD		1N4148		70		200/5	1/5			
1N44	G	SD		1N4938		115		1K/50	1/3			
1N45	G	SD		1N4454		75		410/50	1/3			
1N46	G	SD		1N4454		60		1M/50	1/3			
1N47	G	SD		1N4938		150		500/100	1/4			
1N48	G	SD		1N4454		80		833/50	1/4			
1N49	G	SD		1N4148		75		200/20	1/5			
1N50	G	SD		1N4148		75		80/20	1/5			
1N51	G	SD		1N4454		50		1M/50	1/2.5			
1N52	G	SD		1N4454		80		150/50	1/4			
1N52A	G	SD		1N4454		50		100/50	1/5			
1N54	G	SD		1N4148		50		7/10	1/5			
1N54A	G	SD		1N4148		50		7/10	1/5			
1N55	G	SD		1N4938		150		800/150	1/5			
1N55A	G	SD		1N4938		170		500/150	1/4			
1N55B	G	SD		1N4938		180		500/150	1/5			
1N56	G	SD		1N4148		40		300/30	1/15			
1N56A	G	SD		1N4148		40		300/30	1/15			
1N57	G	SD		1N4454		80		500/75	1/4			
1N57A	G	SD		1N4454		80		500/75	1/4			
1N58	G	SD		1N4938		115		600/100	1/5			
1N58A	G	SD		1N4938		100		600/100	1/4			
1N59	G	SD		1N647		280		800/250	1/3			
1N60	G	SD		1N4148		40		200/10	1/5			
1N60A	G	SD		1N4148		40		60/10	1/5			
1N60C	G	SD		1N4148		50		67/10	1/5			

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N60S	G	SD		1N4148		25		67/10	1/5			
1N61	G	SD		1N4938		140		300/100	1/5			
1N62	G	SD		1N4938		140		700/100	1/5			
1N63	G	SD		1N4148		100		50/50	1/4			
1N63A	G	SD		1N4148		100		50/50	1/4			
1N64	G	SD		1N4148		20		25/10	1/3			
1N64A	G	SD		1N4148		20		25/10	1/3			
1N65	G	SD		1N4454		80		200/50	1/2.5			
1N66	G	SD		1N4454		60		50/10	1/5			
1N66A	G	SD		1N4454		60		50/10	1/5			
1N67	G	SD		1N4148		92		50/50	1/4			
1N67A	G	SD		1N4148		80		50/50	1/4			
1N68	G	SD		1N4938		100		625/100	1/5			
1N68A	G	SD		1N4938		100		625/100	1/5			
1N69	G	SD		1N4454		75		30/10	1/5			
1N69A	G	SD		1N4454		75		30/10	1/5			
1N70	G	SD		1N4938		120		25/10	1/3			
1N70A	G	SD		1N4148		100		25/10	1/3			
1N71	G	SD				40		300/30	1/15			
1N73	G	SD		1N4454		70		50/10	1.5/15			
1N74	G	SD		1N4148		75		50/10	1.5/15			
1N75	G	SD		1N4938		125		50/50	1/2.5			
1N81	G	SD		1N4148		50		10/10	1/3			
1N81A	G	SD		1N4148		40		10/10	1/3			
1N83	G	SD		1N647		375		30/60	1/5			
1N84	G	SD		1N4148		25		750/15	1/60			
1N86	G	SD		1N4148		70		50/10	1/4			
1N87	G	SD		1N4148		23		30/1.5	.25/.1			
1N87A	G	SD		1N4148		23		10/1.5	.25/.1			
1N87S	G	SD		1N4148		25		220/2	1/5			
1N87T	G	SD		1N4148		25		30/10	1/5			
1N88	G	SD		1N4938		85		75/100	1/2.5			
1N89	G	SD		1N4454		80		100/50	1/3.5			
1N90	G	SD		1N4454		60		500/50	1/5			
1N91	G	RE		1N4002		100		4/100	.5/150			
1N92	G	RE		1N4003		200		2/200	.5/100			
1N93	G	RE		1N4004		300		1.3/300	.5/80			
1N94	G	RE		1N4004		380		.8/380	.7/500			
1N95	G	SD		1N4148		60		500/50	1/10			
1N96	G	SD		1N4447		60		500/50	1/20			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N96A	G	SD		1N4148		60		500/50	1/40			
1N97	G	SD		1N4148		80		100/50	1/10			
1N97A	G	SD		1N4447		92		100/50	1/20			
1N98	G	SD		1N4454		80		100/50	1/20			
1N98A	G	SD		1N4448		80		100/50	1/40			
1N99	G	SD		1N4148		80		50/50	1/10			
1N99A	G	SD		1N4454		92		50/50	1/20			
1N100	G	SD		1N4447		100		50/50	1/20			
1N100A	G	SD		1N4448		80		50/50	1/40			
1N101	G	SD		1N4938		150		10/	1/10			
1N102	G	SD		1N4938		125		3/25	1/15			
1N103	G	SD		1N4448		20		750/15	1/30			
1N104	G	SD		1N4448		25		750/15	1/30			
1N106	G	SD		1N647		300		70/300	1/20			
1N107	G	SD		TID31		10		200/10	1/150			
1N108	G	SD		1N4448		50		200/50	1/50			
1N111	G	SD		1N4148		70		25/10	1/5			
1N112	G	SD		1N4148		70		50/10	1/5			
1N113	G	SD		1N4454		70		25/50	1/2.5			
1N114	G	SD		1N4454		70		50/50	1/2.5			
1N115	G	SD		1N4454		70		100/50	1/2.5			
1N116	G	SD		1N4454		60		100/50	1/5			
1N116A	G	SD		1N4454		70		100/50	1/10			
1N117	G	SD		1N4454		60		100/50	1/10			
1N117A	G	SD		1N4454		70		100/50	1/20			
1N118	G	SD		1N4454		60		100/50	1/20			
1N118A	G	SD		1N4448		60		100/50	1/40			
1N119	G	SD		1N4148		60			1/5	500		
1N120	G	SD		1N4148		60			1/5	500		
1N126	G	SD		1N4148		75		850/50	1/5			
1N126A	G	SD		1N4148		75		850/50	1/5			
1N127	G	SD		1N4938		125		300/50	1/3			
1N127A	G	SD		1N4938		125		300/50	1/3			
1N128	G	SD		1N4148		50		10/10	1/3			
1N128A	G	SD		1N4148		40		10/10	1/3			
1N132	G	SD		1N4148		25		500/50				
1N133	G	SD		1N4148		5		300/5	.5/3			
1N135	G	SD		1N4148		75		850/50	1/5			
1N137A	S	SD		1N483		36		.03/20	1/3			
1N137B	S	SD		1N483		36		.03/20	1/20			

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N138A	S	SD		1N483		18		.01/10	1/5			
1N138B	S	SD		1N483		18		.01/10	1/40			
1N139	G	SD		1N4148		40		.5M/50	1/20			
1N140	G	SD		1N4448		70		300/50	1/40			
1N141	G	SD		1N4148		70		50/50	1/20			
1N142	G	SD		1N4938		100		100/100	1/5			
1N143	G	SD		1N4938		100		100/100	1/40			
1N144	G	SD		1N4454		30		200/20	1/100			
1N145	G	SD		1N4449		30		100/10	1/40			
1N151	G	RE				100	.5		.7/			
1N152	G	RE				200	.5		.7/			
1N153	G	RE				300	.5		.7/			
1N158	G	RE				380	.5	800/	1.4/			
1N175	G	SD		1N4938		125		50/50	5/1			
1N190	G	SD				3		800/	.75/10			
1N191	G	SD		1N4148		90			1/5	500		
1N192	G	SD		1N4148		70			1/5	500		
1N193	S	SD		1N4148		40		40/40	2/1	500		
1N194	S	SD		1N4148		50		60/40	2/1.5	100		
1N194A	S	SD		1N4148		40		10/40	1/1	200		
1N195	S	SD		1N4148		50		80/40	2/2	100		
1N196	S	SD		1N4148		50		40/50	2/1	100		
1N198	G	SD		1N4148		80		10/10	1/4			
1N198A	G	SD		1N4148		80		50/50	1/4			
1N198B	G	SD		1N4454		100		50/50	1/4	300		
1N198M	G	SD		1N4148		80		75/10	1/4			
1N225	S	ZD			150						8.75/.2	10
1N225A	S	ZD			150						8.75/.2	5
1N226	S	ZD			150						10.5/.2	10
1N226A	S	ZD			150						10.5/.2	5
1N227	S	ZD			150						12.8/.2	10
1N227A	S	ZD			150						12.8/.2	5
1N228	S	ZD			150						15.7/.2	10
1N228A	S	ZD			150						15.7/.2	5
1N229	S	ZD			150						19/.2	10
1N229A	S	ZD			150						19/.2	5
1N230	S	ZD			150						23.5/.2	10
1N230A	S	ZD			150						23.5/.2	5
1N231	S	ZD			150						28.5/.2	10
1N231A	S	ZD			150						28.5/.2	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N232	S	ZD			150						34.5/.2	10
1N232A	S	ZD			150						34.5/.2	5
1N233	S	ZD			150						41/.2	10
1N233A	S	ZD			150						41/.2	5
1N234	S	ZD			150						48/.2	10
1N234A	S	ZD			150						48/.2	5
1N235	S	ZD			150						58/.2	10
1N235A	S	ZD			150						58/.2	5
1N236	S	ZD			150						71/.2	10
1N237	S	ZD			150						88/.2	10
1N238	S	ZD			150						105/.2	10
1N239	S	ZD			150						128/.2	10
1N248	S	RE				50	10	5M/	1.5/			
1N248A	S	RE				50	20	5M/	1.5/			
1N248B	S	RE				50	20	5M/	1.5/			
1N248C	S	RE				39	20	4M/	1.2/			
1N249	S	RE				100	10	5M/	1.5/			
1N249A	S	RE				100	20	5M/	1.5/			
1N249B	S	RE				100	20	5M/	1.5/			
1N249C	S	RE				110	20	4M/	1.2/			
1N250	S	RE				200	10	5M/	1.5/			
1N250A	S	RE				200	20	5M/	1.5/			
1N250B	S	RE				200	20	5M/	1.5/			
1N250C	S	RE				210	20	3M/	1.2/			
1N251	S	SD	1N251			30		100/10	1/5	150		
1N251A	S	SD		1N4938		125		10/10	1/5	150		
1N252	S	SD		1N914		20		.1/5	1/10	150		
1N252A	S	SD		1N4938		125		10/10	1/5	150		
1N265	G	SD		1N4148		80		30M/60	1/4			
1N266	G	SD		1N4148		50		30M/30	1/5			
1N267	G	SD		1N4148		30		50M/10	1/5			
1N268	G	SD		1N4148		30		850/30	1/2.5			
1N270	G	SD		TID31		80		100/50	1/200	300		
1N273	G	SD		1N4448		30		20/20	1/100			
1N276	G	SD		1N4454		50		100/50	1/40	300		
1N277	G	SD		1N4938		150		75/10	1/100	300		
1N277M	G	SD		1N4448		100		75/10	1/100	300		
1N278	G	SD		1N4446		50		125/50	1/20			
1N279	G	SD		1N4448		30		200/20	1/100			
1N281	G	SD		1N4448		60		30/10	1/100	300		

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R μA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N282	G	SD		1N4449		15		20/10	1/40			
1N283	G	SD		TID33		20		20/10	1/200			
1N287	G	SD		1N4148		60		1M/50	1/20			
1N288	G	SD		1N4148		85		350/50	1/40			
1N289	G	SD		1N4148		85		50/50	1/20			
1N290	G	SD		1N4938		120		100/100	1/5			
1N291	G	SD		1N4938		120		100/100	1/40			
1N292	G	SD		1N4448		75		200/50	1/100			
1N294	G	SD		1N4148		60		10/10	1/5			
1N294A	G	SD		1N4148		60		10/10	1/5			
1N295	G	SD		1N4148		40		200/10				
1N295A	G	SD		1N4148		40		200/10				
1N295S	G	SD		1N4148		30		800/30	1/6.5			
1N295X	G	SD		1N4148		30		385/24	1/4.5			
1N296	G	SD		1N4148		40		200/				
1N297	G	SD		1N4148		80		10/5	1/3.5			
1N297A	G	SD		1N4148		80		10/5	1/3.5			
1N298	G	SD		1N4148		70		250/40	2/30			
1N298A	G	SD		1N4148		70		10/5	2/30			
1N299	G	SD		1N4305				200/6	.5/3			
1N300	S	SD		1N482		15		1N/10	1/15			
1N300A	S	SD		1N482		15		1N/10	1/30			
1N300B	S	SD		1N482		15		1N/10	1/50			
1N301	S	SD		1N457		70		.01/10	1/5			
1N301A	S	SD		1N457		70		.01/10	1/18			
1N301B	S	SD		1N457		70		.01/10	1/50			
1N302	S	SD		1N645		225		.1/10	1/1			
1N302A	S	SD		1N645		225		.1/10	1/5			
1N302B	S	SD		1N645		225		.01/10	1/20			
1N303	S	SD		1N458		125		.01/10	1/3			
1N303A	S	SD		1N484		125		.01/10	1/12			
1N303B	S	SD		1N484		125		.01/10	1/50			
1N304	S	SD		1N4148		55		2/10	1.5/2			
1N305	G	SD		1N4607		60		2/10	.8/100			
1N306	G	SD		1N4607		15		2/10	.8/100			
1N307	G	SD		1N4938		125		5/10	1/100			
1N308	G	SD		1N4607		8		500/8	1/300			
1N309	G	SD		1N4148		40		100/20	1/100			
1N310	G	SD		1N4148		100		20/20	1/15			
1N312	G	SD		1N4448		50		50/50	1/30			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N313	G	SD		1N4148		100		10/20	1/20			
1N314	G	SD		1N4148		75		50/10	1/15			
1N315	G	RE		1N4004		300	.075	300/300	.48/100			
1N315A	G	RE		1N4003		200	.1	160/200	.48/100			
1N316	S	RE		1N645		50	.25	300/50	2/400			
1N316A	S	RE		1N645		50	.2	1/50	.60/400			
1N317	S	RE		1N645		100	.2	300/100	2/400			
1N317A	S	RE		1N645		100	.2	1/100	.6/400			
1N318	S	RE		1N645		200	.2	300/200	2/400			
1N318A	S	RE		1N645		200	.2	1/200	.6/400			
1N319	S	RE		1N646		350	.2	300/350	2/300			
1N319A	S	RE		1N646		350	.2	1/350	.6/400			
1N320	S	RE		1N648		500	.2	300/500	2/400			
1N320A	S	RE		1N648		500	.2	2/500	.6/400			
1N321	S	RE		1N4007		850	.25	300/850	.6/400			
1N321A	S	RE		1N4007		850	.25	2/850	.6/400			
1N322	S	RE		1N4007		1K	.25	300/1K	.6/400			
1N322A	S	RE		1N4007		1K	.25	2/1K	.6/400			
1N323	S	RE		1N4001		50	.4	300/50	2/650			
1N323A	S	RE		1N4001		50	.4	1/50	.6/650			
1N324	S	RE		1N4002		100	.4	300/100	2/650			
1N324A	S	RE		1N4002		100	.4	1/100	.6/650			
1N325	S	RE		1N4003		200	.4	300/200	2/650			
1N325A	S	RE		1N4003		200	.4	1/200	.6/650			
1N326	S	RE		1N4004		350	.4	300/350	2/650			
1N326A	S	RE		1N4004		350	.4	1/350	.6/650			
1N327	S	RE		1N4005		500	.4	300/500	2/650			
1N327A	S	RE		1N4005		500	.4	1/500	.6/650			
1N328	S	RE		1N4007		850	.4	300/850	1.2/650			
1N328A	S	RE		1N4007		850	.4	2/850	.6/650			
1N329	S	RE		1N4007		1K	.4	10/1K	1.2/650			
1N329A	S	RE		1N4007		1K	.4	2M/1K	.6/650			
1N330	S	SD		1N456		32		.03/20	1/3			
1N331	S	SD		1N458		16		.01/10	1/5			
1N332	S	RE				400	.4		2/800			
1N333	S	RE				400	.2		2/400			
1N334	S	RE				300	.4		2/400			
1N335	S	RE				300	.2		2/400			
1N336	S	RE				200	.4		2/800			
1N337	S	RE				200	.2		2/400			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N338	S	RE				100	1		2/1A			
1N339	S	RE				100	.4		2/800			
1N340	S	RE				100	.2		2/400			
1N341	S	RE				400	.4		2/800			
1N342	S	RE				400	.2		2/400			
1N343	S	RE				300	.4		2/800			
1N344	S	RE				300	.2		2/800			
1N345	S	RE				200	.4		2/800			
1N346	S	RE				200	.2		2/400			
1N347	S	RE				100	1		2/1A			
1N348	S	RE				100	.4		2/800			
1N349	S	RE				100	.2		2/400			
1N350	S	SD		1N457		70		.03/60	1/20			
1N351	S	SD		1N484		120		.03/100	1/20			
1N352	S	SD		1N485		170		.05/150	1/20			
1N353	S	SD		1N646		250		.1/200	1/20			
1N354	S	SD		1N647		325		.1/300	1/20			
1N355	G	SD		1N4148		100		5/5	1/4			
1N359	S	RE		1N4001		50	.15	250/50	2/200			
1N359A	S	RE		1N4001		50	.15	1/50	.6/250			
1N360	S	RE		1N4002		100	.1	250/100	2/200			
1N360A	S	RE		1N4002		100	.15	1/100	.6/250			
1N361	S	RE		1N4003		200	.1	250/200	2/200			
1N361A	S	RE		1N4003		200	.15	1/200	.6/250			
1N362	S	RE		1N4004		350	.1	250/300	2/200			
1N362A	S	RE		1N4004		350	.15	1/350	.6/250			
1N363	S	RE		1N4005		500	.1	250/500	2/200			
1N363A	S	RE		1N4005		500	.15	2/500	.6/250			
1N364	S	RE		1N4007		850	.1	250/850	1.2/200			
1N364A	S	RE		1N4007		850	.15	2/850	.6/200			
1N365	S	RE		1N4007		1K	.1	250/1K	1.2/200			
1N365A	S	RE		1N4007		1K	.15	2/1K	.6/200			
1N368	G	RE		1N4003		200	.1		.48/100			
1N368A	G	RE		1N4003		200	.1		.48/100			
1N370	S	ZD			200						1.8/20	20
1N371	S	ZD			200						2.4/20	15
1N372	S	ZD			200						2.9/15	15
1N373	S	ZD		1N703	200						3.5/10	10
1N374	S	ZD		1N704	200						4.1/5	10
1N375	S	ZD		1N704A	200						4.1/5	5

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N376	S	ZD		1N705A	200						4.95/5	5
1N377	S	ZD		1N706A	200						5.9/5	5
1N378	S	ZD		1N707A	200						7.15/.2	5
1N379	S	SD		1N4448		8.2		.5/8.2	1/35			
1N380	S	SD		1N4448		10		.5/10	1/30			
1N381	S	SD		1N4448		12		.5/12	1/23			
1N382	S	SD		1N4448		15		.5/15	1/17			
1N383	S	SD		1N4448		18		.1/18	1/12			
1N384	S	SD		1N4148		22		.1/22	1/9			
1N385	S	SD		1N4148		27		.1/27	1/7			
1N386	S	SD		1N4148		33		.1/33	1/5.5			
1N387	S	SD		1N4148		39		.1/39	1/4.5			
1N388	S	SD		1N4148		47		.1/47	1/3.5			
1N389	S	SD		1N4148		56		.1/56	1/2.7			
1N390	S	SD		1N4148		68		1/68	1/2			
1N391	S	SD		1N4148		82		1/82	1/1.5			
1N392	S	SD		1N4148		100		1/100	1/1.2			
1N393	S	SD		1N4938		120		1/120	1/.9			
1N394	S	SD		1N4938		150		5/150	1/.7			
1N417	G	SD		1N4448		60		120/60	1/50	300		
1N418	G	SD		1N4148		60		120/60	1/7	300		
1N419	G	SD		TID32		80		180/80	1/125	300		
1N429	S	RD			200						6.2/7.5	5
1N430	S	RD			250						8.4/10	5
1N430A	S	RD			250						8.4/10	5
1N430B	S	RD			250						8.4/10	5
1N431	S	SD		1N4938		68		1/68	.55/15			
1N432	S	SD		1N4148		40		3M/10	1/1	3		
1N432A	S	SD		1N4446		40		3M/10	1/20	3		
1N432B	S	SD		1N4448		40		3M/10	1/50	3		
1N433	S	SD		1N4938		145		7M/100	1/3	3		
1N433A	S	SD		1N4938		145		7M/100	1/10	3		
1N433B	S	SD		1N4938		145		7M/100	1/50	3		
1N434	S	SD		1N4938		180		2M/150	1/2	3		
1N434A	S	SD		1N4938		180		7M/150	1/7	3		
1N434B	S	SD		1N4938		180		2M/150	1/2	3		
1N435	S	SD		1N4148		40		300/30				
1N440	S	RE		1N4002		100	.3	.3/100	1.5/300			
1N440B	S	RE		1N4002		100	.75	.3/100	1.5/750			
1N441	S	RE		1N4003		200	.3	.75/200	1.5/300			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N441B	S	RE		1N4003		200	.75	.75/200	1.5/750			
1N442	S	RE		1N4004		300	.3	1/300	1.5/300			
1N442B	S	RE		1N4004		300	.75	1/300	1.5/750			
1N443	S	RE		1N4004		400	.3	1.5/400	1.5/300			
1N443B	S	RE		1N4004		400	.75	1.5/400	1.5/750			
1N444	S	RE		1N4005		500	.3	1.7/500	1.5/300			
1N444B	S	RE		1N4005		500	.75	1.7/500	1.5/750			
1N445	S	RE		1N4005		600	.3	2.0/600	1.5/300			
1N445B	S	RE		1N4005		600	.75	2.0/600	1.5/750			
1N447	G	SD		1N4449		40		20/10	1/25			
1N448	G	SD		1N4449		100		30/30	1/25			
1N449	G	SD		1N4151		40		30/30	1/50			
1N450	G	SD		1N4151		100		50/50	1/50			
1N451	G	SD		1N4938		150		150/150	1/50			
1N452	G	SD		1N4448		35		30/30	1/100			
1N453	G	SD		1N4938		115		30/30	1/100			
1N454	G	SD		TID33		58		50/50	1/200			
1N455	G	SD		1N4607		35		30/30	1/300			
1N456	S	SD	1N456			30		25N/25	1/40			
1N456A	S	SD	1N456A			30		25N/25	1/100			
1N457	S	SD	1N457			70		25N/60	1/20			
1N457A	S	SD	1N457A			70		25N/60	1/100			
1N457M	S	SD	1N457			80		25N/60	1/20			
1N458	S	SD	1N458			150		25N/125	1/2			
1N458A	S	SD	1N458A			150		25N/125	1/100			
1N458M	S	SD	1N458			175		25N/125	1/7			
1N459	S	SD	1N459			200		25N/175	1/3			
1N459A	S	SD	1N459A			200		25N/175	1/100			
1N459M	S	SD	1N459			230		25N/175	1/3			
1N460	S	SD		1N4148		90		10/75	1/5	2U		
1N460A	S	SD		1N4148		90		10/75	1/15	2U		
1N460B	S	SD		1N4448		90		10/75	1/50	2U		
1N461	S	SD	1N461			35		.5/25	1/15			
1N461A	S	SD	1N461A			30		.5/25	1/100			
1N462	S	SD	1N462			80		.5/60	1/5			
1N462A	S	SD	1N462A			70		.5/60	1/100			
1N463	S	SD	1N463			230		.5/175	1/1			
1N463A	S	SD	1N463A			200		.5/175	1/100			
1N464	S	SD	1N464			175		.5/125	1/3			
1N464A	S	SD	1N464A			150		.5/125	1/100			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R μA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N465	S	ZD			250						2.6/5	10
1N465A	S	ZD			250						2.6/5	5
1N465B	S	ZD			250						2.6/5	1
1N466	S	ZD		1N746	250						3.5/5	10
1N466A	S	ZD		1N746A	250						3.5/5	5
1N466B	S	ZD			250						3.5/5	1
1N467	S	ZD		1N748	250						4.1/5	10
1N467A	S	ZD		1N748A	250						4.1/5	5
1N467B	S	ZD			250						4.1/5	1
1N468	S	ZD		1N750	250						4.9/5	10
1N468A	S	ZD		1N750A	250						4.9/5	5
1N468B	S	ZD			250						4.9/5	1
1N469	S	ZD		1N752	250						5.8/5	10
1N469A	S	ZD		1N752A	250						5.8/5	5
1N469B	S	ZD			250						5.8/5	1
1N470	S	ZD		1N754	250						7.1/5	10
1N470A	S	ZD		1N754A	250						7.1/5	5
1N470B	S	ZD			250						7.1/5	1
1N471	S	ZD			200						3.5/5	10
1N471A	S	ZD			200						3.5/5	5
1N471B	S	ZD			200						3.5/5	1
1N472	S	ZD			200						4.1/5	10
1N472A	S	ZD			200						4.1/5	5
1N472B	S	ZD			200						4.1/5	1
1N473	S	ZD			200						4.9/5	10
1N473A	S	ZD			200						4.9/5	5
1N473B	S	ZD			200						4.9/5	1
1N474	S	ZD			200						5.8/5	10
1N474A	S	ZD			200						5.8/5	5
1N474B	S	ZD			200						5.8/5	1
1N475	S	ZD			200						7.1/5	10
1N475A	S	ZD			200						7.1/5	5
1N475B	S	ZD			200						7.1/5	1
1N476	G	SD		1N4148		90		180/75	1/3			
1N477	G	SD		1N4148		90		180/75	1/3			
1N478	G	SD		1N4148		90		155/75	1/5			
1N479	G	SD		1N4148		90		155/75	1/5			
1N480	G	SD		1N4148		60			1/5	500		
1N482	S	SD	1N482			36		.25/30	1.1/100			
1N482A	S	SD	1N482A			36		25N/30	1/100			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	CHARACTERISTICS TOL %
1N482B	S	SD	1N482B			36		25N/30	1/100			
1N482C	S	SD		1N482B		36		5N/30	1/100			
1N483	S	SD	1N483			70		.25/60	1.1/100			
1N483A	S	SD	1N483A			70		25N/60	1/100			
1N483B	S	SD	1N483B			70		25N/60	1/100			
1N483BM	S	SD		1N483B		80		25N/60	1/100			
1N483C	S	SD		1N483B		70		5N/60	1/100			
1N484	S	SD	1N484			130		.25/125	1.1/100			
1N484A	S	SD	1N484A			130		25N/125	1/100			
1N484B	S	SD	1N484B			130		25N/125	1/100			
1N484C	S	SD		1N484B		130		5N/125	1/100			
1N485	S	SD	1N485			180		.25/175	1.1/100			
1N485A	S	SD	1N485A			180		25N/175	1/100			
1N485B	S	SD	1N485B			180		25N/175	1/100			
1N485C	S	SD		1N485B		180		5N/175	1/100			
1N486	S	SD		1N645		225		.25/225	1.1/100			
1N486A	S	SD		1N645		225		.05/25	1/100			
1N486B	S	SD		1N646		250		.05/225	1/100			
1N487	S	SD		1N646		300		.25/300	1.1/100			
1N487A	S	SD		1N646		300		.1/300	1/100			
1N487B	S	SD		1N646		300		.1/300	1/100			
1N488	S	SD		1N647		380		.25/380	1.1/100			
1N488A	S	SD		1N647		380		.1/380	1/100			
1N488B	S	SD		1N647		380		.1/380	1/100			
1N490	G	SD		1N4148		90			1/5	500		
1N497	G	SD		1N4448		30		20/20	1/100			
1N498	G	SD		1N4448		60		25/40	1/100			
1N499	G	SD		1N4448		75		30/60	1/100			
1N500	G	SD		1N4448		80		40/60	1/100			
1N501	G	SD		1N4448		100		40/80	1/100			
1N502	G	SD		1N4938		120		50/100	1/100			
1N503	S	RE				50	.33	500/	1.2/			
1N504	S	RE				100	.44	500/	1.2/			
1N505	S	RE				200	.33	500/	1.2/			
1N506	S	RE				300	.33	500/	1.2/			
1N507	S	RE				400	.33	250/	1.2/			
1N508	S	RE				600	.33	250/	1.2/			
1N509	S	RE				800	.33	250/	1.2/			
1N510	S	RE				1K	.33	250/	1.2/			
1N511	S	RE				50	1	500/	1.2/			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N512	S	RE				100	1	500/	1.2/			
1N513	S	RE				200	1	500/	1.2/			
1N514	S	RE				300	1	500/	1.2/			
1N515	S	RE				400	1	250/	1.2/			
1N516	S	RE				600	1	250/	1.2/			
1N517	S	RE				800	1	250/	1.2/			
1N518	S	RE				1K	1	250/	1.2/			
1N519	S	RE				50	1.25	500/	1.2/			
1N520	S	RE				100	1.25	500/	1.2/			
1N521	S	RE				200	1.25	500/	1.2/			
1N522	S	RE				300	1.25	500/	1.2/			
1N523	S	RE				400	1.25	250/	1.2/			
1N524	S	RE				600	1.25	250/	1.2/			
1N525	S	RE				800	1.25	250/	1.2/			
1N526	S	RE				1K	1.25	250/	1.2/			
1N527	G	SD		1N4305		10		50/10	.3/1			
1N530	S	RE		1N4002		100	.3	3/100	2/300			
1N531	S	RE		1N4003		200	.3	7.5/200	2/300			
1N532	S	RE		1N4004		300	.3	10/300	2/300			
1N533	S	RE		1N4004		400	.3	15/400	2/300			
1N534	S	RE		1N4005		500	.3	17/500	2/300			
1N535	S	RE		1N4005		600	.3	20/600	2/300			
1N536	S	RE		1N4001		50	.75	10/50	1/500			
1N537	S	RE		1N4002		100	.75	10/100	1/500			
1N538	S	RE		1N4003		200	.75	10/200	1/500			
1N539	S	RE		1N4004		300	.75	10/300	1/500			
1N540	S	RE		1N4004		400	.75	10/400	1/500			
1N541	G	SD		1N4305		30		18/10	.3/.1			
1N542	G	SD		1N4305		30		18/10	.3/.1			
1N543	S	RE				1.2K	.005	100/	10/			
1N543A	S	RE				1.2K	.025	100/	8/			
1N544	S	RE				1K	.015	100/	10/			
1N544A	S	RE				1K	.075	100/	10/			
1N547	S	RE		1N4005		600	.75	500/600	1.1/250			
1N548	S	RE		1N4007		900	.3	500/900	1.1/300			
1N549	S	RE				1.2K	.3		1.1/300			
1N550	S	RE				100	.5		1.5/			
1N551	S	RE				200	.5		1.5/			
1N552	S	RE				300	.5		1.5/			
1N553	S	RE				400	.5		1.5/			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N554	S	RE				500	.5		1.5/			
1N555	S	RE				600	.5	5/	1.5/			
1N560	S	RE		1N4006		800	.75	15/800	1.1/500			
1N561	S	RE		1N4007		1K	.75	20/1K	1.1/500			
1N562	S	RE				800	.4	15/800	1.8/400			
1N563	S	RE				1K	.4	20/1K	1.8/400			
1N566	G	SD		1N4938		220		200/200	1/20			
1N567	G	SD		1N4938		125		150/100	1/150			
1N568	G	SD		1N4305		50		100/5	.32/5			
1N569	G	SD		1N4305		25		50/10	.5/250			
1N570	S	RE				1.5K	.75	50/1.5K	10/			
1N571	G	RE		TID33		15	.2	100/15	1/200			
1N584	G	RE				380			.15/400			
1N588	S	RE				1.5K		100/	1.7/100			
1N589	S	RE				1.5K		100/	1.7/250			
1N590	S	RE				1.5K		100/	8/75			
1N591	S	RE				1.5K		100/	8/75			
1N596	S	RE		1N4005		600	.15	25/600	3/170			
1N597	S	RE		1N4006		800	.15	25/800	3/170			
1N598	S	RE		1N4007		1K	.15	25/1K	3/170			
1N599	S	RE		1N4001		50	.3	25/50	1.5/200			
1N599A	S	RE		1N4001		50	.3	1/50	1.5/400			
1N600	S	RE		1N4002		100	.3	25/100	1.5/200			
1N600A	S	RE		1N4002		100	.3	1/100	1.5/400			
1N601	S	RE		1N4003		150	.3	25/150	1.5/200			
1N601A	S	RE		1N4003		150	.3	1/150	1.5/400			
1N602	S	RE		1N4003		200	.3	25/200	1.5/200			
1N602A	S	RE		1N4003		200	.3	1/200	1.5/400			
1N603	S	RE		1N4004		300	.3	25/300	1.5/200			
1N603A	S	RE		1N4004		300	.3	1/300	1.5/400			
1N604	S	RE		1N4004		400	.3	25/400	1.5/200			
1N604A	S	RE		1N4004		400	.3	1.5/400	1.5/400			
1N605	S	RE		1N4005		500	.3	25/500	1.5/200			
1N605A	S	RE		1N4005		500	.3	2.0/500	1.5/400			
1N606	S	RE		1N4005		600	.3	25/600	1.5/200			
1N606A	S	RE		1N4005		600	.3	2.5/600	1.5/400			
1N607	S	RE				50	.8	25/50	1.5/200			
1N607A	S	RE				50	.8	1/50	1.5/400			
1N608	S	RE				100	.8	25/100	1.5/200			
1N608A	S	RE				100	.8	1/100	1.5/400			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R μA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N609	S	RE				150	.8	25/150	1.5/200			
1N609A	S	RE				150	.8	1/150	1.5/400			
1N610	S	RE				200	.8	25/200	1.5/200			
1N610A	S	RE				200	.8	1/200	1.5/400			
1N611	S	RE				300	.8	25/300	1.5/200			
1N611A	S	RE				300	.8	1/300	1.5/400			
1N612	S	RE				400	.8	25/400	1.5/200			
1N612A	S	RE				400	.8	1.5/400	1.5/400			
1N613	S	RE				500	.8	25/500	1.5/200			
1N613A	S	RE				500	.8	2/500	1.5/400			
1N614	S	RE				600	.8	25/600	1.5/200			
1N614A	S	RE				600	.8	2.5/600	1.5/400			
1N615	G	RE		1N4004		300		1M/300	/75			
1N616	G	SD		1N4148		30		18/1.5	1/8			
1N617	G	SD		1N4148		90		11/10	1/3			
1N618	G	SD		1N4148		90		7/10	1/5			
1N619	S	SD		1N4148		30		.08/10	1/3			
1N622	S	SD		1N4938		150		.16/150	1/7			
1N625	S	SD	1N625			30		1/20	1.5/4	1U		
1N625A	S	SD		1N4148		20		.1/20	1.5/10	500		
1N625M	S	SD	1N625			30		1/20	1.5/4	1U		
1N626	S	SD	1N626			50		1/20	1.5/4	1U		
1N626A	S	SD		1N4148		35		.1/35	1.5/1	500		
1N626M	S	SD	1N626			50		1/35	1.5/4	1U		
1N627	S	SD	1N627			100		1/20	1.5/4	1U		
1N627A	S	SD		1N4938		75		.1/75	1.5/10	500		
1N628	S	SD	1N628			150		1/20	1.5/4	1U		
1N628A	S	SD		1N4938		125		.1/125	1.5/10	500		
1N629	S	SD	1N629			200		1/20	1.5/4	1U		
1N629A	S	SD		1N4938		175		.1/175	1.5/10	500		
1N631	G	SD		1N4148		60			3.5/50	300		
1N632	G	SD		1N4148		60		120/60	1.0/7	300		
1N633	G	SD		1N4938		90			1/125	300		
1N634	G	SD		1N4938		125		35/30	1/50			
1N635	G	SD		1N4938		175		175/150	1/50			
1N636	G	SD		1N4448		50		10/10	1/2.5			
1N643	S	SD	1N643			200		1/100	1/10	300		
1N643A	S	SD	1N643			200		1/100	1/100	300		
1N643M	S	SD	1N643			200		15/100	1/1	300		
1N645	S	SD	1N645			275		.2/225	1/400			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA / @ V_R (V)	V_F (V) / @ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N645A	S	SD	1N645A			275		50N/225	1/400			
1N645B	S	SD		1N645A		225		25N/225	1/400			
1N645J	S	SD		1N645A		250		25N/250	1/400			
1N646	S	SD	1N646			360		.2/300	1/400			
1N647	S	SD	1N647			480		.2/400	1/400			
1N648	S	SD	1N648			600		.2/500	1/400			
1N649	S	SD	1N649			720		.2/600	1/400			
1N658	S	SD	1N658			120		50N/40	1/100	300		
1N658A	S	SD		1N658		120		30N/50	1/100	300		
1N659	S	SD	1N659			60		5/50	1/6	300		
1N659A	S	SD		1N659		60		30N/50	1/10	300		
1N660	S	SD	1N660			120		5/100	1/6	300		
1N660A	S	SD		1N660		120		30N/100	1/10	300		
1N661	S	SD	1N661			240		10/200	1/6	300		
1N661A	S	SD		1N661		240		30N/200	1/10	300		
1N662	S	SD	1N662			80		1/50	1/10	500		
1N662A	S	SD		1N662		80			1/100	500		
1N663	S	SD	1N663			80		5/75	1/100	500		
1N663A	S	SD		1N663		80		.1/75	1/100	300		
1N663M	S	SD		1N663		100		.1/75	1/100	300		
1N664	S	ZD		1N756A	250						8.2/10	5
1N665	S	ZD		1N759A	250						12/10	5
1N666	S	ZD		1N965B	250						15/5	5
1N667	S	ZD		1N967B	250						18/5	5
1N668	S	ZD		1N969B	250						22/5	5
1N669	S	ZD		1N971B	250						27/5	5
1N670	S	ZD			250						68/1	1
1N671	S	ZD			250						100/1	1
1N672	S	ZD			250						150/1	1
1N673	S	SD		1N647		400		1/300	1/250			
1N674	S	ZD		1N750	250						4.7/20	10
1N675	S	ZD		1N753A	250						6.2/20	5
1N676	S	RE		1N645		100	.2	1/100	1/400			
1N677	S	RE		1N645		100	.4	1/100	1/400			
1N678	S	RE		1N645		200	.2	1/200	1/400			
1N679	S	RE		1N645		200	.4	1/200	1/400			
1N681	S	RE		1N646		300	.075	200/300	1/200			
1N682	S	RE		1N646		300	.150	200/300	1/400			
1N683	S	RE		1N647		400	.075	200/400	1/200			
1N684	S	RE		1N647		400	.150	200/400	1/400			

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N685	S	RE		1N648		500	.075	200/500	1/200			
1N686	S	RE		1N648		500	.150	200/500	1/400			
1N687	S	RE		1N649		600	.075	200/500	1/200			
1N689	S	RE		1N649		600	.150	200/600	1/400			
1N690	S	SD		1N4607		36		.25/30	1/400	800		
1N691	S	SD		1N4607		80		.25/60	1/400	800		
1N692	S	SD		1N4607		100		.25/90	1/400	800		
1N693	S	SD		1N4607		130		.25/120	1/400	800		
1N695	G	SD		1N4148		20		2/10	1/100	300		
1N695A	G	SD		1N4148		25		2/10	.5/10	300		
1N696	S	SD		1N4148		30		15N/20	1/10	5		
1N697	S	SD		1N4607		120		2/50	1.1/400	100		
1N698	G	SD		1N4305		15		1/1.5	.21/1	500		
1N699	G	SD		1N4448		105		250/75	1/100	300		
1N701	S	ZD		1N758A	250						10.5/10	5
1N702	S	ZD	1N702		250						2.6/5	20
1N702A	S	ZD	1N702A		250						2.6/5	5
1N703	S	ZD	1N703		250						3.5/5	20
1N703A	S	ZD	1N703A		250						3.5/5	5
1N704	S	ZD	1N704		250						4.1/5	20
1N704A	S	ZD	1N704A		250						4.4/5	5
1N705	S	ZD	1N705		250						4.8/5	20
1N705A	S	ZD	1N705A		250						4.8/5	5
1N706	S	ZD	1N706		250						5.8/5	20
1N706A	S	ZD	1N706A		250						5.8/5	5
1N707	S	ZD	1N707		250						7.1/5	20
1N707A	S	ZD	1N707A		250						7.1/5	5
1N708	S	ZD	1N708		250						5.6/25	10
1N708A	S	ZD	1N708A		250						5.6/25	5
1N708B	S	ZD	1N708		250						5.6/25	20
1N709	S	ZD	1N709		250						6.2/25	10
1N709A	S	ZD	1N709A		250						6.2/25	5
1N709B	S	ZD	1N709		250						6.2/25	20
1N710	S	ZD	1N710		250						6.8/25	10
1N710A	S	ZD	1N710A		250						6.8/25	5
1N710B	S	ZD	1N710		250						6.8/25	20
1N711	S	ZD	1N711		250						7.5/25	10
1N711A	S	ZD	1N711A		250						7.5/25	5
1N711B	S	ZD	1N711		250						7.5/25	20
1N712	S	ZD	1N712		250						8.2/25	10

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R μA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N712A	S	ZD	1N712A		250						8.2/25	5
1N712B	S	ZD	1N712		250						8.2/25	20
1N713	S	ZD	1N713		250						9.1/12	10
1N713A	S	ZD	1N713A		250						9.1/12	5
1N713B	S	ZD	1N713		250						9.1/12	20
1N714	S	ZD	1N714		250						10/12	10
1N714A	S	ZD	1N714A		250						10/12	5
1N714B	S	ZD	1N714		250						10/12	20
1N715	S	ZD	1N715		250						11/12	10
1N715A	S	ZD	1N715A		250						11/12	5
1N715B	S	ZD	1N715		250						11/12	20
1N716	S	ZD	1N716		250						12/12	10
1N716A	S	ZD	1N716A		250						12/12	5
1N716B	S	ZD	1N716		250						12/12	20
1N717	S	ZD	1N717		250						13/12	10
1N717A	S	ZD	1N717A		250						13/12	5
1N717B	S	ZD	1N717		250						13/12	20
1N718	S	ZD	1N718		250						15/12	10
1N718A	S	ZD	1N718A		250						15/12	5
1N718B	S	ZD	1N718		250						15/12	20
1N719	S	ZD	1N719		250						16/12	10
1N719A	S	ZD	1N719A		250						16/12	5
1N719B	S	ZD	1N719		250						16/12	20
1N720	S	ZD	1N720		250						18/12	10
1N720A	S	ZD	1N720A		250						18/12	5
1N720B	S	ZD	1N720		250						18/12	20
1N721	S	ZD	1N721		250						20/4	10
1N721A	S	ZD	1N721A		250						20/4	5
1N721B	S	ZD	1N721		250						20/4	20
1N722	S	ZD	1N722		250						22/4	10
1N722A	S	ZD	1N722A		250						22/4	5
1N722B	S	ZD	1N722		250						22/4	20
1N723	S	ZD	1N723		250						24/4	10
1N723A	S	ZD	1N723A		250						24/4	5
1N723B	S	ZD	1N723		250						24/4	20
1N724	S	ZD	1N724		250						27/4	10
1N724A	S	ZD	1N724A		250						27/4	5
1N724B	S	ZD	1N724		250						27/4	20
1N725	S	ZD	1N725		250						30/4	10
1N725A	S	ZD	1N725A		250						30/4	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA / @ V_R (V)	V_F (V) / @ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N725B	S	ZD	1N725		250						30/4	20
1N726	S	ZD	1N726		250						33/4	10
1N726A	S	ZD	1N726A		250						33/4	5
1N726B	S	ZD	1N726		250						33/4	20
1N727	S	ZD			250						36/4	10
1N727A	S	ZD			250						36/4	5
1N727B	S	ZD			250						36/4	20
1N728	S	ZD			250						39/4	10
1N728A	S	ZD			250						39/4	5
1N728B	S	ZD			250						39/4	20
1N729	S	ZD			250						43/4	10
1N729A	S	ZD			250						43/4	5
1N729B	S	ZD			250						43/4	20
1N730	S	ZD			250						47/4	10
1N730A	S	ZD			250						47/4	5
1N730B	S	ZD			250						47/4	20
1N731	S	ZD			250						51/4	10
1N731A	S	ZD			250						51/4	5
1N731B	S	ZD			250						51/4	20
1N732	S	ZD			250						56/4	10
1N732A	S	ZD			250						56/4	5
1N732B	S	ZD			250						56/4	20
1N733	S	ZD			250						62/2	10
1N733A	S	ZD			250						62/2	5
1N733B	S	ZD			250						62/2	20
1N734	S	ZD			250						68/2	10
1N734A	S	ZD			250						68/2	5
1N734B	S	ZD			250						68/2	20
1N735	S	ZD			250						75/2	10
1N735A	S	ZD			250						75/2	5
1N735B	S	ZD			250						75/2	20
1N736	S	ZD			250						82/2	10
1N736A	S	ZD			250						82/2	5
1N736B	S	ZD			250						82/2	20
1N737	S	ZD			250						91/1	10
1N737A	S	ZD			250						91/1	5
1N737B	S	ZD			250						91/1	20
1N738	S	ZD			250						100/1	10
1N738A	S	ZD			250						100/1	5
1N738B	S	ZD			250						100/1	20

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N739	S	ZD			250						110/1	10
1N739A	S	ZD			250						110/1	5
1N739B	S	ZD			250						110/1	20
1N740	S	ZD			250						120/1	10
1N740A	S	ZD			250						120/1	5
1N740B	S	ZD			250						120/1	20
1N741	S	ZD			250						130/1	10
1N741A	S	ZD			250						130/1	5
1N741B	S	ZD			250						130/1	20
1N742	S	ZD			250						150/1	10
1N742A	S	ZD			250						150/1	5
1N742B	S	ZD			250						150/1	20
1N743	S	ZD			250						160/1	10
1N743A	S	ZD			250						160/1	5
1N743B	S	ZD			250						160/1	20
1N744	S	ZD			250						180/1	10
1N744A	S	ZD			250						180/1	5
1N744B	S	ZD			250						180/1	20
1N745	S	ZD			250						200/1	10
1N745A	S	ZD			250						200/1	5
1N745B	S	ZD			250						200/1	20
1N746	S	ZD	1N746		400						3.3/20	10
1N746A	S	ZD	1N746A		400						3.3/20	5
1N747	S	ZD	1N747		400						3.6/20	10
1N747A	S	ZD	1N747A		400						3.6/20	5
1N748	S	ZD	1N748		400						3.9/20	10
1N748A	S	ZD	1N748A		400						3.9/20	5
1N749	S	ZD	1N749		400						4.3/20	10
1N749A	S	ZD	1N749A		400						4.3/20	5
1N750	S	ZD	1N750		400						4.7/20	10
1N750A	S	ZD	1N750A		400						4.7/20	5
1N751	S	ZD	1N751		400						5.1/20	10
1N751A	S	ZD	1N751A		400						5.1/20	5
1N752	S	ZD	1N752		400						5.6/20	10
1N752A	S	ZD	1N752A		400						5.6/20	5
1N753	S	ZD	1N753		400						6.2/20	10
1N753A	S	ZD	1N753A		400						6.2/20	5
1N754	S	ZD	1N754		400						6.8/20	10
1N754A	S	ZD	1N754A		400						6.8/20	5
1N755	S	ZD	1N755		400						7.5/20	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R (V)	V_F (V)	@ I_F (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N755A	S	ZD	1N755A		400								7.5/20	5
1N756	S	ZD	1N756		400								8.2/20	10
1N756A	S	ZD	1N756A		400								8.2/20	5
1N757	S	ZD	1N757		400								9.1/20	10
1N757A	S	ZD	1N757A		400								9.1/20	5
1N758	S	ZD	1N758		400								10/20	10
1N758A	S	ZD	1N758A		400								10/20	5
1N759	S	ZD	1N759		400								12/20	10
1N759A	S	ZD	1N759A		400								12/20	5
1N761	S	ZD	1N761		250								4.85/10	10
1N761-1	S	ZD	1N761		250								4.5/10	5
1N761-2	S	ZD	1N761		250								5/10	5
1N761A	S	ZD	1N761		250								4.9/10	5
1N762	S	ZD	1N762		250								5.8/10	10
1N762-1	S	ZD	1N762		250								5.5/10	5
1N762-2	S	ZD	1N762		250								6/10	5
1N762A	S	ZD	1N762		250								5.8/10	5
1N763	S	ZD	1N763		250								7.1/10	10
1N763-1	S	ZD	1N763		250								6.5/10	5
1N763-2	S	ZD	1N763		250								7/10	5
1N763-3	S	ZD	1N763		250								7.5/10	5
1N763A	S	ZD	1N763		250								7.1/10	5
1N764	S	ZD	1N764		250								8.75/10	10
1N764-1	S	ZD	1N764		250								8/10	5
1N764-2	S	ZD	1N764		250								8.5/10	5
1N764-3	S	ZD	1N764		250								9/10	5
1N764-4	S	ZD	1N764		250								9.5/10	5
1N764A	S	ZD	1N764		250								8.8/10	5
1N765	S	ZD	1N765		250								10.5/5	10
1N765-1	S	ZD	1N765		250								10/5	5
1N765-2	S	ZD	1N765		250								11/5	5
1N765A	S	ZD	1N765		250								10/5	5
1N766	S	ZD	1N766		250								12.7/5	10
1N766-1	S	ZD	1N766		250								12/5	5
1N766-2	S	ZD	1N766		250								13/5	5
1N766-3	S	ZD	1N766		250								14/5	5
1N766A	S	ZD	1N766		250								12.8/5	5
1N767	S	ZD	1N767		250								15.7/5	10
1N767-1	S	ZD	1N767		250								15/5	5
1N767-2	S	ZD	1N767		250								16/5	5

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N767-3	S	ZD	1N767		250						17/5	5
1N767A	S	ZD	1N767		250						15.8/5	5
1N768	S	ZD	1N768		250						19/5	10
1N768-1	S	ZD	1N768		250						18/5	5
1N768-2	S	ZD	1N768		250						19/5	5
1N768-3	S	ZD	1N768		250						20/5	5
1N768A	S	ZD	1N768		250						19/5	5
1N769	S	ZD	1N769		250						23.5/5	10
1N769-1	S	ZD	1N769		250						22/5	5
1N769-2	S	ZD	1N769		250						24/5	5
1N769-3	S	ZD	1N769		250						26/5	5
1N769-4	S	ZD	1N769		250						28/5	5
1N769A	S	ZD	1N769		250						23.5/5	5
1N770	G	SD		1N4305		20		40/10	.5/15	350		
1N771	G	SD		1N4448		92		25/50	1/100			
1N771A	G	SD		TID32		92		25/50	1/200			
1N771B	G	SD		1N645		92		25/50	1/400			
1N772	G	SD		1N4448		80		50/50	1/100			
1N772A	G	SD		TID32		80		50/50	1/200			
1N773	G	SD		1N4448		75		10/10	1/100			
1N773A	G	SD		TID32		75		10/10	1/200			
1N774	G	SD		1N4448		70		15/10	1/100			
1N774A	G	SD		TID32		70		15/10	1/200			
1N775	G	SD		1N4448		70		20/10	1/100			
1N776	G	SD		1N4448		20		200/10	1/50			
1N777	G	SD		1N4448		75		125/50	1/100	500		
1N778	S	SD		1N4148		100		.5/40	1/10	300		
1N779	S	SD		1N4938		175		.5/175	1/10	300		
1N781	G	SD		1N4305		40		5/10	.45/10			
1N781A	G	SD		1N4305		40		5/10	.45/10			
1N788	G	SD		1N4448		60		200/10	1/100	200		
1N789	S	SD		1N4148		27		1/20	1/10	500		
1N789M	S	SD		1N4148		30		1/20	1/10	500		
1N790	S	SD		1N4148		30		5/20	1/10	250		
1N790M	S	SD		1N4148		30		5/20	1/10	250		
1N791	S	SD		1N4448		27		5/20	1/50	500		
1N791M	S	SD		1N4448		30		5/20	1/50	500		
1N792	S	SD		1N4448		27		5/20	1/100	500		
1N792M	S	SD		1N4448		30		5/20	1/100	500		
1N793	S	SD		1N4148		60		1/50	1/10	500		

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N793M	S	SD		1N4148		60		1/50	1/10	500		
1N794	S	SD		1N4148		60		5/50	1/10	250		
1N795	S	SD		1N4448		60		5/50	1/50	500		
1N796	S	SD		1N4448		60		5/50	1/100	500		
1N798	S	SD		1N4938		120		5/100	1/10	250		
1N797	S	SD		1N4938		120		1/100	1/10	500		
1N799	S	SD		1N4938		120		5/100	1/50	500		
1N800	S	SD		1N4938		120		5/100	1/100	500		
1N801	S	SD		1N4938		150		1/125	1/10	500		
1N802	S	SD		1N4938		150		5/125	1/50	500		
1N803	S	SD		1N4938		200		5/175	1/10	500		
1N804	S	SD		1N4938		200		10/175	1/50	500		
1N805	G	SD		1N4148		40		100/10	1/3			
1N806	S	SD		1N4148		100		.5/40	1/4	300		
1N807	S	SD		1N4938		200		.5/125	1/4	300		
1N808	S	SD		1N4448		100		1/35	1/100	300		
1N809	S	SD		1N4938		200		1/200	1/100	300		
1N810	S	SD		1N4148		50		1/40	1/10	50		
1N811	S	SD		1N4148		20		1/10	1/1	250		
1N811M	S	SD		1N4148		30		10/20	1/1	250		
1N812	S	SD		1N4149		30		.1/10	1/2	250		
1N812M	S	SD		1N4149		40		10/10	1/2	250		
1N813	S	SD		1N4148		15		.5/5	1/5	250		
1N813M	S	SD		1N4148		20		10/5	1/5	250		
1N814	S	SD		1N4148		40		.1/2	1/2	250		
1N814M	S	SD		1N4148		50		10/20	1/2	250		
1N815	S	SD		1N4448		15		.5/5	1.5/100	250		
1N815M	S	SD		1N4448		20		.5/5	1/100	250		
1N817	S	SD		1N4938		200		20/175	1.5/6	1U		
1N818	S	SD		1N4148		70		.25/60	1.5/30	500		
1N819	S	SD		1N645		80		25N/70	1/200			
1N821	S	RD			250						6.2/7.5	5
1N821A	S	RD			250						6.2/7.5	5
1N822	S	RD			250						6.2/7.5	5
1N822A	S	RD			250						6.2/7.5	5
1N823	S	RD			250						6.2/7.5	5
1N823A	S	RD			250						6.2/7.5	5
1N824	S	RD			250						6.2/7.5	5
1N824A	S	RD			250						6.2/7.5	5
1N825	S	RD			250						6.2/7.5	5

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA / @ V_R (V)	V_F (V) / @ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N825A	S	RD			250						6.2/7.5	5
1N826	S	RD			250						6.55/7.5	5
1N826A	S	RD			250						6.55/7.5	5
1N827	S	RD			250						6.2/7.5	5
1N827A	S	RD			250						6.2/7.5	5
1N828	S	RD			250						6.55/7.5	5
1N828A	S	RD			250						6.55/7.5	5
1N829	S	RD			250						6.2/7.5	5
1N829A	S	RD			250						6.2/7.5	5
1N835	G	SD		1N4305		30		20/30	.5/5	500		
1N837	S	SD		TID32		100			1/150	500		
1N837A	S	SD		TID32		100		.1/80	1/150	300		
1N838	S	SD		1N4938		150			1/150	500		
1N839	S	SD		1N4938		200			1/150	500		
1N840	S	SD		TID32		40		.1/40	1/150	300		
1N840M	S	SD		1N4938		50		.1/40	1/150	300		
1N841	S	SD		1N4938		120		.1/120	1/150	300		
1N842	S	SD		1N4938		160		.1/160	1/150	300		
1N843	S	SD		1N4938		200		.1/200	1/150	300		
1N844	S	SD		1N4938		100		.1/80	1/200	500		
1N845	S	SD		1N4938		200		.1/160	1/200	500		
1N846	S	RE		1N4001		50	.2	20/50	.6/200			
1N847	S	RE		1N4002		100	.2	20/100	.6/200			
1N848	S	RE		1N4003		200	.2	20/200	.6/200			
1N849	S	RE		1N4004		300	.2	20/300	.6/200			
1N850	S	RE		1N4004		400	.2	20/400	.6/200			
1N851	S	RE		1N4005		500	.2	20/500	.6/200			
1N852	S	RE		1N4005		600	.2	20/600	.6/200			
1N853	S	RE		1N4006		700	.2	20/700	.6/200			
1N854	S	RE		1N4006		800	.2	20/800	.6/200			
1N855	S	RE		1N4007		900	.2	20/900	.6/200			
1N856	S	RE		1N4007		1K	.2	20/1K	.6/200			
1N857	S	RE		1N4001		50	.15	20/50	.6/150			
1N858	S	RE		1N4002		100	.15	20/100	.6/150			
1N859	S	RE		1N4003		200	.15	20/200	.6/150			
1N860	S	RE		1N4004		300	.15	20/300	.6/150			
1N861	S	RE		1N4004		400	.15	20/400	.6/150			
1N862	S	RE		1N4005		500	.15	20/500	.6/150			
1N863	S	RE		1N4005		600	.15	20/600	.6/150			
1N864	S	RE		1N4006		700	.15	20/700	.6/150			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N865	S	RE		1N4006		800	.15	20/800	.6/150			
1N866	S	RE		1N4007		900	.15	20/900	.6/150			
1N867	S	RE		1N4007		1K	.15	20/1K	.6/150			
1N868	S	RE		1N4001		50	.1	20/50	.6/100			
1N869	S	RE		1N4002		100	.1	20/100	.6/100			
1N870	S	RE		1N4003		200	.1	20/200	.6/100			
1N871	S	RE		1N4004		300	.1	20/300	.6/100			
1N872	S	RE		1N4004		400	.1	20/400	.6/100			
1N873	S	RE		1N4005		500	.1	20/500	.6/100			
1N874	S	RE		1N4005		600	.1	20/600	.6/100			
1N875	S	RE		1N4006		700	.1	20/700	.6/100			
1N876	S	RE		1N4006		800	.1	20/800	.6/100			
1N877	S	RE		1N4007		900	.1	20/900	.6/100			
1N878	S	RE		1N4007		1K	.1	20/1K	.6/100			
1N879	S	RE		1N4001		50	.05	20/50	.6/50			
1N880	S	RE		1N4002		100	.05	20/100	.6/50			
1N881	S	RE		1N4003		200	.05	20/200	.6/50			
1N882	S	RE		1N4004		300	.05	20/300	.6/50			
1N883	S	RE		1N4004		400	.05	20/400	.6/50			
1N884	S	RE		1N4005		500	.05	20/500	.6/50			
1N885	S	RE		1N4005		600	.05	20/600	.6/50			
1N886	S	RE		1N4006		700	.05	20/700	.6/50			
1N887	S	RE		1N4006		800	.05	20/800	.6/50			
1N888	S	RE		1N4007		900	.05	20/900	.6/50			
1N889	S	RE		1N4007		1K	.05	20/1K	.6/50			
1N890	S	SD		1N4447		60		25N/60	1/20			
1N891	S	SD		1N4448		60		.1/50	1/50	300		
1N892	S	SD		1N4448		100		.1/40	1/50	300		
1N893	S	SD		1N4938		240		.1/200	1/50	300		
1N897	S	SD		1N4148		50		.1/40	1/5			
1N898	S	SD		1N4448		50		.5/40	1/100			
1N899	S	SD		1N4938		100		.1/80	1/5			
1N900	S	SD		1N4938		100		.1/80	1/50			
1N901	S	SD		1N4938		100		.5/80	1/100			
1N902	S	SD		1N4938		200		1/100	1/10			
1N903	S	SD		1N4148		20		.1/20	1/10	4		
1N903A	S	SD		1N4154		50		.1/40	1/20	4		
1N903AM	S	SD		1N4154		50		.1/40	1/20	4		
1N903M	S	SD		1N4154		50		.1/40	1/10	4		
1N904	S	SD		1N4154		30		.1/30	1/10	4		

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	CHARACTERISTICS TOL %
1N904A	S	SD		1N4154		40		.1/30	1/20	4		
1N904AM	S	SD		1N4154		40		.1/30	1/20	4		
1N904M	S	SD		1N4154		40		.1/30	1/10	4		
1N905	S	SD		1N4151		40		.1/40	1/10	4		
1N905A	S	SD		1N4154		30		.1/20	1/20	4		
1N905AM	S	SD		1N4154		30		.1/20	1/20	4		
1N905M	S	SD		1N4154		30		.1/20	1/10	4		
1N906	S	SD		1N4149		20		.1/20	1/10	4		
1N906A	S	SD		1N4447		30		.1/20	1/20	4		
1N906AM	S	SD		1N4447		30		.1/20	1/20	4		
1N906M	S	SD		1N4447		30		.1/20	1/10	4		
1N907	S	SD		1N4149		40		.1/30	1/10	4		
1N907A	S	SD		1N4448		40		.1/30	1/20	4		
1N907AM	S	SD		1N4447		40		.1/30	1/20	4		
1N907M	S	SD		1N4149		40		.1/30	1/10	4		
1N908	S	SD		1N4149		50		.1/40	1/10	4		
1N908A	S	SD		1N4447		50		.1/40	1/20	4		
1N908AM	S	SD		1N4447		50		.1/40	1/20	4		
1N908M	S	SD		1N4149		50		.1/40	1/10	4		
1N909	G	SD		1N4449		50		10/50	1/100			
1N910	G	SD		1N4449		30		10/30	1/100			
1N911	G	SD		1N4449		20		10/20	1/100			
1N912	S	ZD			500						.62/1	5
1N912A	S	ZD			500						.62/1	10
1N913	S	ZD			600						.62/1	5
1N913A	S	ZD			600						.62/1	10
1N914	S	SD	1N914			100		5/75	1/10	4		
1N914A	S	SD	1N914A			100		5/75	1/20	4		
1N914B	S	SD	1N914B			100		5/75	1/100	4		
1N914M	S	SD	1N914			75		25N/20	1/10	4		
1N915	S	SD	1N915			65		5/50	1/50	10		
1N916	S	SD	1N916			100		5/75	1/10	4		
1N916A	S	SD	1N916A			100		5/75	1/20	4		
1N916B	S	SD	1N916B			100		5/75	1/30	4		
1N917	S	SD	1N917			40		.05/10	1/10	3		
1N919	S	SD		1N4938		150		.5/150	1/100	300		
1N920	S	SD		1N4608		36		.25/30	1/500	300		
1N921	S	SD		1N4608		80		.25/60	1/500	300		
1N922	S	SD		1N4608		100		.25/90	1/500	300		
1N923	S	SD		1N4608		130		.25/120	1/500	300		

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N924	S	SD		1N483		60		25N/60	1/30	2U		
1N925	S	SD		1N4148		40		1/10	1/5	150		
1N926	S	SD		1N4148		40		.1/10	1/5	150		
1N927	S	SD		1N4148		65		.1/10	1/10	150		
1N928	S	SD		1N4938		120		.1/100	1/10	150		
1N929	S	SD		1N4446		25		100/25	1/20			
1N930	S	SD		1N4446		75		100/75	1/20			
1N931	S	SD		1N4938		125		100/125	1/20			
1N932	S	SD		1N4938		250		100/250	1/20			
1N933	G	SD		1N4148		100		10/10	1/4	400		
1N934	S	SD		1N4938		70		25N/60	1/30	1U		
1N935	S	RD			500						9/7.5	5
1N935A	S	RD			500						9/7.5	5
1N935B	S	RD			500						9/7.5	5
1N936	S	RD			500						9/7.5	5
1N936A	S	RD			500						9/7.5	5
1N936B	S	RD			500						9/7.5	5
1N937	S	RD			500						9/7.5	5
1N937A	S	RD			500						9/7.5	5
1N937B	S	RD			500						9/7.5	5
1N938	S	RD			500						9/7.5	5
1N938A	S	RD			500						9/7.5	5
1N938B	S	RD			500						9/7.5	5
1N939	S	RD			500						9/7.5	5
1N939A	S	RD			500						9/7.5	5
1N939B	S	RD			500						9/7.5	5
1N940	S	RD			500						9/7.5	5
1N940A	S	RD			500						9/7.5	5
1N940B	S	RD			500						9/7.5	5
1N941	S	RD			500						11.7/7.5	5
1N941A	S	RD			500						11.7/7.5	5
1N941B	S	RD			500						11.7/7.5	5
1N942	S	RD			500						11.7/7.5	5
1N942A	S	RD			500						11.7/7.5	5
1N942B	S	RD			500						11.7/7.5	5
1N943	S	RD			500						11.7/7.5	5
1N943A	S	RD			500						11.7/7.5	5
1N943B	S	RD			500						11.7/7.5	5
1N944	S	RD			500						11.7/7.5	5
1N944A	S	RD			500						11.7/7.5	5

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N944B	S	RD			500						11.7/7.5	5
1N945	S	RD			500						11.7/7.5	5
1N945A	S	RD			500						11.7/7.5	5
1N945B	S	RD			500						11.7/7.5	5
1N946	S	RD			500						11.7/7.5	5
1N946A	S	RD			500						11.7/7.5	5
1N946B	S	RD			500						11.7/7.5	5
1N947	S	SD		1N647		600		2/480	1/400			
1N948	S	SD		1N4448		36		.25/30	1.5/100	1		
1N949	G	SD		1N4305		50		10/10	.39/10			
1N957	S	ZD	1N957		400						6.8/18	20
1N957A	S	ZD	1N957A		400						6.8/18	10
1N957B	S	ZD	1N957B		400						6.8/18	5
1N958	S	ZD	1N958		400						7.5/16	20
1N958A	S	ZD	1N958A		400						7.5/16	10
1N958B	S	ZD	1N958B		400						7.5/16	5
1N959	S	ZD	1N959		400						8.2/15	20
1N959A	S	ZD	1N959A		400						8.2/15	10
1N959B	S	ZD	1N959B		400						8.2/15	5
1N960	S	ZD	1N960		400						9.1/14	20
1N960A	S	ZD	1N960A		400						9.1/14	10
1N960B	S	ZD	1N960B		400						9.1/14	5
1N961	S	ZD	1N961		400						10/12	20
1N961A	S	ZD	1N961A		400						10/12	10
1N961B	S	ZD	1N961B		400						10/12	5
1N962	S	ZD	1N962		400						11/11	20
1N962A	S	ZD	1N962A		400						11/11	10
1N962B	S	ZD	1N962B		400						11/11	5
1N963	S	ZD	1N963		400						12/10	20
1N963A	S	ZD	1N963A		400						12/10	10
1N963B	S	ZD	1N963B		400						12/10	5
1N964	S	ZD	1N964		400						13/9.5	20
1N964A	S	ZD	1N964A		400						13/9.5	10
1N964B	S	ZD	1N964B		400						13/9.5	5
1N965	S	ZD	1N965		400						15/8.5	20
1N965A	S	ZD	1N965A		400						15/8.5	10
1N965B	S	ZD	1N965B		400						15/8.5	5
1N966	S	ZD	1N966		400						16/7.8	20
1N966A	S	ZD	1N966A		400						16/7.8	10
1N966B	S	ZD	1N966B		400						16/7.8	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N967	S	ZD	1N967		400						18/7.0	20
1N967A	S	ZD	1N967A		400						18/7.0	10
1N967B	S	ZD	1N967B		400						18/7.0	5
1N968	S	ZD	1N968		400						20/6.2	20
1N968A	S	ZD	1N968A		400						20/6.2	10
1N968B	S	ZD	1N968B		400						20/6.2	5
1N969	S	ZD	1N969		400						22/5.6	20
1N969A	S	ZD	1N969A		400						22/5.6	10
1N969B	S	ZD	1N969B		400						22/5.6	5
1N970	S	ZD	1N970		400						24/5.2	20
1N970A	S	ZD	1N970A		400						24/5.2	10
1N970B	S	ZD	1N970B		400						24/5.2	5
1N971	S	ZD	1N971		400						27/4.6	20
1N971A	S	ZD	1N971A		400						27/4.6	10
1N971B	S	ZD	1N971B		400						27/4.6	5
1N972	S	ZD	1N972		400						30/4.2	20
1N972A	S	ZD	1N972A		400						30/4.2	10
1N972B	S	ZD	1N972B		400						30/4.2	5
1N973	S	ZD	1N973		400						33/3.8	20
1N973A	S	ZD	1N973A		400						33/3.8	10
1N973B	S	ZD	1N973B		400						33/3.8	5
1N974	S	ZD			400						36/3.4	20
1N974A	S	ZD			400						36/3.4	10
1N974B	S	ZD			400						36/3.4	5
1N975	S	ZD			400						39/3.2	20
1N975A	S	ZD			400						39/3.2	10
1N975B	S	ZD			400						39/3.2	5
1N976	S	ZD			400						43/3.0	20
1N976A	S	ZD			400						43/3.0	10
1N976B	S	ZD			400						43/3.0	5
1N977	S	ZD			400						47/2.7	20
1N977A	S	ZD			400						47/2.7	10
1N977B	S	ZD			400						47/2.7	5
1N978	S	ZD			400						51/2.5	20
1N978A	S	ZD			400						51/2.5	10
1N978B	S	ZD			400						51/2.5	5
1N979	S	ZD			400						56/2.2	20
1N979A	S	ZD			400						56/2.2	10
1N979B	S	ZD			400						56/2.2	5
1N980	S	ZD			400						62/2	20

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N980A	S	ZD			400						62/2	10
1N980B	S	ZD			400						62/2	5
1N981	S	ZD			400						68/1.8	20
1N981A	S	ZD			400						68/1.8	10
1N981B	S	ZD			400						68/1.8	5
1N982	S	ZD			400						75/1.7	20
1N982A	S	ZD			400						75/1.7	10
1N982B	S	ZD			400						75/1.7	5
1N983	S	ZD			400						82/1.5	20
1N983A	S	ZD			400						82/1.5	10
1N983B	S	ZD			400						82/1.5	5
1N984	S	ZD			400						91/1.4	20
1N984A	S	ZD			400						91/1.4	10
1N984B	S	ZD			400						91/1.4	5
1N985	S	ZD			400						100/1.3	20
1N985A	S	ZD			400						100/1.3	10
1N985B	S	ZD			400						100/1.3	5
1N986	S	ZD			400						110/1.1	20
1N986A	S	ZD			400						110/1.1	10
1N986B	S	ZD			400						110/1.1	5
1N987	S	ZD			400						120/1	20
1N987A	S	ZD			400						120/1	10
1N987B	S	ZD			400						120/1	5
1N988	S	ZD			400						130/.95	20
1N988A	S	ZD			400						130/.95	10
1N988B	S	ZD			400						130/.95	5
1N989	S	ZD			400						150/.85	20
1N989A	S	ZD			400						150/.85	10
1N989B	S	ZD			400						150/.85	5
1N990	S	ZD			400						160/.8	20
1N990A	S	ZD			400						160/.8	10
1N990B	S	ZD			400						160/.8	5
1N991	S	ZD			400						180/.68	20
1N991A	S	ZD			400						180/.68	10
1N991B	S	ZD			400						180/.68	5
1N992	S	ZD			400						200/.65	20
1N992A	S	ZD			400						200/.65	10
1N992B	S	ZD			400						200/.65	5
1N993	S	SD		1N4447		8		1/6	1.2/10	4		
1N994	G	SD		1N4151		6.5		30/6	1/10	2		

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N995	G	SD		1N4305		15		10/6	.5/10	6		
1N996	G	SD		1N4607		20		15/15	.8/40	300		
1N997	S	SD		1N4148		35		30N/12	1/10	150		
1N998	S	SD		1N484		150		1N/125	1/200			
1N999	S	SD		1N4444		100		1N/75	1/50	4		
1N1005	G	RE				380	.25		.15/			
1N1007	G	RE				380	.35		.3/			
1N1008	G	RE				380	.4		.3/			
1N1013	G	RE				380	.25		.15/			
1N1016	G	RE				380	.4		.15/			
1N1021	G	RE				380	.25		.15/			
1N1022	G	RE				380	.3		.15/			
1N1023	G	RE				380	.35		.15/			
1N1024	G	RE				380	.4		.15/			
1N1028	S	RE		1N4001		50	.5	200/50	1.5/500			
1N1029	S	RE		1N4002		100	.5	200/100	1.5/500			
1N1030	S	RE		1N4003		150	.5	200/150	1.5/500			
1N1031	S	RE		1N4003		200	.5	200/200	1.5/500			
1N1032	S	RE		1N4004		300	.5	200/300	1.5/500			
1N1033	S	RE		1N4004		400	.5	200/400	1.5/500			
1N1034	S	RE				50	1	200/50	1.5/1			
1N1035	S	RE				100	1	200/100	1.5/1			
1N1036	S	RE				150	1	200/150	1.5/1			
1N1037	S	RE				200	1	200/200	1.5/1			
1N1038	S	RE				300	1	200/300	1.5/1			
1N1039	S	RE				400	1	200/400	1.5/1			
1N1040	S	RE				50	1	200/50	1.5/1			
1N1041	S	RE				100	1	200/100	1.5/1			
1N1042	S	RE				150	1	200/150	1.5/1			
1N1043	S	RE				200	1	200/200	1.5/1			
1N1044	S	RE				300	1	200/300	1.5/1			
1N1045	S	RE				400	1	200/400	1.5/1			
1N1046	S	RE				50	1	200/50	1.5/1			
1N1047	S	RE				100	1	200/100	1.5/1			
1N1048	S	RE				150	1	200/150	1.5/1			
1N1049	S	RE				200	1	200/200	1.5/1			
1N1050	S	RE				300	1	200/300	1.5/1			
1N1051	S	RE				400	1	200/400	1.5/1			
1N1052	S	RE				50	1.5	1M/50	1.5/1.5			
1N1053	S	RE				100	1.5	1M/100	1.5/1.5			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1054	S	RE				150	1.5	1M/150	1.5/1.5			
1N1055	S	RE				200	1.5	1M/200	1.5/1.5			
1N1056	S	RE				300	1.5	1M/300	1.5/1.5			
1N1057	S	RE				400	1.5	1M/400	1.5/1.5			
1N1058	S	RE				50	5	1M/50	1.5/5			
1N1059	S	RE				100	5	1M/100	1.5/5			
1N1060	S	RE				150	5	1M/150	1.5/5			
1N1061	S	RE				200	5	1M/200	1.5/5			
1N1062	S	RE				300	5	1M/300	1.5/5			
1N1063	S	RE				400	5	1M/400	1.5/5			
1N1064	S	RE				50	5	1M/50	1.5/5			
1N1065	S	RE				100	5	1M/100	1.5/5			
1N1066	S	RE				150	5	1M/150	1.5/5			
1N1067	S	RE				200	5	1M/200	1.5/5			
1N1068	S	RE				300	5	1M/300	1.5/5			
1N1069	S	RE				400	5	1M/400	1.5/5			
1N1070	S	RE				50	5	1M/50	1.5/5			
1N1071	S	RE				100	5	1M/100	1.5/5			
1N1072	S	RE				150	5	1M/150	1.5/5			
1N1073	S	RE				200	5	1M/200	1.5/5			
1N1074	S	RE				300	5	1M/300	1.5/5			
1N1075	S	RE				400	5	1M/400	1.5/5			
1N1076	S	RE				50	15	20M/50	1.5/15			
1N1077	S	RE				100	15	20M/100	1.5/15			
1N1078	S	RE				150	15	20M/150	1.5/15			
1N1079	S	RE				200	15	20M/200	1.5/15			
1N1080	S	RE				300	15	20M/300	1.5/15			
1N1081	S	RE				100	.5	2M/100	1.5/500			
1N1082	S	RE				200	.5	2M/200	1.5/500			
1N1083	S	RE				300	.5	2M/300	1.5/500			
1N1083A	S	RE				300	.75	10/300	1/1A			
1N1084	S	RE				400	.5	2M/400	1.5/500			
1N1084A	S	RE				400	.75	10/400	1/1A			
1N1085	S	RE				100	1.5	2M/100	1.5/			
1N1085A	S	RE				100	2	25N/100				
1N1086	S	RE				200	1.5	2M/200	1.5/			
1N1086A	S	RE				200	2	25N/200				
1N1087	S	RE				300	1.5	2M/300	1.5/			
1N1087A	S	RE				300	2	25N/300				
1N1088	S	RE				400	1.5	2M/400	1.5/			

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1088A	S	RE				400	2	25N/400				
1N1089	S	RE				100	5	2M/100	1.5/5A			
1N1089A	S	RE				100	5		1.5/5A			
1N1090	S	RE				200	5	2M/200	1.5/5A			
1N1090A	S	RE				200	5		1.5/5A			
1N1091	S	RE				300	5		1.5/5A			
1N1091A	S	RE				300	5		1.5/5A			
1N1092	S	RE				400	5		1.5/5A			
1N1092A	S	RE				400	5		1.5/5A			
1N1093	G	SD				15			.4/5	500		
1N1095	S	RE				500	.75		.5/250			
1N1096	S	RE				600	.75		.5/250			
1N1100	S	RE				100	.77		1.5/12A			
1N1101	S	RE				200	.77		1.5/12A			
1N1102	S	RE				300	.77		1.5/12A			
1N1103	S	RE				400	.77		1.5/12A			
1N1104	S	RE				500	.77		1.5/12A			
1N1105	S	RE				600	.75		1.5/12A			
1N1108	S	RE				800	.45	2M/800				
1N1109	S	RE				1.2K	.43	2M/1.2K				
1N1110	S	RE				1.6K	.4	2M/1.6K				
1N1111	S	RE				20K	.38	2M/20K				
1N1112	S	RE				24K	.35	2M/24K				
1N1113	S	RE				28K	.33	2M/28K				
1N1115	S	RE				100	1.5		.65/			
1N1116	S	RE				200	1.5		.65/			
1N1117	S	RE				300	1.5		.65/			
1N1118	S	RE				400	1.5		.65/			
1N1119	S	RE				500	1.5		.65/			
1N1120	S	RE				600	1.5		.65/			
1N1124	S	RE				200	3		1.1/1A			
1N1124A	S	RE				250	3.3	10/250	1/1A			
1N1125	S	RE				300	3		1.1/1A			
1N1125A	S	RE				300	3.3	10/300	1.1/1A			
1N1126	S	RE				400	1		1.1/1A			
1N1126A	S	RE				400	3.3	10/400	1.1/1A			
1N1127	S	RE				500	1		1.1/1A			
1N1127A	S	RE				500	3.3	10/500	1.1/1A			
1N1128	S	RE				600	1		1.1/1A			
1N1128A	S	RE				600	3.3	10/600	1.1/1A			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1130	S	RE				1.5K	.3	50/	15/			
1N1131	S	RE				1.5K	.3	50/	15/			
1N1133	S	RE				1.5K	.075		15/85			
1N1134	S	RE				1.5K	.1		7.5/115			
1N1135	S	RE				1.8K	.065		18/75			
1N1136	S	RE				1.8K	.065		9/95			
1N1137	S	RE				2.4K	.057		24/57			
1N1138	S	RE				2.4K	.06		12/70			
1N1139	S	RE				3.6K	.055		27/75			
1N1140	S	RE				3.6K	.055		18/75			
1N1141	S	RE				4.8K	.05		36/70			
1N1142	S	RE				4.8K	.05		24/57			
1N1143	S	RE				6K	.05		45/57			
1N1143A	S	RE				6K	.055		30/75			
1N1144	S	RE				7.2K	.05		54/57			
1N1145	S	RE				7.2K	.06		36/70			
1N1146	S	RE				8K	.045		60/50			
1N1147	S	RE				12K	.045		60/50			
1N1148	S	RE				14K	.05		52/57			
1N1149	S	RE				16K	.045		60/50			
1N1150	S	RE				1.6K	.75	200/1.6K				
1N1150A	S	RE				1.6K	.75	2M/1.6K				
1N1169	S	RE				400	.79		.9/500			
1N1169A	S	RE				400	.5	100/400	1.2/800			
1N1170	G	SD		1N4148		50		5/50	1/4			
1N1183	S	RE				50	35		1.7/35A			
1N1183A	S	RE				50	40		1.1/			
1N1184	S	RE				100	35		1.7/35A			
1N1184A	S	RE				100	40		1.1/			
1N1185	S	RE				150	35		1.7/35A			
1N1185A	S	RE				150	40		1.1/			
1N1186	S	RE				200	35		1.7/35A			
1N1186A	S	RE				200	40		1.1/			
1N1187	S	RE				300	35		1.7/35A			
1N1187A	S	RE				300	40	15/300				
1N1188	S	RE				400	35		1.7/35A			
1N1188A	S	RE				400	40	15/400				
1N1189	S	RE				500	35		1.7/35A			
1N1189A	S	RE				500	40	15/500				
1N1190	S	RE				600	35		1.7/35A			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1190A	S	RE				600	40	15/600				
1N1191	S	RE				50	18		1.4/30A			
1N1191A	S	RE				50	22		1.2/60A			
1N1192	S	RE				100	25	10/100	1.4/30A			
1N1192A	S	RE				100	22		1.2/60A			
1N1193	S	RE				150	25	10/150	1.4/30A			
1N1193A	S	RE				150	22		1.2/60A			
1N1194	S	RE				200	25	10/200	1.4/30A			
1N1194A	S	RE				200	22		1.2/60A			
1N1195	S	RE				300	25	10/300	1.4/30A			
1N1195A	S	RE				300	20		.6/20A			
1N1196	S	RE				400	25	10/400	1.4/30A			
1N1196A	S	RE				400	20		.6/20A			
1N1197	S	RE				500	25	10/500	1.4/30A			
1N1197A	S	RE				500	20		.6/20A			
1N1198	S	RE				600	25	10/600	1.4/30A			
1N1198A	S	RE				600	20		.6/20A			
1N1199	S	RE				50	12	10/50	1.4/20A			
1N1199A	S	RE				50	12		1.3/12A			
1N1199B	S	RE				50	12		1.1/12A			
1N1200	S	RE				100	12	10/100	1.4/20A			
1N1200A	S	RE				100	12		1.3/12A			
1N1200B	S	RE				100	12		1.1/12A			
1N1201	S	RE				150	12	10/150	1.4/20A			
1N1201A	S	RE				150	12		1.3/12A			
1N1201B	S	RE				150	12		1.1/12A			
1N1202	S	RE				200	12	10/200	1.4/20A			
1N1202A	S	RE				200	12		1.3/12A			
1N1202B	S	RE				200	12		1.1/12A			
1N1203	S	RE				300	12	10/300	1.4/20A			
1N1203A	S	RE				300	12		1.3/12A			
1N1203B	S	RE				300	12		1.1/12A			
1N1204	S	RE				400	12	10/400	1.4/20A			
1N1204A	S	RE				400	12		1.3/12A			
1N1204B	S	RE				400	12		1.1/12A			
1N1205	S	RE				500	12	10/500	1.4/20A			
1N1205A	S	RE				500	12		1.3/12A			
1N1205B	S	RE				500	12		1.1/12A			
1N1206	S	RE				600	12	10/600	1.4/20A			
1N1206A	S	RE				600	12		1.3/12A			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1206B	S	RE				600	12		1.1/12A			
1N1217	S	RE				50	1.6	500/50	1.5/			
1N1217A	S	RE				50	1.6	50/50	1.5/			
1N1217B	S	RE				50	1.6	300/50	1.7/			
1N1218	S	RE				100	1.6	500/100	1.5/			
1N1218A	S	RE				100	1.6	50/100	1.5/			
1N1218B	S	RE				100	1.6	300/100	1.7/			
1N1219	S	RE				150	1.6	500/150	1.5/			
1N1219A	S	RE				150	1.6	50/150	1.5/			
1N1219B	S	RE				150	1.6	300/150	1.7/			
1N1220	S	RE				200	1.6	500/200	1.5/			
1N1220A	S	RE				200	1.6	50/200	1.5/			
1N1220B	S	RE				200	1.6	300/200	1.7/			
1N1221	S	RE				300	1.6	500/300	1.5/			
1N1221A	S	RE				300	1.6	50/300	1.5/			
1N1221B	S	RE				300	1.6	300/300	1.7/			
1N1222	S	RE				400	1.6	500/400	1.5/			
1N1222A	S	RE				400	1.6	50/400	1.5/			
1N1222B	S	RE				400	1.6	300/400	1.7/			
1N1223	S	RE				500	1.6	500/500	1.5/			
1N1223A	S	RE				500	1.6	50/500	1.5/			
1N1223B	S	RE				500	1.6	300/500	1.7/			
1N1224	S	RE				600	1.6	500/600	1.5/			
1N1224A	S	RE				600	1.6	50/600	1.5/			
1N1224B	S	RE				600	1.6	300/600	1.7/			
1N1225	S	RE				700	1.6	500/700	1.5/			
1N1225A	S	RE				700	1.6	50/700	1.5/1A			
1N1225B	S	RE				700	1.6	300/700	1.6/			
1N1226	S	RE				800	1.6	500/800	1.5/			
1N1226A	S	RE				800	1.6	50/800	1.5/1A			
1N1226B	S	RE				800	1.6	300/800	1.5/			
1N1227	S	RE				50	1.6	500/50	1.5/			
1N1227A	S	RE				50	1.6	50/50	1.5/			
1N1227B	S	RE				50	1.6	10/50	1.2/1A			
1N1228	S	RE				100	1.6	500/100	1.5/			
1N1228A	S	RE				100	1.6	50/100	1.5/			
1N1228B	S	RE				100	1.6	10/100	1.2/1A			
1N1229	S	RE				150	1.6	500/150	1.5/			
1N1229A	S	RE				150	1.6	50/150	1.5/			
1N1229B	S	RE				150	1.6	10/150	1.2/1A			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1230	S	RE				200	1.6	500/200	1.5/			
1N1230A	S	RE				200	1.6	50/200	1.5/			
1N1230B	S	RE				200	1.6	10/200	1.2/1A			
1N1231	S	RE				300	1.6	500/300	1.5/			
1N1231A	S	RE				300	1.6	50/300	1.5/			
1N1231B	S	RE				300	1.6	10/300	1.2/1A			
1N1232	S	RE				400	1.6	500/400	1.5/			
1N1232A	S	RE				400	1.6	50/400	1.5/			
1N1232B	S	RE				400	1.6	10/400	1.2/1A			
1N1233	S	RE				500	1.6	500/500	1.5/			
1N1233A	S	RE				500	1.6	50/500	1.5/			
1N1233B	S	RE				500	1.6	10/500	1.2/1A			
1N1234	S	RE				600	1.6	500/600	1.5/			
1N1234A	S	RE				600	1.6	50/600	1.5/			
1N1234B	S	RE				600	1.6	10/600	1.2/1A			
1N1235	S	RE				700	1.6	500/700	1.5/			
1N1235A	S	RE				700	1.6	50/700	1.2/1A			
1N1235B	S	RE				700	1.6	10/700	1.2/1A			
1N1236	S	RE				800	1.6	500/800	1.5/			
1N1236A	S	RE				800	1.6	50/800	1.2/1A			
1N1236B	S	RE				800	1.6	10/800	1.2/1A			
1N1237	S	RE				1.6K	.75	/1.6K	6/750			
1N1238	S	RE				1.6K	.75	/1.6K	6/750			
1N1239	S	RE				2.8K	.5	/2.8K	12/500			
1N1240	S	RE		1N4001		50	.25	500/50	1/250			
1N1241	S	RE		1N4002		100	.25	500/100	1/250			
1N1242	S	RE		1N4003		200	.25	500/200	1/250			
1N1243	S	RE		1N4004		300	.2	500/300	1/200			
1N1244	S	RE		1N4004		400	.15	500/400	1/150			
1N1244A	S	RE		1N4004		400	.2	500/400	1/200			
1N1245	S	RE		1N4005		500	.13	400/500	1/130			
1N1246	S	RE		1N4005		600	.115	300/600	1/115			
1N1247	S	RE		1N4006		700	.1	200/700	1/100			
1N1248	S	RE		1N4006		800	.08	100/800	1/80			
1N1249	S	RE		1N4007		900	.065	100/900	1/65			
1N1250	S	RE		1N4007		1K	.05	100/1K	1/50			
1N1251	S	RE		1N4001		50	.5	500/50	1/500			
1N1252	S	RE		1N4002		100	.5	500/100	1/500			
1N1253	S	RE		1N4003		200	.5	500/200	1/500			
1N1254	S	RE		1N4004		300	.5	500/300	1/500			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1255	S	RE		1N4004		400	.5	500/400	1/500			
1N1255A	S	RE		1N4004		400	.5	500/400	1/500			
1N1256	S	RE		1N4005		500	.32	400/500	1/320			
1N1257	S	RE		1N4005		600	.3	300/600	1/300			
1N1258	S	RE		1N4006		700	.28	200/700	1/280			
1N1259	S	RE		1N4006		800	.27	100/800	1/270			
1N1260	S	RE		1N4007		900	.25	100/900	1/250			
1N1261	S	RE		1N4007		1K	.24	100/1K	1/240			
1N1262	S	RE				4.5K	.25	2M/4.5K	12/250			
1N1313	S	ZD		1N959A	150						8.75/.2	10
1N1313A	S	ZD		1N959B	150						8.75/.2	5
1N1314	S	ZD		1N961A	150						10.5/.2	10
1N1314A	S	ZD		1N961B	150						10.5/.2	5
1N1315	S	ZD		1N963A	150						12.8/.2	10
1N1315A	S	ZD		1N963B	150						12.8/.2	5
1N1316	S	ZD		1N965A	150						15.7/.2	10
1N1316A	S	ZD		1N965B	150						15.7/.2	5
1N1317	S	ZD		1N967A	150						19/.2	10
1N1317A	S	ZD		1N967B	150						19/.2	5
1N1318	S	ZD		1N969A	150						23.5/.2	10
1N1318A	S	ZD		1N969B	150						23.5/.2	5
1N1319	S	ZD		1N971A	150						28.5/.2	10
1N1319A	S	ZD		1N971B	150						28.5/.2	5
1N1320	S	ZD			150						34.5/.2	10
1N1320A	S	ZD			150						34.5/.2	5
1N1321	S	ZD			150						41/.2	10
1N1321A	S	ZD			150						41/.2	5
1N1322	S	ZD			150						48.5/.2	10
1N1322A	S	ZD			150						48.5/.2	5
1N1323	S	ZD			150						58/.2	10
1N1323A	S	ZD			150						58/.2	5
1N1324	S	ZD			150						71/.2	10
1N1324A	S	ZD			150						71/.2	5
1N1325	S	ZD			150						87/.2	10
1N1325A	S	ZD			150						87/.2	5
1N1326	S	ZD			150						105/.2	10
1N1326A	S	ZD			150						105/.2	5
1N1327	S	ZD			150						128/.2	10
1N1327A	S	ZD			150						128/.2	5
1N1329	S	RE				1.5K	.1	20/	1.3/100			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1406	S	RE		1N4005		600	.125	10/600	5/			
1N1407	S	RE		1N4006		800	.125	10/800	5/			
1N1408	S	RE		1N4007		1K	.125	10/1K	5/			
1N1409	S	RE				1.2K	.125	10/1.2K	5/			
1N1410	S	RE				1.5K	.125	10/1.5K	6.2/			
1N1411	S	RE				1.8K	.125	10/1.8K	7.5/			
1N1412	S	RE				2K	.125	10/2K	6.2/			
1N1413	S	RE				2.4K	.125	10/2.4K	7.5/			
1N1415	S	SD		1N4004		400	1	2/320	1.1/1A			
1N1425	S	ZD		1N4738A	1W						8.2/20	5
1N1426	S	ZD		1N4742A	1W						12/20	5
1N1427	S	ZD		1N4744A	1W						15/10	5
1N1428	S	ZD		1N4746A	1W						18/10	5
1N1429	S	ZD		1N4748A	1W						22/10	5
1N1430	S	ZD		1N4750A	1W						27/5	5
1N1431	S	ZD			1W						68/2	5
1N1432	S	ZD			1W						100/2	5
1N1433	S	ZD			1W						150/1	5
1N1440	S	RE		1N4003		200	.75	500/	1.2/750			
1N1441	S	RE		1N4004		300	.75	500/	1.2/750			
1N1442	S	RE		1N4004		400	.75	500/	1.2/750			
1N1443	S	RE				1K	1.6	1M/	1/			
1N1443A	S	RE				1K	1.1	500/	1.4/			
1N1443B	S	RE				1K	1.1	300/	1.5/			
1N1444	S	RE				1K	1.6	1M/	1/			
1N1444A	S	RE				1K	1.6	50/	1.2/			
1N1444B	S	RE				1K	1.6	10/	1.2/			
1N1445	S	RE				360	.2	4M/	2/			
1N1446	S	RE				100	1.8	2M/	2/			
1N1447	S	RE				200	1.8	2M/	2/			
1N1448	S	RE				300	1.8	2M/	1.4/			
1N1449	S	RE				400	1.8	2M/	2/			
1N1450	S	RE				100	1.8	5M/	1.4/			
1N1451	S	RE				200	1.8	5M/	1.4/			
1N1452	S	RE				300	1.8	5M/	1.4/			
1N1453	S	RE				400	1.8	5M/	1.4/			
1N1484	S	ZD		1N4732A	1W						4.7/50	5
1N1485	S	ZD		1N4735A	1W						6.2/50	5
1N1486	S	RE		1N4006		500	.5	400/500	.55/250			
1N1487	S	RE		1N4002		100	.75	300/100	.55/250			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1488	S	RE		1N4003		200	.75	300/200	.55/250			
1N1489	S	RE		1N4004		300	.75	300/300	.55/250			
1N1490	S	RE		1N4004		400	.75	300/400	.55/250			
1N1491	S	RE		1N4005		500	.75	300/500	.55/250			
1N1492	S	RE		1N4005		600	.75	300/600	.55/250			
1N1507	S	ZD		1N4730	750						3.9/35	10
1N1507A	S	ZD		1N4730A	750						3.9/35	5
1N1508	S	ZD		1N4732	750						4.7/30	10
1N1508A	S	ZD		1N4732A	750						4.7/30	5
1N1509	S	ZD		1N4734	750						5.6/25	10
1N1509A	S	ZD		1N4734A	750						5.6/25	5
1N1510	S	ZD		1N4736	750						6.8/22	10
1N1510A	S	ZD		1N4736A	750						6.8/22	5
1N1511	S	ZD		1N4738	750						8.2/18	10
1N1511A	S	ZD		1N4738A	750						8.2/18	5
1N1512	S	ZD		1N4740	750						10/15	10
1N1512A	S	ZD		1N4740A	750						10/15	5
1N1513	S	ZD		1N4742	750						12/12	10
1N1513A	S	ZD		1N4742A	750						12/12	5
1N1514	S	ZD		1N4744	750						15/10	10
1N1514A	S	ZD		1N4744A	750						15/10	5
1N1515	S	ZD		1N4746	750						18/8	10
1N1515A	S	ZD		1N4746A	750						18/8	5
1N1516	S	ZD		1N4748	750						22/6	10
1N1516A	S	ZD		1N4748A	750						22/6	5
1N1517	S	ZD		1N4750	750						27/5	10
1N1517A	S	ZD		1N4750A	750						27/5	5
1N1518	S	ZD		1N4730	1W						3.9/50	10
1N1518A	S	ZD		1N4730A	1W						3.9/50	5
1N1519	S	ZD		1N4732	1W						4.7/40	10
1N1519A	S	ZD		1N4732A	1W						4.7/40	5
1N1520	S	ZD		1N4734	1W						5.6/35	10
1N1520A	S	ZD		1N4734A	1W						5.6/35	5
1N1521	S	ZD		1N4736	1W						6.8/30	10
1N1521A	S	ZD		1N4736A	1W						6.8/30	5
1N1522	S	ZD		1N4738	1W						8.2/25	10
1N1522A	S	ZD		1N4738A	1W						8.2/25	5
1N1523	S	ZD		1N4740	1W						10/20	10
1N1523A	S	ZD		1N4740A	1W						10/20	5
1N1524	S	ZD		1N4742	1W						12/15	10

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1524A	S	ZD		1N4742A	1W						12/15	5
1N1525	S	ZD		1N4744	1W						15/13	10
1N1525A	S	ZD		1N4744A	1W						15/13	5
1N1526	S	ZD		1N4746	1W						18/10	10
1N1526A	S	ZD		1N4746A	1W						18/10	5
1N1527	S	ZD		1N4747	1W						22/9	10
1N1527A	S	ZD		1N4747A	1W						22/9	5
1N1528	S	ZD		1N4748	1W						27/7	10
1N1528A	S	ZD		1N4748A	1W						27/7	5
1N1537	S	RE				50	1.6	50/	1.5/			
1N1538	S	RE				100	1.6	50/	1.5/			
1N1539	S	RE				150	1.6	50/	1.5/			
1N1540	S	RE				200	1.6	50/	1.5/			
1N1541	S	RE				300	1.6	50/	1.5/			
1N1542	S	RE				400	1.6	50/	1.5/			
1N1543	S	RE				500	1.6	50/	1.5/			
1N1544	S	RE				600	1.6	50/	1.5/			
1N1551	S	RE				100	1	1M/	1.4/			
1N1552	S	RE				200	1	1M/	1.4/			
1N1553	S	RE				300	1	1M/	1.4/			
1N1554	S	RE				400	1	1M/	1.4/			
1N1555	S	RE				500	1	1M/	1.4/			
1N1556	S	RE				100	.75	1M/	1.4/			
1N1557	S	RE				200	.75	1M/	1.4/			
1N1558	S	RE				300	.75	1M/	1.4/			
1N1559	S	RE				400	.75	1M/	1.4/			
1N1560	S	RE				500	.75	1M/	1.4/			
1N1561	G	SD		1N4305		25		25/20	.4/12			
1N1562	G	SD		1N4305		25		25/20	.4/8			
1N1563	S	RE		TID382		100	1	3/100	1.5/500			
1N1563A	S	RE		TID382		100	1.5	3/100	1.5/500			
1N1564	S	RE		TID383		200	1	3/200	1.5/500			
1N1564A	S	RE		TID383		200	1.5	3/200	1.5/500			
1N1565	S	RE		TID384		300	1	3/300	1.5/500			
1N1565A	S	RE		TID384		300	1.5	3/300	1.5/500			
1N1566	S	RE		TID384		400	1	3/400	1.5/500			
1N1566A	S	RE		TID384		400	1.5	3/400	1.5/500			
1N1567	S	RE		TID385		500	1	5/500	1.2/500			
1N1567A	S	RE		TID385		500	1.5	3/500	1.5/500			
1N1568	S	RE		TID385		600	1	5/600	1.2/500			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1568A	S	RE		TID385		600	1.5	3/600	1.5/500			
1N1577	S	RE				300	3.5	5/	1.5/			
1N1578	S	RE				400	3.5	5/	1.5/			
1N1579	S	RE				500	3.5	5/	1.5/			
1N1580	S	RE				600	3.5	5/	1.5/			
1N1581	S	RE				50	3	5M/	1.5/			
1N1582	S	RE				100	3	5M/	1.5/			
1N1583	S	RE				200	3	5M/	1.5/			
1N1584	S	RE				300	3	5M/	1.5/			
1N1585	S	RE				400	3	5M/	1.5/			
1N1586	S	RE				500	3	5M/	1.5/			
1N1587	S	RE				600	3	5M/	1.5/			
1N1612	S	RE				50	5		1.5/10A			
1N1612A	S	RE				50	5		1.1/6A			
1N1612R	S	RE				50	7		.7/1A			
1N1613	S	RE				100	5		1.5/10A			
1N1613A	S	RE				100	5		1.1/6A			
1N1613R	S	RE				100	7		.7/1A			
1N1614	S	RE				200	5		1.5/10A			
1N1614A	S	RE				200	5		1.1/6A			
1N1614R	S	RE				200	7		.7/1A			
1N1615	S	RE				400	5		1.5/10A			
1N1615A	S	RE				400	5		1.1/6A			
1N1615R	S	RE				400	7		.7/1A			
1N1616	S	RE				600	5		1.5/10A			
1N1616A	S	RE				600	5		1.1/6A			
1N1616R	S	RE				600	7		.7/1A			
1N1617	S	RE				100	1.5		1.2/			
1N1618	S	RE				200	1.5		1.2/			
1N1619	S	RE				300	1.5		1.2/			
1N1620	S	RE				400	1.5		1.2/			
1N1644	S	RE		1N4001		50	.25	400/50	.5/250			
1N1645	S	RE		1N4002		100	.25	400/100	.5/250			
1N1646	S	RE		1N4003		150	.25	300/150	.5/250			
1N1647	S	RE		1N4003		200	.25	300/200	.5/250			
1N1648	S	RE		1N4004		250	.25	300/250	.5/250			
1N1649	S	RE		1N4004		300	.25	300/300	.5/250			
1N1650	S	RE		1N4004		350	.25	300/350	.5/250			
1N1651	S	RE		1N4004		400	.25	300/400	.5/250			
1N1652	S	RE		1N4005		500	.25	300/500	.5/250			

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R μA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1653	S	RE		1N4005		600	.25	300/600	.5/250			
1N1692	S	RE		1N4002		100	.25	500/100	.6/250			
1N1693	S	RE		1N4003		200	.25	500/200	.6/250			
1N1694	S	RE		1N4004		300	.25	500/300	.6/250			
1N1695	S	RE		1N4004		400	.25	500/400	.6/250			
1N1696	S	RE		1N4005		500	.6	500/500	.6/250			
1N1697	S	RE		1N4005		600	.6	500/600	.6/250			
1N1698	S	RE				6.6K	.062		33/68			
1N1699	S	RE				10K	.058		37/58			
1N1700	S	RE				12K	.05		45/50			
1N1701	S	RE		1N4001		50	.3	200/50	1.3/300			
1N1702	S	RE		1N4002		100	.3	200/100	1.3/300			
1N1703	S	RE		1N4003		200	.3	200/200	1.3/300			
1N1704	S	RE		1N4004		300	.3	200/300	1.3/300			
1N1705	S	RE		1N4004		400	.3	200/400	1.3/300			
1N1706	S	RE		1N4005		500	.3	200/500	1.3/300			
1N1707	S	RE		1N4001		50	.5	200/50	1.1/500			
1N1708	S	RE		1N4002		100	.5	200/100	1.1/500			
1N1709	S	RE		1N4003		200	.5	200/200	1.1/500			
1N1710	S	RE		1N4004		300	.5	200/300	1.1/500			
1N1711	S	RE		1N4004		400	.5	200/400	1.1/500			
1N1712	S	RE		1N4005		500	.5	200/500	1.1/500			
1N1730	S	RE		1N4007		1K	.2	10/1K	5/100			
1N1730A	S	RE		1N4007		1K	.35	1/1K	3/400			
1N1731	S	RE				1.5K	.2	10/1.5K	5/100			
1N1731A	S	RE				1.5K	.35	1/1.5K	3/400			
1N1732	S	RE				2K	.2	10/2K	9/100			
1N1732A	S	RE				2K	.5	1/2K	3/400			
1N1733	S	RE				3K	.15	10/3K	12/100			
1N1733A	S	RE				3K	.5	1/3K	6/400			
1N1734	S	RE				5K	.1	10/5K	18/100			
1N1734A	S	RE				5K	.5	1/5K	8/400			
1N1735	S	RD			200						6.2/7.5	5
1N1736	S	RD			400						12.4/7.5	5
1N1736A	S	RD			400						12.4/7.5	5
1N1737	S	RD			600						18.6/7.5	5
1N1737A	S	RD			600						18.6/7.5	5
1N1738	S	RD			800						24.8/7.5	5
1N1738A	S	RD			800						24.8/7.5	5
1N1739	S	RD			1W						31/7.5	5

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1739A	S	RD			1W						31/7.5	5
1N1740	S	RD			1.2W						37.2/7.5	5
1N1740A	S	RD			1.2W						37.2/7.5	5
1N1741	S	RD			1.4W						43.4/7.5	5
1N1741A	S	RD			1.4W						43.4/7.5	5
1N1742	S	RD			1.6W						49.6/7.5	5
1N1742A	S	RD			1.6W						49.6/7.5	5
1N1745	S	RE				1.5K	.38	25/1.5K	15/600			
1N1746	S	RE				1.5K	.44	25/1.5K	7.5/700			
1N1747	S	RE				1.8K	.36	25/1.8K	18/600			
1N1748	S	RE				1.8K	.42	25/1.8K	9/700			
1N1749	S	RE				2.4K	.32	25/2.4K	24/600			
1N1750	S	RE				2.4K	.38	25/2.4K	12/600			
1N1751	S	RE				3.6K	.37	25/3.6K	27/600			
1N1752	S	RE				3.6K	.36	25/3.6K	18/600			
1N1753	S	RE				4.8K	.38	25/4.8K	36/600			
1N1754	S	RE				4.8K	.37	25/4.8K	24/600			
1N1755	S	RE				6K	.33	25/6K	45/500			
1N1756	S	RE				6K	.41	25/6K	30/600			
1N1757	S	RE				7.2K	.33	25/7.2K	54/500			
1N1758	S	RE				7.2K	.38	25/7.2K	36/600			
1N1759	S	RE				8K	.29	25/8K	60/400			
1N1760	S	RE				12K	.29	25/12K	60/400			
1N1761	S	RE				14K	.34	25/14K	52/500			
1N1762	S	RE				16K	.29	25/16K	60/400			
1N1763	S	RE		TID384		400	.5	100/	3/			
1N1763A	S	RE		TID384		400	1	500/	1.2/			
1N1764	S	RE		TID385		500	.5	100/	3/			
1N1764A	S	RE		TID385		500	1	500/	1.2/			
1N1765	S	ZD		1N4734	1W						5.6/100	10
1N1765A	S	ZD		1N4734A	1W						5.6/100	5
1N1766	S	ZD		1N4735	1W						6.2/100	10
1N1766A	S	ZD		1N4735A	1W						6.2/100	5
1N1767	S	ZD		1N4736	1W						6.8/100	10
1N1767A	S	ZD		1N4736A	1W						6.8/100	5
1N1768	S	ZD		1N4737	1W						7.5/100	10
1N1768A	S	ZD		1N4737A	1W						7.5/100	5
1N1769	S	ZD		1N4738	1W						8.2/100	10
1N1769A	S	ZD		1N4738A	1W						8.2/100	5
1N1770	S	ZD		1N4739	1W						9.1/50	10

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1770A	S	ZD		1N4739A	1W								9.1/50	5
1N1771	S	ZD		1N4740	1W								10/50	10
1N1771A	S	ZD		1N4740A	1W								10/50	5
1N1772	S	ZD		1N4741	1W								11/50	10
1N1772A	S	ZD		1N4741A	1W								11/50	5
1N1773	S	ZD		1N4742	1W								12/50	10
1N1773A	S	ZD		1N4742A	1W								12/50	5
1N1774	S	ZD		1N4743	1W								13/50	10
1N1774A	S	ZD		1N4743A	1W								13/50	5
1N1775	S	ZD		1N4744	1W								15/50	10
1N1775A	S	ZD		1N4744A	1W								15/50	5
1N1776	S	ZD		1N4745	1W								16/50	10
1N1776A	S	ZD		1N4745A	1W								16/50	5
1N1777	S	ZD		1N4746	1W								18/50	10
1N1777A	S	ZD		1N4746A	1W								18/50	5
1N1778	S	ZD		1N4747	1W								20/15	10
1N1778A	S	ZD		1N4747A	1W								20/15	5
1N1779	S	ZD		1N4748	1W								22/15	10
1N1779A	S	ZD		1N4748A	1W								22/15	5
1N1780	S	ZD		1N4749	1W								24/15	10
1N1780A	S	ZD		1N4749A	1W								24/15	5
1N1781	S	ZD		1N4750	1W								27/15	10
1N1781A	S	ZD		1N4750A	1W								27/15	5
1N1782	S	ZD		1N4751	1W								30/15	10
1N1782A	S	ZD		1N4751A	1W								30/15	5
1N1783	S	ZD		1N4752	1W								33/15	10
1N1783A	S	ZD		1N4752A	1W								33/15	5
1N1784	S	ZD			1W								36/15	10
1N1784A	S	ZD			1W								36/15	5
1N1785	S	ZD			1W								39/15	10
1N1785A	S	ZD			1W								39/15	5
1N1786	S	ZD			1W								43/15	10
1N1786A	S	ZD			1W								43/15	5
1N1787	S	ZD			1W								47/15	10
1N1787A	S	ZD			1W								47/15	5
1N1788	S	ZD			1W								51/15	10
1N1788A	S	ZD			1W								51/15	5
1N1789	S	ZD			1W								56/15	10
1N1789A	S	ZD			1W								56/15	5
1N1790	S	ZD			1W								62/5	10

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1790A	S	ZD			1W						62/5	5
1N1791	S	ZD			1W						68/5	10
1N1791A	S	ZD			1W						68/5	5
1N1792	S	ZD			1W						75/5	10
1N1792A	S	ZD			1W						75/5	5
1N1793	S	ZD			1W						82/5	10
1N1793A	S	ZD			1W						82/5	5
1N1794	S	ZD			1W						91/5	10
1N1794A	S	ZD			1W						91/5	5
1N1795	S	ZD			1W						100/5	10
1N1795A	S	ZD			1W						100/5	5
1N1796	S	ZD			1W						110/5	10
1N1796A	S	ZD			1W						110/5	5
1N1797	S	ZD			1W						120/5	10
1N1797A	S	ZD			1W						120/5	5
1N1798	S	ZD			1W						130/5	10
1N1798A	S	ZD			1W						130/5	5
1N1799	S	ZD			1W						150/5	10
1N1799A	S	ZD			1W						150/5	5
1N1800	S	ZD			1W						160/5	10
1N1800A	S	ZD			1W						160/5	5
1N1801	S	ZD			1W						180/5	10
1N1801A	S	ZD			1W						180/5	5
1N1802	S	ZD			1W						200/5	10
1N1802A	S	ZD			1W						200/5	5
1N1839	S	RE				6.8	.085	.5/6.8	1/50			
1N1840	S	RE				10	.077	.5/10	1/35			
1N1841	S	RE				15	.063	.5/15	1/23			
1N1842	S	RE				22	.05	.1/22	1/12			
1N1843	S	RE				33	.04	.1/33	1/7			
1N1844	S	RE				47	.03	.1/47	1/4.5			
1N1845	S	RE				68	.023	1/68	1/2.7			
1N1846	S	RE				100	.016	1/100	1/1.5			
1N1847	S	RE				150	.011	3/150	1/1			
1N1848	S	RE				220	.009	5/220	4/6.5			
1N1849	S	RE				330	.007	5/330	4/3			
1N1850	S	RE				470	.006	5/470	4/2			
1N1851	S	RE				6.8	.085	.5/6.8	1/50			
1N1852	S	RE				10	.077	.5/10	1/35			
1N1853	S	RE				15	.063	.5/15	1/23			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R ● V_R µA / (V)	V_F ● I_F (V) / (mA)	t_{rr} (ns)	V_Z ● I_Z (V) / (mA)	TOL %
1N1854	S	RE				22	.05	.1/22	1/12			
1N1855	S	RE				33	.04	.1/33	1/7			
1N1856	S	RE				47	.03	.1/47	1/4.5			
1N1857	S	RE				68	.023	1/68	1/2.7			
1N1858	S	RE				100	.016	1/100	1/1.5			
1N1859	S	RE				150	.011	3/150	1/1			
1N1860	S	RE				220	.009	5/220	4/6.5			
1N1861	S	RE				330	.007	5/330	4/3			
1N1862	S	RE				470	.006	5/470	4/2			
1N1863	S	RE				6.8	.085	.5/6.8	1/50			
1N1864	S	RE				10	.077	.5/10	1/35			
1N1865	S	RE				15	.063	.5/15	1/23			
1N1866	S	RE				22	.05	.1/22	1/12			
1N1867	S	RE				33	.04	.1/33	1/7			
1N1868	S	RE				47	.03	.1/47	1/4.5			
1N1869	S	RE				68	.023	1/68	1/2.7			
1N1870	S	RE				100	.016	1/100	1/1.5			
1N1871	S	RE				150	.011	3/150	1/1			
1N1872	S	RE				220	.009	5/220	4/6.5			
1N1873	S	RE				330	.007	5/330	4/3			
1N1874	S	RE				470	.006	5/470	4/2			
1N1875	S	ZD		1N4738	1W						8.2/25	10
1N1875A	S	ZD		1N4738A	1W						8.2/25	5
1N1875B	S	ZD			1W						8.2/25	1
1N1876	S	ZD		1N4740	1W						10/25	10
1N1876A	S	ZD		1N4740A	1W						10/25	5
1N1876B	S	ZD			1W						10/25	1
1N1877	S	ZD		1N4742	1W						12/25	10
1N1877A	S	ZD		1N4742A	1W						12/25	5
1N1877B	S	ZD			1W						12/25	1
1N1878	S	ZD		1N4744	1W						15/25	10
1N1878A	S	ZD		1N4744A	1W						15/25	5
1N1878B	S	ZD			1W						15/25	1
1N1879	S	ZD		1N4746	1W						18/25	10
1N1879A	S	ZD		1N4746A	1W						18/25	5
1N1879B	S	ZD			1W						18/25	1
1N1880	S	ZD		1N4748	1W						22/8	10
1N1880A	S	ZD		1N4748A	1W						22/8	5
1N1880B	S	ZD			1W						22/8	1
1N1881	S	ZD		1N4750	1W						27/8	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1881A	S	ZD		1N4750A	1W						27/8	5
1N1881B	S	ZD			1W						27/8	1
1N1882	S	ZD		1N4752	1W						33/8	10
1N1882A	S	ZD		1N4752A	1W						33/8	5
1N1882B	S	ZD			1W						33/8	1
1N1883	S	ZD			1W						39/8	10
1N1883A	S	ZD			1W						39/8	5
1N1883B	S	ZD			1W						39/8	1
1N1884	S	ZD			1W						47/8	10
1N1884A	S	ZD			1W						47/8	5
1N1884B	S	ZD			1W						47/8	1
1N1885	S	ZD			1W						56/8	10
1N1885A	S	ZD			1W						56/8	5
1N1885B	S	ZD			1W						56/8	1
1N1886	S	ZD			1W						68/3	10
1N1886A	S	ZD			1W						68/3	5
1N1886B	S	ZD			1W						68/3	1
1N1887	S	ZD			1W						82/3	10
1N1887A	S	ZD			1W						82/3	5
1N1887B	S	ZD			1W						82/3	1
1N1888	S	ZD			1W						100/3	10
1N1888A	S	ZD			1W						100/3	5
1N1888B	S	ZD			1W						100/3	1
1N1889	S	ZD			1W						120/3	10
1N1889A	S	ZD			1W						120/3	5
1N1889B	S	ZD			1W						120/3	1
1N1890	S	ZD			1W						150/3	10
1N1890A	S	ZD			1W						150/3	5
1N1890B	S	ZD			1W						150/3	1
1N1907	S	RE		1N4001		50	1.5	10/50	1/1			
1N1908	S	RE		1N4002		100	1.5	10/100	1/1			
1N1909	S	RE		1N4003		200	1.5	10/200	1/1			
1N1910	S	RE		1N4004		300	1.5	10/300	1/1			
1N1911	S	RE		1N4004		400	1.5	10/400	1/1			
1N1912	S	RE		1N4005		500	1.5	10/500	1/1			
1N1913	S	RE		1N4005		600	1.5	10/600	1/1			
1N1914	S	RE		1N4006		700	1.5	10/700	1/1			
1N1915	S	RE		1N4006		800	1.5	10/800	1/1			
1N1916	S	RE		1N4007		900	1.5	10/900	1/1			
1N1917	S	RE				50	4	10/50	1/1			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1918	S	RE				100	4	10/100	1/1			
1N1919	S	RE				200	4	10/200	1/1			
1N1920	S	RE				300	4	10/300	1/1			
1N1921	S	RE				400	4	10/400	1/1			
1N1922	S	RE				500	4	10/500	1/1			
1N1923	S	RE				600	4	10/600	1/1			
1N1924	S	RE				700	4	10/700	1/1			
1N1925	S	RE				800	4	10/800	1/1			
1N1926	S	RE				900	4	10/900	1/1			
1N1927	S	ZD		1N5228A	200						3.9/5	10
1N1927A	S	ZD		1N5228B	200						3.9/5	5
1N1927B	S	ZD			200						3.9/5	1
1N1928	S	ZD		1N5230A	200						4.7/5	10
1N1928A	S	ZD		1N5230B	200						4.7/5	5
1N1928B	S	ZD			200						4.7/5	1
1N1929	S	ZD		1N5232A	200						5.6/5	10
1N1929A	S	ZD		1N5232B	200						5.6/5	5
1N1929B	S	ZD			200						5.6/5	1
1N1930	S	ZD		1N5235A	200						6.8/5	10
1N1930A	S	ZD		1N5235B	200						6.8/5	5
1N1930B	S	ZD			200						6.8/5	1
1N1931	S	ZD		1N5237A	200						8.2/5	10
1N1931A	S	ZD		1N5237B	200						8.2/5	5
1N1931B	S	ZD			200						8.2/5	1
1N1932	S	ZD		1N5240A	200						10/5	10
1N1932A	S	ZD		1N5240B	200						10/5	5
1N1932B	S	ZD			200						10/5	1
1N1933	S	ZD		1N5242A	200						12/1	10
1N1933A	S	ZD		1N5242B	200						12/1	5
1N1933B	S	ZD			200						12/1	1
1N1934	S	ZD		1N5245A	200						15/1	10
1N1934A	S	ZD		1N5245B	200						15/1	5
1N1934B	S	ZD			200						15/1	1
1N1935	S	ZD		1N5248A	200						18/1	10
1N1935A	S	ZD		1N5248B	200						18/1	5
1N1935B	S	ZD			200						18/1	1
1N1936	S	ZD		1N5251A	200						22/1	10
1N1936A	S	ZD		1N5251B	200						22/1	5
1N1936B	S	ZD			200						22/1	1
1N1937	S	ZD		1N5254A	200						27/1	10

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1937A	S	ZD		1N5254B	200						27/1	5
1N1937B	S	ZD			200						27/1	1
1N1938	S	ZD		1N5257A	200						33/.2	10
1N1938A	S	ZD		1N5257B	200						33/.2	5
1N1938B	S	ZD			200						33/.2	1
1N1939	S	ZD			200						39/.2	10
1N1939A	S	ZD			200						39/.2	5
1N1939B	S	ZD			200						39/.2	1
1N1940	S	ZD			200						47/.2	10
1N1940A	S	ZD			200						47/.2	5
1N1940B	S	ZD			200						47/.2	1
1N1941	S	ZD			200						56/.2	10
1N1941A	S	ZD			200						56/.2	5
1N1941B	S	ZD			200						56/.2	1
1N1942	S	ZD			200						68/.2	10
1N1942A	S	ZD			200						68/.2	5
1N1942B	S	ZD			200						68/.2	1
1N1943	S	ZD			200						82/.2	10
1N1943A	S	ZD			200						82/.2	5
1N1943B	S	ZD			200						82/.2	1
1N1944	S	ZD			200						100/.2	10
1N1944A	S	ZD			200						100/.2	5
1N1944B	S	ZD			200						100/.2	1
1N1945	S	ZD			200						120/.2	10
1N1945A	S	ZD			200						120/.2	5
1N1945B	S	ZD			200						120/.2	1
1N1946	S	ZD			200						150/.1	10
1N1946A	S	ZD			200						150/.1	5
1N1946B	S	ZD			200						150/.1	1
1N1947	S	ZD			200						180/.1	10
1N1947A	S	ZD			200						180/.1	5
1N1947B	S	ZD			200						180/.1	1
1N1948	S	ZD			200						220/.1	10
1N1948A	S	ZD			200						220/.1	5
1N1948B	S	ZD			200						220/.1	1
1N1949	S	ZD			200						270/.1	10
1N1949A	S	ZD			200						270/.1	5
1N1949B	S	ZD			200						270/.1	1
1N1950	S	ZD			200						330/.1	10
1N1950A	S	ZD			200						330/.1	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R μA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N1950B	S	ZD			200						330/.1	1
1N1951	S	ZD			200						390/.1	10
1N1951A	S	ZD			200						390/.1	5
1N1951B	S	ZD			200						390/.1	1
1N1952	S	ZD			200						470/.1	10
1N1952A	S	ZD			200						470/.1	5
1N1952B	S	ZD			200						470/.1	1
1N1953	S	ZD			200						560/.1	10
1N1953A	S	ZD			200						560/.1	5
1N1953B	S	ZD			200						560/.1	1
1N1954	S	ZD		1N5228A	400						3.9/5	10
1N1954A	S	ZD		1N5228B	400						3.9/5	5
1N1954B	S	ZD			400						3.9/5	1
1N1955	S	ZD		1N5230A	400						4.7/5	10
1N1955A	S	ZD		1N5230B	400						4.7/5	5
1N1955B	S	ZD			400						4.7/5	1
1N1956	S	ZD		1N5232A	400						5.6/5	10
1N1956A	S	ZD		1N5232B	400						5.6/5	5
1N1956B	S	ZD			400						5.6/5	1
1N1957	S	ZD		1N5235A	400						6.8/5	10
1N1957A	S	ZD		1N5235B	400						6.8/5	5
1N1957B	S	ZD			400						6.8/5	1
1N1958	S	ZD		1N5237A	400						8.2/5	10
1N1958A	S	ZD		1N5237B	400						8.2/5	5
1N1958B	S	ZD			400						8.2/5	1
1N1959	S	ZD		1N5240A	400						10/5	10
1N1959A	S	ZD		1N5240B	400						10/5	5
1N1959B	S	ZD			400						10/5	1
1N1960	S	ZD		1N5242A	400						12/1	10
1N1960A	S	ZD		1N5242B	400						12/1	5
1N1960B	S	ZD			400						12/1	1
1N1961	S	ZD		1N5245A	400						15/1	10
1N1961A	S	ZD		1N5245B	400						15/1	5
1N1961B	S	ZD			400						15/1	1
1N1962	S	ZD		1N5248A	400						18/1	10
1N1962A	S	ZD		1N5248B	400						18/1	5
1N1962B	S	ZD			400						18/1	1
1N1963	S	ZD		1N5251A	400						22/1	10
1N1963A	S	ZD		1N5251B	400						22/1	5
1N1963B	S	ZD			400						22/1	1

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N1964	S	ZD		1N5254A	400								27/1	10
1N1964A	S	ZD		1N5254B	400								27/1	5
1N1964B	S	ZD			400								27/1	1
1N1965	S	ZD		1N5257A	400								33/.2	10
1N1965A	S	ZD		1N5257B	400								33/.2	5
1N1965B	S	ZD			400								33/.2	1
1N1966	S	ZD			400								39/.2	10
1N1966A	S	ZD			400								39/.2	5
1N1966B	S	ZD			400								39/.2	1
1N1967	S	ZD			400								47/.2	10
1N1967A	S	ZD			400								47/.2	5
1N1967B	S	ZD			400								47/.2	1
1N1968	S	ZD			400								56/.2	10
1N1968A	S	ZD			400								56/.2	5
1N1968B	S	ZD			400								56/.2	1
1N1969	S	ZD			400								68/.2	10
1N1969A	S	ZD			400								68/.2	5
1N1969B	S	ZD			400								68/.2	1
1N1970	S	ZD			400								82/.2	10
1N1970A	S	ZD			400								82/.2	5
1N1970B	S	ZD			400								82/.2	1
1N1971	S	ZD			400								100/.1	10
1N1971A	S	ZD			400								100/.1	5
1N1971B	S	ZD			400								100/.1	1
1N1972	S	ZD			400								120/.1	10
1N1972A	S	ZD			400								120/.1	5
1N1972B	S	ZD			400								120/.1	1
1N1973	S	ZD			400								150/.1	10
1N1973A	S	ZD			400								150/.1	5
1N1973B	S	ZD			400								150/.1	1
1N1974	S	ZD			400								180/.1	10
1N1974A	S	ZD			400								180/.1	5
1N1974B	S	ZD			400								180/.1	1
1N1975	S	ZD			400								200/.1	10
1N1975A	S	ZD			400								200/.1	5
1N1975B	S	ZD			400								200/.1	1
1N1976	S	ZD			400								270/.1	10
1N1976A	S	ZD			400								270/.1	5
1N1976B	S	ZD			400								270/.1	1
1N1977	S	ZD			400								330/.1	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1977A	S	ZD			400						330/.1	5
1N1977B	S	ZD			400						330/.1	1
1N1978	S	ZD			400						390/.1	10
1N1978A	S	ZD			400						390/.1	5
1N1978B	S	ZD			400						390/.1	1
1N1979	S	ZD			400						470/.1	10
1N1979A	S	ZD			400						470/.1	5
1N1979B	S	ZD			400						470/.1	1
1N1980	S	ZD			400						560/.1	10
1N1980A	S	ZD			400						560/.1	5
1N1980B	S	ZD			400						560/.1	1
1N1981	S	ZD		1N5228A	150						3.9/5	10
1N1981A	S	ZD		1N5228B	150						3.9/5	5
1N1981B	S	ZD			150						3.9/5	1
1N1982	S	ZD		1N5230A	150						4.7/5	10
1N1982A	S	ZD		1N5230B	150						4.7/5	5
1N1982B	S	ZD			150						4.7/5	1
1N1983	S	ZD		1N5232A	150						5.6/5	10
1N1983A	S	ZD		1N5232B	150						5.6/5	5
1N1983B	S	ZD			150						5.6/5	1
1N1984	S	ZD		1N5235A	150						6.8/5	10
1N1984A	S	ZD		1N5235B	150						6.8/5	5
1N1984B	S	ZD			150						6.8/5	1
1N1985	S	ZD		1N5237A	150						8.2/5	10
1N1985A	S	ZD		1N5237B	150						8.2/5	5
1N1985B	S	ZD			150						8.2/5	1
1N1986	S	ZD		1N5240A	150						10/5	10
1N1986A	S	ZD		1N5240B	150						10/5	5
1N1986B	S	ZD			150						10/5	1
1N1987	S	ZD		1N5242A	150						12/1	10
1N1987A	S	ZD		1N5242B	150						12/1	5
1N1987B	S	ZD			150						12/1	1
1N1988	S	ZD		1N5245A	150						15/1	10
1N1988A	S	ZD		1N5245B	150						15/1	5
1N1988B	S	ZD			150						15/1	1
1N1989	S	ZD		1N5248A	150						18/1	10
1N1989A	S	ZD		1N5248B	150						18/1	5
1N1989B	S	ZD			150						18/1	1
1N1990	S	ZD		1N5251A	150						22/1	10
1N1990A	S	ZD		1N5251B	150						22/1	5

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N1990B	S	ZD			150						22/1	1
1N1991	S	ZD		1N5254A	150						27/1	10
1N1991A	S	ZD		1N5254B	150						27/1	5
1N1991B	S	ZD			150						27/1	1
1N1992	S	ZD		1N5257A	150						33/.2	10
1N1992A	S	ZD		1N5257B	150						33/.2	5
1N1992B	S	ZD			150						33/.2	1
1N1993	S	ZD			150						39/.2	10
1N1993A	S	ZD			150						39/.2	5
1N1993B	S	ZD			150						39/.2	1
1N1994	S	ZD			150						47/.2	10
1N1994A	S	ZD			150						47/.2	5
1N1994B	S	ZD			150						47/.2	1
1N1995	S	ZD			150						56/.2	10
1N1995A	S	ZD			150						56/.2	5
1N1995B	S	ZD			150						56/.2	1
1N1995B	S	ZD			150						56/.2	1
1N2000	S	ZD			150						150/.1	10
1N2000A	S	ZD			150						150/.1	5
1N2000B	S	ZD			150						150/.1	1
1N2001	S	ZD			150						180/.1	10
1N2001A	S	ZD			150						180/.1	5
1N2001B	S	ZD			150						180/.1	1
1N2002	S	ZD			150						220/.1	10
1N2002A	S	ZD			150						220/.1	5
1N2002B	S	ZD			150						220/.1	1
1N2003	S	ZD			150						270/.1	10
1N2003A	S	ZD			150						270/.1	5
1N2003B	S	ZD			150						270/.1	1
1N2004	S	ZD			150						330/.1	10
1N2004A	S	ZD			150						330/.1	5
1N2004B	S	ZD			150						330/.1	1
1N2005	S	ZD			150						390/.1	10
1N2005A	S	ZD			150						390/.1	5
1N2005B	S	ZD			150						390/.1	1
1N2006	S	ZD			150						470/.1	10
1N2006A	S	ZD			150						470/.1	5
1N2006B	S	ZD			150						470/.1	1
1N2007	S	ZD			150						560/.1	10
1N2007A	S	ZD			150						560/.1	5

TEXAS INSTRUMENTS
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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2007B	S	ZD			150						560/.1	1
1N2013	S	RE		1N4001		50	.2	1/50	1.5/500			
1N2014	S	RE		1N4002		100	.2	1/100	1.5/500			
1N2015	S	RE		1N4003		150	.2	1/150	1.5/500			
1N2016	S	RE		1N4003		200	.2	1/200	1.5/500			
1N2017	S	RE		1N4004		250	.2	1/250	1.5/500			
1N2018	S	RE		1N4004		300	.2	1/300	1.5/500			
1N2019	S	RE		1N4004		350	.2	1/350	1.5/500			
1N2020	S	RE		1N4004		400	.2	1/400	1.5/500			
1N2021	S	RE				150	10	5M/	1.5/			
1N2022	S	RE				250	10	5M/	1.5/			
1N2023	S	RE				300	10	5M/	1.5/			
1N2024	S	RE				350	10	5M/	1.5/			
1N2025	S	RE				400	10	5M/	1.5/			
1N2026	S	RE				50	1	500/	2.0/			
1N2027	S	RE				200	1	500/	2.0/			
1N2028	S	RE				300	1	500/	2.0/			
1N2029	S	RE				400	1	500/	2.0/			
1N2030	S	RE				500	1	500/	2.0/			
1N2031	S	RE				600	1	500/	2.0/			
1N2032	S	ZD		1N4732	750						4.9/10	5
1N2032A	S	ZD		1N4732	750						4.5/10	5
1N2033	S	ZD		1N4734	750						5.8/10	5
1N2033A	S	ZD		1N4734	750						5.5/10	5
1N2034	S	ZD		1N4736	750						6.6/10	5
1N2034A	S	ZD		1N4736	750						6.5/10	5
1N2035	S	ZD		1N4739	750						8.8/10	5
1N2035A	S	ZD		1N4739	750						8/10	5
1N2036	S	ZD		1N4740	750						10.5/10	5
1N2036A	S	ZD		1N4740	750						10/10	5
1N2037	S	ZD		1N4743	750						12.8/5	5
1N2037A	S	ZD		1N4743	750						12/5	5
1N2038	S	ZD		1N4745	750						15.8/5	5
1N2038A	S	ZD		1N4745	750						15/5	5
1N2039	S	ZD		1N4747	750						19/5	5
1N2039A	S	ZD		1N4747	750						18/5	5
1N2040	S	ZD		1N4749	750						23.5/5	5
1N2040A	S	ZD		1N4749	750						22/5	5
1N2054	S	RE					250	55M/	1.6/			
1N2055	S	RE					250	55M/	1.6/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2056	S	RE					250	55M/	1.6/			
1N2057	S	RE					250	55M/	1.6/			
1N2058	S	RE					250	55M/	1.6/			
1N2059	S	RE					250	55M/	1.6/			
1N2060	S	RE					250	55M/	1.6/			
1N2061	S	RE					250	55M/	1.6/			
1N2062	S	RE					250	55M/	1.6/			
1N2063	S	RE					250	55M/	1.6/			
1N2064	S	RE					250	55M/	1.6/			
1N2065	S	RE					250	55M/	1.6/			
1N2066	S	RE					250	55M/	1.6/			
1N2067	S	RE					250	55M/	1.6/			
1N2068	S	RE					250	55M/	1.6/			
1N2069	S	RE	1N2069			200	.75	10/200	1.2/500			
1N2069A	S	RE	1N2069A			200	.75	5/200	1.0/500			
1N2070	S	RE	1N2070			400	.75	10/400	1.2/500			
1N2070A	S	RE	1N2070A			400	.75	5/400	1.0/500			
1N2071	S	RE	1N2071			600	.75	10/600	1.2/500			
1N2071A	S	RE	1N2071A			600	.75	5/600	1.0/500			
1N2072	S	RE		1N4001		50	.75	250/50	1.1/1A			
1N2073	S	RE		1N4002		100	.75	250/100	1.1/1A			
1N2074	S	RE		1N4003		150	.75	250/150	1.1/1A			
1N2075	S	RE		1N4003		200	.75	250/200	1.1/1A			
1N2076	S	RE		1N4004		250	.75	250/250	1.1/1A			
1N2077	S	RE		1N4004		300	.75	250/300	1.1/1A			
1N2078	S	RE		1N4004		400	.75	250/400	1.1/1A			
1N2079	S	RE		1N4006		500	.75	250/500	1.1/1A			
1N2080	S	RE		1N4001		50	.5	350/50	.75/500			
1N2081	S	RE		1N4002		100	.5	350/100	.75/500			
1N2082	S	RE		1N4003		200	.5	350/200	.75/500			
1N2083	S	RE		1N4004		300	.5	350/300	.75/500			
1N2084	S	RE		1N4004		400	.5	350/400	.75/500			
1N2085	S	RE		1N4005		500	.5	350/500	.75/500			
1N2086	S	RE		1N4005		600	.5	350/600	.75/500			
1N2088	S	RE		1N4001		500	.75	500/500	1/750			
1N2089	S	RE		1N4001		600	.75	500/600	1/750			
1N2090	S	RE		1N4001		50	.5	250/50	.5/500			
1N2091	S	RE		1N4002		100	.5	250/100	.5/500			
1N2092	S	RE		1N4003		200	.5	250/200	.5/500			
1N2093	S	RE		1N4004		300	.5	250/300	.5/500			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2094	S	RE		1N4004		400	.5	250/400	.5/500			
1N2095	S	RE		1N4005		500	.5	250/500	.5/500			
1N2096	S	RE		1N4005		600	.5	250/600	.5/500			
1N2103	S	RE		1N4001		50	.75	300/50	1.2/750			
1N2104	S	RE		1N4002		100	.75	300/100	1.2/750			
1N2105	S	RE		1N4003		200	.75	300/200	1.2/750			
1N2106	S	RE		1N4004		300	.75	300/300	1.2/750			
1N2107	S	RE		1N4004		400	.75	300/400	1.2/750			
1N2108	S	RE		1N4005		500	.75	300/500	1.2/750			
1N2109	S	RE		TID381		50	2	300/50	1.2/750			
1N2110	S	RE		TID382		100	2	300/100	1.2/750			
1N2111	S	RE		TID383		200	2	300/200	1.2/750			
1N2112	S	RE		TID384		300	2	300/300	1.2/750			
1N2113	S	RE		TID385		400	2	300/400	1.2/750			
1N2114	S	RE		TID385		500	2	300/500	1.2/750			
1N2115	S	RE		1N4004		365	.3	250/	.8/200			
1N2116	S	RE		1N4004		400	.75	400/	1.4/500			
1N2117	S	RE		1N4006		720	.75	10/720	1.3/750			
1N2139	S	RE				20K	.052	200/	60/			
1N2146	S	SD		1N4608		120		1/50	1.1/500	100		
1N2147	S	RE				50	6	500/	1.2/			
1N2147A	S	RE				50	6	100/	1/			
1N2148	S	RE				100	6	500/	1.2/			
1N2148A	S	RE				100	6	100/	1/			
1N2149	S	RE				200	6	500/	1.2/			
1N2149A	S	RE				200	6	100/	1/			
1N2150	S	RE				300	6	500/	1.2/			
1N2150A	S	RE				300	6	100/	1/			
1N2151	S	RE				400	6	500/	1.2/			
1N2151A	S	RE				400	6	100/	1/			
1N2152	S	RE				500	6	500/	1.2/			
1N2152A	S	RE				500	6	100/	1/			
1N2153	S	RE				600	6	500/	1.2/			
1N2153A	S	RE				600	6	100/	1/			
1N2163	S	ZD			1W						9.4/10	4
1N2163A	S	ZD			1W						9.4/10	2
1N2164	S	ZD			1W						9.4/10	4
1N2164A	S	ZD			1W						9.4/10	2
1N2165	S	ZD			1W						9.4/10	4
1N2165A	S	ZD			1W						9.4/10	2

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2166	S	ZD			1W						9.4/10	4
1N2166A	S	ZD			1W						9.4/10	2
1N2167	S	ZD			1W						9.4/10	4
1N2167A	S	ZD			1W						9.4/10	2
1N2168	S	ZD			1W						9.4/10	4
1N2168A	S	ZD			1W						9.4/10	2
1N2169	S	ZD			1W						9.4/10	4
1N2169A	S	ZD			1W						9.4/10	2
1N2170	S	ZD			1W						9.4/10	4
1N2170A	S	ZD			1W						9.4/10	2
1N2171	S	ZD			1W						9.4/10	4
1N2171A	S	ZD			1W						9.4/10	2
1N2172	S	RE				50	50	250/	1.5/			
1N2173	S	RE				100	50	250/	1.5/			
1N2174	S	RE				200	50	250/	1.5/			
1N2176	S	RE				50	3	300/	1.1/			
1N2177	S	RE				100	3	300/	1.1/			
1N2178	S	RE				150	3	300/	1.1/			
1N2179	S	RE				200	3	300/	1.1/			
1N2180	S	RE				300	3	300/	1.1/			
1N2181	S	RE				400	3	300/	1.1/			
1N2182	S	RE				500	3	300/	1.1/			
1N2183	S	RE				600	3	300/	1.1/			
1N2184	S	RE				50	3	5M/	1.5/			
1N2185	S	RE				100	3	5M/	1.5/			
1N2186	S	RE				150	3	5M/	1.5/			
1N2187	S	RE				200	3	5M/	1.5/			
1N2188	S	RE				300	3	5M/	1.5/			
1N2189	S	RE				400	3	5M/	1.5/			
1N2190	S	RE				500	3	5M/	1.5/			
1N2191	S	RE				600	3	5M/	1.5/			
1N2192	S	RE				800	3	5M/	1.5/			
1N2193	S	RE				1K	3	5M/	1.5/			
1N2194	S	RE				50	6	10M/	1.2/			
1N2195	S	RE				100	6	10M/	1.2/			
1N2196	S	RE				150	6	10M/	1.2/			
1N2197	S	RE				200	6	10M/	1.2/			
1N2198	S	RE				300	6	10M/	1.2/			
1N2199	S	RE				400	6	10M/	1.2/			
1N2200	S	RE				500	6	10M/	1.2/			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2201	S	RE				600	6	10M/	1.2/			
1N2202	S	RE				800	6	10M/	1.2/			
1N2203	S	RE				1K	6	10M/	1.2/			
1N2204	S	RE				50	12	10M/	1.2/			
1N2205	S	RE				100	12	10M/	1.2/			
1N2206	S	RE				150	12	10M/	1.2/			
1N2207	S	RE				200	12	10M/	1.2/			
1N2208	S	RE				300	12	10M/	1.2/			
1N2209	S	RE				400	12	10M/	1.2/			
1N2210	S	RE				500	12	10M/	1.2/			
1N2211	S	RE				600	12	10M/	1.2/			
1N2212	S	RE				800	12	10M/	1.2/			
1N2213	S	RE				1K	12	10M/	1.2/			
1N2214	S	ZD			1W						5.6/35	2
1N2217	S	RE				50	1.5	3/	1.5/			
1N2218	S	RE				500	.4	3/	1.2/			
1N2219	S	RE				500	1.5	3/				
1N2220	S	RE				600	.4	3/	1.2/			
1N2221	S	RE				600	1.5	3/				
1N2222	S	RE				800	.3	3/	1.2/			
1N2222A	S	RE				800	.3	3/				
1N2223	S	RE				800	1	3/	1.2/			
1N2223A	S	RE				800	1	3/				
1N2224	S	RE				1K	.3	3/	1.2/			
1N2224A	S	RE				1K	.3	3/	1.2/			
1N2225	S	RE				1K	1	3/				
1N2225A	S	RE				1K	1	3/				
1N2226	S	RE				1.2K	.3	3/	1.2/			
1N2226A	S	RE				1.2K	.3	3/	1.2/			
1N2227	S	RE				1.2K	1	3/				
1N2227A	S	RE				1.2K	1	3/				
1N2228	S	RE				50	1	3/	1.2/			
1N2228A	S	RE				50	1.6	3/	1.2/			
1N2229	S	RE				50	5	3/				
1N2229A	S	RE				50	5	3/				
1N2230	S	RE				200	1	3/	1.2/			
1N2230A	S	RE				200	1.6	3/	1.2/			
1N2231	S	RE				200	5	3/				
1N2231A	S	RE				200	5	3/				
1N2232	S	RE				300	1	3/	1.2/			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2232A	S	RE				300	1.6	3/	1.2/			
1N2233	S	RE				300	5	3/				
1N2233A	S	RE				300	5	3/				
1N2234	S	RE				400	1	3/	1.2/			
1N2234A	S	RE				400	1.6	3/	1.2/			
1N2235	S	RE				400	5	3/				
1N2235A	S	RE				400	5	3/				
1N2236	S	RE				500	1	3/	1.2/			
1N2236A	S	RE				500	1.6	3/	1.2/			
1N2237	S	RE				500	5	3/				
1N2237A	S	RE				500	5	3/				
1N2238	S	RE				600	1	3/	1.2/			
1N2238A	S	RE				600	1.6	3/	1.2/			
1N2239	S	RE				600	5	3/				
1N2239A	S	RE				600	5	3/				
1N2240	S	RE				800	1.5	3/	1.2/			
1N2240A	S	RE				800	1.5	3/	1.2/			
1N2241	S	RE				800	5	3/				
1N2241A	S	RE				800	5	3/				
1N2242	S	RE				1K	1.5	3/	1.2/			
1N2242A	S	RE				1K	1.6	3/	1.2/			
1N2243	S	RE				1K	5	3/				
1N2243A	S	RE				1K	5	3/				
1N2240	S	RE				1.2K	1.5	3/	1.2/			
1N2244A	S	RE				1.2K	1.6	3/	1.2/			
1N2245	S	RE				1.2K	5	3/				
1N2245A	S	RE				1.2K	5	3/				
1N2246	S	RE				50	3	5/	1.2/			
1N2246A	S	RE				50	3	3/	1.2/			
1N2247	S	RE				50	10	5/				
1N2247A	S	RE				50	10	3/				
1N2248	S	RE				100	3	5/	1.2/			
1N2248A	S	RE				100	3	3/	1.2/			
1N2249	S	RE				100	10	5/				
1N2249A	S	RE				100	10	3/				
1N2250	S	RE				200	3	5/	1.2/			
1N2250A	S	RE				200	3	3/	1.2/			
1N2251	S	RE				200	10					
1N2251A	S	RE				200	10					
1N2252	S	RE				300	3		1.2/			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2252A	S	RE				300	3		1.2/			
1N2253	S	RE				300	10					
1N2253A	S	RE				300	10					
1N2254	S	RE				400	3		1.2/			
1N2254A	S	RE				400	3		1.2/			
1N2255	S	RE				400	10					
1N2255A	S	RE				400	10					
1N2256	S	RE				500	3	5/	1.2/			
1N2256A	S	RE				500	3	3/	1.2/			
1N2257	S	RE				500	10	5/				
1N2257A	S	RE				500	10	3/				
1N2258	S	RE				600	3	3/	1.2/			
1N2258A	S	RE				600	3	5/	1.2/			
1N2259	S	RE				600	10	5/				
1N2259A	S	RE				600	10	3/				
1N2260	S	RE				800	3	5/	1.2/			
1N2260A	S	RE				800	3	3/	1.2/			
1N2261	S	RE				800	10	10/				
1N2261A	S	RE				800	10	5/				
1N2262	S	RE				1K	3	10/	1.2/			
1N2262A	S	RE				1K	3	5/	1.2/			
1N2263	S	RE				1K	10					
1N2263A	S	RE				1K	5					
1N2264	S	RE				1.2K	3	10/	1.2/			
1N2264A	S	RE				1.2K	3	5/	1.2/			
1N2265	S	RE				1.2K	10	10/				
1N2265A	S	RE				1.2K	10	5/				
1N2266	S	RE				50	.3	3/	1.2/			
1N2267	S	RE				50	1	3/				
1N2268	S	RE				500	.3	3/	1.2/			
1N2269	S	RE				500	1	3/				
1N2270	S	RE				600	.3	3/	1.2/			
1N2271	S	RE				600	1	3/				
1N2272	S	RE				50	6	1M/	1.2/			
1N2273	S	RE				100	6	1M/	1.2/			
1N2274	S	RE				200	6	1M/	1.2/			
1N2275	S	RE				300	6	1M/	1.2/			
1N2276	S	RE				400	6	1M/	1.2/			
1N2277	S	RE				500	6	1M/	1.2/			
1N2278	S	RE				600	6	1M/	1.2/			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2279	S	RE				800	6	1M/	1.2/			
1N2280	S	RE				1K	6	1M/	1.2/			
1N2281	S	RE				1.2K	6	1M/	1.2/			
1N2282	S	RE				300	20	5M/	1.2/			
1N2283	S	RE				400	20	5M/	1.2/			
1N2284	S	RE				500	20	5M/	1.2/			
1N2285	S	RE				600	20	5M/	1.2/			
1N2286	S	RE				800	20	5M/	1.2/			
1N2287	S	RE				1K	20	5M/	1.5/			
1N2288	S	RE				1.2K	20	5M/	1.5/			
1N2289	S	RE				100	1.5	3/	.6/			
1N2289A	S	RE				100	1.5	3/	.6/			
1N2290	S	RE				100	5.0	3/	.6/			
1N2290A	S	RE				100	5.0	3/	.6/			
1N2291	S	RE				200	1.5	3/	.6/			
1N2291A	S	RE				200	1.5	3/	.6/			
1N2292	S	RE				300	1.5	3/	.6/			
1N2292A	S	RE				300	1.5	3/	.6/			
1N2293	S	RE				400	1.5	3/	.6/			
1N2293A	S	RE				400	1.5	3/	.6/			
1N2294	S	RE				50	22	1M/	1.1/			
1N2295	S	RE				100	22	1M/	1.1/			
1N2296	S	RE				150	22	1M/	1.1/			
1N2297	S	RE				200	22	1M/	1.1/			
1N2298	S	RE				250	22	1M/	1.1/			
1N2299	S	RE				300	22	1M/	1.1/			
1N2300	S	RE				350	22	1M/	1.1/			
1N2301	S	RE				400	22	1M/	1.1/			
1N2302	S	RE				50	22	1M/	1.1/			
1N2303	S	RE				100	22	1M/	1.1/			
1N2304	S	RE				150	22	1M/	1.1/			
1N2305	S	RE				200	22	1M/	1.1/			
1N2306	S	RE				250	22	1M/	1.1/			
1N2307	S	RE				300	22	1M/	1.1/			
1N2308	S	RE				350	22	1M/	1.1/			
1N2309	S	RE				400	22	1M/	1.1/			
1N2310	S	RE				50	35	2M/	1.1/			
1N2311	S	RE				100	35	2M/	1.1/			
1N2312	S	RE				150	35	2M/	1.1/			
1N2313	S	RE				200	35	2M/	1.1/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2314	S	RE				250	35	2M/	1.1/			
1N2315	S	RE				300	35	2M/	1.1/			
1N2316	S	RE				350	35	2M/	1.1/			
1N2317	S	RE				400	35	2M/	1.1/			
1N2318	S	RE				50	35	2M/	1.1/			
1N2319	S	RE				100	35	2M/	1.1/			
1N2320	S	RE				150	35	2M/	1.1/			
1N2321	S	RE				200	35	2M/	1.1/			
1N2322	S	RE				250	35	2M/	1.1/			
1N2323	S	RE				300	35	2M/	1.1/			
1N2324	S	RE				350	35	2M/	1.1/			
1N2325	S	RE				400	35	2M/	1.1/			
1N2327	S	SD				1.1K	1	1.5/750	3.3/400			
1N2328	S	SD				2.2K		1.5/1.5K	3.3/400			
1N2348	S	RE				50	3	300/	1.1/			
1N2349	S	RE				100	3	300/	1.1/			
1N2350	S	RE				150	3	300/	1.1/			
1N2357	S	RE				1.4K	.4	1/	2/			
1N2358	S	RE				1.5K	.4	1/	2/			
1N2359	S	RE				1.6K	.4	1/	2/			
1N2360	S	RE				1.8K	.4	1/	2/			
1N2361	S	RE				2.0K	.4	1/	2/			
1N2362	S	RE				1.4K	1	1/	2/			
1N2362A	S	RE				1.4K	5	1/	2/			
1N2362B	S	RE				1.4K	10	1/	2/			
1N2363	S	RE				1.4K	1	1/	2/			
1N2363A	S	RE				1.4K	5	1/	2/			
1N2363B	S	RE				1.4K	10	1/	2/			
1N2364	S	RE				1.5K	1	1/	2/			
1N2364A	S	RE				1.5K	5	1/	2/			
1N2364B	S	RE				1.5K	10	1/	2/			
1N2365	S	RE				1.5K	1	1/	2/			
1N2365A	S	RE				1.5K	5	1/	2/			
1N2365B	S	RE				1.5K	10	1/	2/			
1N2366	S	RE				1.6K	1	1/	2/			
1N2366A	S	RE				1.6K	5	1/	2/			
1N2366B	S	RE				1.6K	10	1/	2/			
1N2367	S	RE				1.6K	1	1/	2/			
1N2367A	S	RE				1.6K	5	1/	2/			
1N2367B	S	RE				1.6K	10	1/	2/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2368	S	RE				1.8K	1	1/	2/			
1N2368A	S	RE				1.8K	5	1/	2/			
1N2368B	S	RE				1.8K	10	1/	2/			
1N2369	S	RE				1.8K	1	1/	2/			
1N2369A	S	RE				1.8K	5	1/	2/			
1N2369B	S	RE				1.8K	10	1/	2/			
1N2370	S	RE				2K	1	1/	2/			
1N2370A	S	RE				2K	5	1/	2/			
1N2370B	S	RE				2K	10	1/	2/			
1N2371	S	RE				2K	1	1/	2/			
1N2371A	S	RE				2K	5	1/	2/			
1N2371B	S	RE				2K	10	1/	2/			
1N2372	S	RE				1K	.2	500/	2/			
1N2373	S	RE		1N4005		600	.1	250/	3/			
1N2374	S	RE		1N4007		1K	.1	250/	3/			
1N2375	S	RE				1.5K	.1	250/	4.5/			
1N2376	S	RE				2K	.1	250/	7.5/			
1N2377	S	RE				2.4K	.075	250/	9/			
1N2378	S	RE				3K	.075	250/	9/			
1N2379	S	RE				4K	.05	250/	15/			
1N2380	S	RE				6K	.05	250/	22/			
1N2381	S	RE				10K	.025	250/	37/			
1N2382	S	RE				4K	.15	200/	18/			
1N2382A	S	RE				4K	.35	200/	6/			
1N2383	S	RE				6K	.1	200/	27/			
1N2383A	S	RE				6K	.35	200/	9/			
1N2384	S	RE				8K	.07	200/	27/			
1N2384A	S	RE				8K	.275	200/	12/			
1N2385	S	RE				10K	.07	200/	39/			
1N2385A	S	RE				10K	.2	200/	15/			
1N2387	S	ZD		1N4751	1W						30/8	10
1N2389	S	RE				1.6K	.6	500/	4.8/			
1N2390	S	RE				50	1.5	300/	1.2/			
1N2391	S	RE				100	1.5	300/	1.2/			
1N2392	S	RE				200	1.5	300/	1.2/			
1N2393	S	RE				300	1.5	300/	1.2/			
1N2394	S	RE				400	1.5	300/	1.2/			
1N2395	S	RE				500	1.5	300/	1.2/			
1N2396	S	RE				600	1.5	300/	1.2/			
1N2397	S	RE				700	1.5	300/	1.2/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R µA / @ V_R (V)	CHARACTERISTICS V_F (V) / @ I_F (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z (V) / @ I_Z (mA)	TOL %
1N2398	S	RE				800	1.5	300/	1.2/			
1N2399	S	RE				50	1.5	300/	1.2/			
1N2400	S	RE				100	1.5	300/	1.2/			
1N2401	S	RE				200	1.5	300/	1.2/			
1N2402	S	RE				300	1.5	300/	1.2/			
1N2403	S	RE				400	1.5	300/	1.2/			
1N2404	S	RE				500	1.5	300/	1.2/			
1N2405	S	RE				600	1.5	300/	1.2/			
1N2406	S	RE				700	1.5	300/	1.2/			
1N2407	S	RE				800	1.5	300/	1.2/			
1N2408	S	RE				50	1.5	300/	1.2/			
1N2409	S	RE				100	1.5	300/	1.2/			
1N2410	S	RE				200	1.5	300/	1.2/			
1N2411	S	RE				300	1.5	300/	1.2/			
1N2412	S	RE				400	1.5	300/	1.2/			
1N2413	S	RE				500	1.5	300/	1.2/			
1N2414	S	RE				600	1.5	300/	1.2/			
1N2415	S	RE				700	1.5	300/	1.2/			
1N2416	S	RE				800	1.5	300/	1.2/			
1N2417	S	RE				50	1.5	300/	1.2/			
1N2418	S	RE				100	1.5	300/	1.2/			
1N2419	S	RE				200	1.5	300/	1.2/			
1N2420	S	RE				300	1.5	300/	1.2/			
1N2421	S	RE				400	1.5	300/	1.2/			
1N2422	S	RE				500	1.5	300/	1.2/			
1N2423	S	RE				600	1.5	300/	1.2/			
1N2424	S	RE				700	1.5	300/	1.2/			
1N2425	S	RE				800	1.5	300/	1.2/			
1N2482	S	RE		TID383		200	.75	500/200	1.2/750			
1N2483	S	RE		TID384		400	.75	500/400	1.2/750			
1N2484	S	RE		TID385		500	.75	500/500	1.2/750			
1N2485	S	RE		TID383		200	.75	500/200	1.2/750			
1N2486	S	RE		TID384		300	.75	500/300	1.2/750			
1N2487	S	RE		TID384		400	.75	500/400	1.2/750			
1N2488	S	RE		TID385		500	.75	500/500	1.2/750			
1N2489	S	RE		TID385		600	.75	500/600	1.2/750			
1N2490	S	RE				1.6K	.5	500/	4.8/			
1N2501	S	RE		1N4006		800	.15	200/800	1.7/100			
1N2502	S	RE		1N4007		1K	.15	200/1K	1.7/100			
1N2503	S	RE				1.2K	.15	200/	1.7/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2504	S	RE				1.5K	.15	200/	1.7/			
1N2505	S	RE		1N4006		800	.3	200/800	1.7/200			
1N2506	S	RE		1N4007		1K	.3	200/1K	1.7/200			
1N2507	S	RE				1.2K	.3	200/	1.7/			
1N2508	S	RE				1.5K	.3	200/	1.7/			
1N2512	S	RE				100	4	2/	1.1/			
1N2513	S	RE				200	4	2/	1.1/			
1N2514	S	RE				300	4	2/	1.1/			
1N2515	S	RE				400	4	2/	1.1/			
1N2516	S	RE				500	4	2/	1.1/			
1N2517	S	RE				600	4	2/	1.1/			
1N2518	S	RE				100	4	2/	1.1/			
1N2519	S	RE				200	4	2/	1.1/			
1N2520	S	RE				300	4	2/	1.1/			
1N2521	S	RE				400	4	2/	1.1/			
1N2522	S	RE				500	4	2/	1.1/			
1N2523	S	RE				600	4	2/	1.1/			
1N2524	S	RE				50	2.5	500/	1.2/			
1N2525	S	RE				100	2.5	500/	1.2/			
1N2526	S	RE				200	2.5	500/	1.2/			
1N2527	S	RE				300	2.5	500/	1.2/			
1N2528	S	RE				400	2.5	500/	1.2/			
1N2529	S	RE				500	2.5	500/	1.2/			
1N2530	S	RE				600	2.5	500/	1.2/			
1N2531	S	RE				700	2.5	500/	1.2/			
1N2532	S	RE				800	2.5	500/	1.2/			
1N2533	S	RE				900	2.5	500/	1.2/			
1N2534	S	RE				1K	2.5	500/	1.2/			
1N2535	S	RE				50	2.5	100/	1/			
1N2536	S	RE				100	2.5	100/	1/			
1N2537	S	RE				200	2.5	100/	1/			
1N2538	S	RE				300	2.5	100/	1/			
1N2539	S	RE				400	2.5	100/	1/			
1N2540	S	RE				500	2.5	100/	1/			
1N2541	S	RE				600	2.5	100/	1/			
1N2542	S	RE				700	2.5	100/	1/			
1N2543	S	RE				800	2.5	100/	1/			
1N2544	S	RE				900	2.5	100/	1/			
1N2545	S	RE				1K	2.5	100/	1/			
1N2546	S	RE				50	2.5	1M/	1.5/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2547	S	RE				100	2.5	1M/	1.5/			
1N2548	S	RE				200	2.5	1M/	1.5/			
1N2549	S	RE				300	2.5	1M/	1.5/			
1N2550	S	RE				400	2.5	1M/	1.5/			
1N2551	S	RE				500	2.5	1M/	1.5/			
1N2552	S	RE				600	2.5	1M/	1.5/			
1N2553	S	RE				700	2.5	1M/	1.5/			
1N2554	S	RE				800	2.5	1M/	1.5/			
1N2555	S	RE				900	2.5	1M/	1.5/			
1N2556	S	RE				1K	2.5	1M/	1.5/			
1N2557	S	RE				700	6	500/	1.2/			
1N2558	S	RE				800	6	500/	1.2/			
1N2559	S	RE				900	6	500/	1.2/			
1N2560	S	RE				1K	6	500/	1.2/			
1N2561	S	RE				700	6	100/	1/			
1N2562	S	RE				800	6	100/	1/			
1N2563	S	RE				900	6	100/	1.5/			
1N2564	S	RE				1K	6	100/	1.5/			
1N2565	S	RE				50	6	1M/	1.5/			
1N2566	S	RE				100	6	1M/	1.5/			
1N2567	S	RE				200	6	1M/	1.5/			
1N2568	S	RE				300	6	1M/	1.5/			
1N2569	S	RE				400	6	1M/	1.5/			
1N2570	S	RE				500	6	1M/	1.5/			
1N2571	S	RE				600	6	1M/	1.5/			
1N2572	S	RE				700	6	1M/	1.5/			
1N2573	S	RE				800	6	1M/	1.5/			
1N2574	S	RE				900	6	1M/	1.5/			
1N2575	S	RE				1K	6	1M/	1.5/			
1N2576	S	RE				50	12	1M/	1.2/			
1N2577	S	RE				100	12	1M/	1.2/			
1N2578	S	RE				200	12	1M/	1.2/			
1N2579	S	RE				300	12	1M/	1.2/			
1N2580	S	RE				400	12	1M/	1.2/			
1N2581	S	RE				500	12	1M/	1.2/			
1N2582	S	RE				600	12	1M/	1.2/			
1N2583	S	RE				700	12	1M/	1.2/			
1N2584	S	RE				800	12	1M/	1.2/			
1N2585	S	RE				900	12	1M/	1.2/			
1N2586	S	RE				1K	12	1M/	1.2/			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2587	S	RE				50	12	200/	1/			
1N2588	S	RE				100	12	200/	1/			
1N2589	S	RE				200	12	200/	1/			
1N2590	S	RE				300	12	200/	1/			
1N2591	S	RE				400	12	200/	1/			
1N2592	S	RE				500	12	200/	1/			
1N2593	S	RE				600	12	200/	1/			
1N2594	S	RE				700	12	200/	1/			
1N2595	S	RE				800	12	200/	1/			
1N2596	S	RE				900	12	200/	1/			
1N2597	S	RE				1K	12	200/	1/			
1N2598	S	RE				50	12	2M/	1.5/			
1N2599	S	RE				100	12	2M/	1.5/			
1N2600	S	RE				200	12	2M/	1.5/			
1N2601	S	RE				300	12	2M/	1.5/			
1N2602	S	RE				400	12	2M/	1.5/			
1N2603	S	RE				500	12	2M/	1.5/			
1N2604	S	RE				600	12	2M/	1.5/			
1N2605	S	RE				700	12	2M/	1.5/			
1N2606	S	RE				800	12	2M/	1.5/			
1N2607	S	RE				900	12	2M/	1.5/			
1N2608	S	RE				1K	12	2M/	1.5/			
1N2609	S	RE		1N4001		50	.75	10/50	1.1/500			
1N2610	S	RE		1N4002		100	.75	10/100	1.1/500			
1N2611	S	RE		1N4003		200	.75	10/200	1.1/500			
1N2612	S	RE		1N4004		300	.75	10/300	1.1/500			
1N2613	S	RE		1N4004		400	.75	10/400	1.1/500			
1N2614	S	RE		1N4005		500	.75	10/500	1.1/500			
1N2615	S	RE		1N4005		600	.75	10/600	1.1/500			
1N2616	S	RE		1N4006		800	.75	10/800	1.1/500			
1N2617	S	RE		1N4007		1K	.75	10/1K	1.1/500			
1N2618	S	RE				1.2K	.75	10/	1.1/			
1N2619	S	RE				1.5K	.75	10/	1.1/			
1N2620	S	RD			750						9.7/10	
1N2620A	S	RD			750						9.7/10	
1N2620B	S	RD			750						9.7/10	
1N2621	S	RD			750						9.7/10	
1N2621A	S	RD			750						9.7/10	
1N2621B	S	RD			750						9.7/10	
1N2622	S	RD			750						9.7/10	

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R (µA / (V))	CHARACTERISTICS V_F @ I_F ((V) / (mA))	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z ((V) / (mA))	TOL %
1N2622A	S	RD			750						9.7/10	
1N2622B	S	RD			750						9.7/10	
1N2623	S	RD			750						9.7/10	
1N2623A	S	RD			750						9.7/10	
1N2623B	S	RD			750						9.7/10	
1N2624	S	RD			750						9.7/10	
1N2624A	S	RD			750						9.7/10	
1N2624B	S	RD			750						9.7/10	
1N2625	S	RD			750						9.4/10	
1N2625A	S	RD			750						9.4/10	
1N2625B	S	RD			750						9.4/10	
1N2626	S	RD			750						9.4/10	
1N2626A	S	RD			750						9.4/10	
1N2626B	S	RD			750						9.4/10	
1N2629	G	SD		1N4305		5						
1N2630	S	RE				1.5K	.085	500/	2.2/			
1N2631	S	RE				1.6K	.6	500/	3/			
1N2632	S	RE				2.8K	.2	500/	6/			
1N2633	S	RE				1.6K	.6	500/	3/			
1N2634	S	RE				1.6K	.6	500/	3/			
1N2635	S	RE				1.5K	.085	500/	2.2/			
1N2636	S	RE				1.5K	.085	500/	2.2/			
1N2637	S	RE				10K	.25	500/	28/			
1N2638	S	RE				100	1.5	300/	1.3/			
1N2641	S	RE				200	1.5	300/	1.3/			
1N2644	S	RE				300	1.5	300/	1.3/			
1N2647	S	RE				400	1.5	300/	1.3/			
1N2650	S	RE				600	1.5	300/	2.6/			
1N2653	S	RE				800	1.5	300/	2.6/			
1N2656	S	RE				1.2K	1.5	800/	3.9/			
1N2659	S	RE				1.6K	1.5	800/	5.2/			
1N2662	S	RE				2K	1.5	800/	6.5/			
1N2664	S	RE				2.4K	1.5	800/	7.8/			
1N2666	S	RE				3.2K	1.5	800/	10/			
1N2667	S	RE				4K	1.5	800/	13/			
1N2668	S	RE				4.8K	1.5	800/	15/			
1N2669	S	RE				100	3.6	300/	1.3/			
1N2673	S	RE				200	3.6	300/	1.3/			
1N2677	S	RE				300	3.6	300/	1.3/			
1N2681	S	RE				400	3.6	300/	1.3/			

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2685	S	RE				600	3.6	300/	2.6/			
1N2687	S	RE				800	3.6	300/	2.6/			
1N2689	S	RE				900	3.6	800/	3.9/			
1N2690	S	RE				1.2K	3.6	800/	3.9/			
1N2691	S	RE				1.6K	3.6	800/	5.2/			
1N2702	S	RE				100	3	200/	1.3/			
1N2705	S	RE				200	3	200/	1.3/			
1N2708	S	RE				300	3	200/	1.3/			
1N2711	S	RE				400	3	200/	1.3/			
1N2714	S	RE				600	3	200/	2.6/			
1N2717	S	RE				800	3	200/	2.6/			
1N2720	S	RE				1.2K	3	800/	3.9/			
1N2722	S	RE				1.6K	3	800/	5.2/			
1N2723	S	RE				2K	3	800/	6.5/			
1N2724	S	RE				2.4K	3	800/	7.8/			
1N2725	S	RE				100	3	300/	1.3/			
1N2728	S	RE				200	3	300/	1.3/			
1N2731	S	RE				300	3	300/	1.3/			
1N2734	S	RE				400	3	300/	1.3/			
1N2737	S	RE				600	3	300/	2.6/			
1N2738	S	RE				800	3	300/	2.6/			
1N2739	S	RE				1.2K	3	800/	3.9/			
1N2740	S	RE				100	3.6	300/	1.3/			
1N2742	S	RE				200	3.6	300/	1.3/			
1N2744	S	RE				300	3.6	300/	1.3/			
1N2746	S	RE				400	3.6	300/	1.3/			
1N2748	S	RE				600	3.6	300/	2.6/			
1N2749	S	RE				800	3.6	300/	2.6/			
1N2750	S	RE				100	3	300/	1.3/			
1N2753	S	RE				200	3	300/	1.3/			
1N2756	S	RE				300	3	300/	1.3/			
1N2759	S	RE				400	3	300/	1.3/			
1N2762	S	RE				600	3	300/	2.6/			
1N2763	S	RE				800	3	300/	2.6/			
1N2764	S	RE				1.2K	3	300/	3.9/			
1N2765	S	RD									6.8/7.5	5
1N2765A	S	RD									6.8/7.5	5
1N2766	S	RD									13.6/7.5	5
1N2766A	S	RD									13.6/7.5	5
1N2767	S	RD									20.4/7.5	5

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA @ V_R / (V)	V_F (V) @ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N2767A	S	RD									20.4/7.5	5
1N2768	S	RD									27.2/7.5	5
1N2768A	S	RD									27.2/7.5	5
1N2769	S	RD									34/7.5	5
1N2769A	S	RD									34/7.5	5
1N2770	S	RD									40.8/7.5	5
1N2770A	S	RD									40.8/7.5	5
1N2772	S	RE				700	.5		1.8/			
1N2773	S	RE				800	.5		1.8/			
1N2774	S	RE				900	.5		1.8/			
1N2775	S	RE				1K	.5		1.8/			
1N2776	S	RE				1.1K	.5		1.8/			
1N2777	S	RE				1.2K	.5		1.8/			
1N2778	S	RE				1.3K	.5		1.8/			
1N2779	S	RE				1.4K	.5		1.8/			
1N2780	S	RE				1.5K	.5		1.8/			
1N2781	S	RE				1.6K	.5		1.8/			
1N2790	S	RD			1W						8.5/2U	10
1N2791	S	SD		1N647		350		50N/	1.3/50	4U		
1N2793	S	RE				50	5	5M/	1.2/			
1N2794	S	RE				100	5	5M/	1.2/			
1N2795	S	RE				150	5	5M/	1.2/			
1N2796	S	RE				200	5	5M/	1.2/			
1N2797	S	RE				250	5	5M/	1.2/			
1N2798	S	RE				300	5	5M/	1.2/			
1N2799	S	RE				350	5	5M/	1.2/			
1N2800	S	RE				400	5	5M/	1.2/			
1N2801	G	SD				20		2/	.36/5	50U		
1N2803	S	RE				400	250	36M/	1.2/			
1N2847	S	RE				100	1.5	300/	2/			
1N2848	S	RE				200	1.5	200/	2/			
1N2849	S	RE				300	1.5	200/	2/			
1N2850	S	RE				400	1.5	200/	2/			
1N2851	S	RE				500	1.5	200/	2/			
1N2852	S	RE				600	1.5	200/	2/			
1N2855	S	RE				600	250	25M/	1.2/			
1N2856	S	RE				800	250	10M/	1.2/			
1N2857	S	RE				1K	250	15M/	1.2/			
1N2858	S	RE		1N4001		50	.75	300/50	1.2/500			
1N2858A	S	RE		1N4001		50	1	300/50	1.2/1A			

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2859	S	RE		1N4002		100	.75	300/100	1.2/500			
1N2859A	S	RE		1N4002		100	1	300/100	1.2/1A			
1N2860	S	RE		1N4003		200	.75	300/200	1.2/500			
1N2860A	S	RE		1N4003		200	1	300/200	1.2/1A			
1N2861	S	RE		1N4004		300	.75	300/300	1.2/500			
1N2861A	S	RE		1N4004		300	1	300/300	1.2/1A			
1N2862	S	RE		1N4004		400	.75	300/400	1.2/500			
1N2862A	S	RE		1N4004		400	1	300/400	1.2/1A			
1N2863	S	RE		1N4005		500	.75	200/500	1.2/500			
1N2863A	S	RE		1N4005		500	1	300/500	1.2/1A			
1N2864	S	RE		1N4005		600	.75	200/600	1.2/500			
1N2864A	S	RE		1N4005		600	1	300/600	1.2/1A			
1N2865	S	RE				1K	.7	100/	2.5/			
1N2866	S	RE				1.5K	.7	100/	2.5/			
1N2867	S	RE				1K	.7	100/	2.5/			
1N2868	S	RE				1.5K	.7	100/	2.5/			
1N2878	S	SD	1N2878			700		.5/	2/250			
1N2879	S	SD	1N2879			700		.5/	2/250			
1N2880	S	SD	1N2880			1K		.5/	2/250			
1N2881	S	SD	1N2881			1K		.5/	2/250			
1N2882	S	SD	1N2882			500		.5/	3/250			
1N2883	S	SD	1N2883			500		.5/	3/250			
1N2884	S	SD	1N2884			400		.5/	4/250			
1N2885	S	SD	1N2885			400		.5/	4/250			
1N2886	S	SD	1N2886			500		.5/	3/250			
1N2887	S	SD	1N2887			500		.5/	3/250			
1N2888	S	SD	1N2888			750		.5/	5/250			
1N2889	S	SD	1N2889			750		.5/	5/250			
1N2890	S	SD	1N2890			2K		.5/	4/250			
1N2891	S	SD	1N2891			2K		.5/	4/250			
1N2892	S	SD	1N2892			100		.5/	6/250			
1N2893	S	SD	1N2893			100		.5/	6/250			
1N2894	S	SD	1N2894			450		.5/	7/250			
1N2895	S	SD	1N2895			450		.5/	7/250			
1N2896	S	SD	1N2896			500		.5/	5/250			
1N2897	S	SD	1N2897			500		.5/	5/250			
1N2898	S	SD	1N2898			800		.5/	8/250			
1N2899	S	SD	1N2899			800		.5/	8/250			
1N2900	S	SD	1N2900			3K		.5/	6/250			
1N2901	S	SD	1N2901			3K		.5/	6/250			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N2902	S	SD	1N2902			150		.5/	9/250			
1N2903	S	SD	1N2903			150		.5/	9/250			
1N2904	S	SD	1N2904			500		.5/	7/250			
1N2905	S	SD	1N2905			500		.5/	7/250			
1N2906	S	SD	1N2906			500		.5/	10/250			
1N2907	S	SD	1N2907			500		.5/	10/250			
1N2908	S	SD	1N2908			850		.5/	11/250			
1N2909	S	SD	1N2909			850		.5/	11/250			
1N2910	S	SD	1N2910			4K		.5/	8/250			
1N2911	S	SD	1N2911			4K		.5/	8/250			
1N2912	S	SD	1N2912			200		.5/	12/250			
1N2913	S	SD	1N2913			200		.5/	12/250			
1N2914	S	SD	1N2914			500		.5/	9/250			
1N2915	S	SD	1N2915			500		.5/	9/250			
1N2916	S	SD	1N2916			550		.5/	13/250			
1N2917	S	SD	1N2917			550		.5/	13/250			
1N2918	S	SD	1N2918			5K		.5/	10/250			
1N2919	S	SD	1N2919			5K		.5/	10/250			
1N2920	S	SD	1N2920			500		.5/	11/250			
1N2921	S	SD	1N2921			500		.5/	11/250			
1N2922	S	SD	1N2922			6K		.5/	12/250			
1N2923	S	SD	1N2923			6K		.5/	12/250			
1N2924	S	SD	1N2924			500		.5/	13/250			
1N2925	S	SD	1N2925			500		.5/	13/250			
1N2938	S	ZD			2W						.9/100	15
1N3016	S	ZD		1N4736	1W						6.8/37	20
1N3016A	S	ZD		1N4736	1W						6.8/37	10
1N3016B	S	ZD		1N4736A	1W						6.8/37	5
1N3017	S	ZD		1N4737	1W						7.5/34	20
1N3017A	S	ZD		1N4737	1W						7.5/34	10
1N3017B	S	ZD		1N4737A	1W						7.5/34	5
1N3018	S	ZD		1N4738	1W						8.2/31	20
1N3018A	S	ZD		1N4738	1W						8.2/31	10
1N3018B	S	ZD		1N4738A	1W						8.2/31	5
1N3019	S	ZD		1N4739	1W						9.1/38	20
1N3019A	S	ZD		1N4739	1W						9.1/38	10
1N3019B	S	ZD		1N4739A	1W						9.1/38	5
1N3020	S	ZD		1N4740	1W						10/25	20
1N3020A	S	ZD		1N4740	1W						10/25	10
1N3020B	S	ZD		1N4740A	1W						10/25	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3021	S	ZD		1N4741	1W								11/23	20
1N3021A	S	ZD		1N4741	1W								11/23	10
1N3021B	S	ZD		1N4741A	1W								11/23	5
1N3022	S	ZD		1N4742	1W								12/21	20
1N3022A	S	ZD		1N4742	1W								12/21	10
1N3022B	S	ZD		1N4742A	1W								12/21	5
1N3023	S	ZD		1N4743	1W								13/19	20
1N3023A	S	ZD		1N4743	1W								13/19	10
1N3023B	S	ZD		1N4743A	1W								13/19	5
1N3024	S	ZD		1N4744	1W								15/17	20
1N3024A	S	ZD		1N4744	1W								15/17	10
1N3024B	S	ZD		1N4744A	1W								15/17	5
1N3025	S	ZD		1N4745	1W								16/15	20
1N3025A	S	ZD		1N4745	1W								16/15	10
1N3025B	S	ZD		1N4745A	1W								16/15	5
1N3026	S	ZD		1N4746	1W								18/14	20
1N3026A	S	ZD		1N4746	1W								18/14	10
1N3026B	S	ZD		1N4746A	1W								18/14	5
1N3027	S	ZD		1N4747	1W								20/12	20
1N3027A	S	ZD		1N4747	1W								20/12	10
1N3027B	S	ZD		1N4747A	1W								20/12	5
1N3028	S	ZD		1N4748	1W								22/11	20
1N3028A	S	ZD		1N4748	1W								22/11	10
1N3028B	S	ZD		1N4748A	1W								22/11	5
1N3029	S	ZD		1N4749	1W								24/10	20
1N3029A	S	ZD		1N4749	1W								24/10	10
1N3029B	S	ZD		1N4749A	1W								24/10	5
1N3030	S	ZD		1N4750	1W								27/9.5	20
1N3030A	S	ZD		1N4750	1W								27/9.5	10
1N3030B	S	ZD		1N4750A	1W								27/9.5	5
1N3031	S	ZD		1N4751	1W								30/8.5	20
1N3031A	S	ZD		1N4751	1W								30/8.5	10
1N3031B	S	ZD		1N4751A	1W								30/8.5	5
1N3032	S	ZD		1N4752	1W								33/7.5	20
1N3032A	S	ZD		1N4752	1W								33/7.5	10
1N3032B	S	ZD		1N4752A	1W								33/7.5	5
1N3033	S	ZD			1W								36/7	20
1N3033A	S	ZD			1W								36/7	10
1N3033B	S	ZD			1W								36/7	5
1N3034	S	ZD			1W								39/6.5	20

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA @ V_R / (V)	V_F (V) @ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N3034A	S	ZD			1W						39/6.5	10
1N3034B	S	ZD			1W						39/6.5	5
1N3035	S	ZD			1W						43/6	20
1N3035A	S	ZD			1W						43/6	10
1N3035B	S	ZD			1W						43/6	5
1N3036	S	ZD			1W						47/5.5	20
1N3036A	S	ZD			1W						47/5.5	10
1N3036B	S	ZD			1W						47/5.5	5
1N3037	S	ZD			1W						51/5	20
1N3037A	S	ZD			1W						51/5	10
1N3037B	S	ZD			1W						51/5	5
1N3038	S	ZD			1W						56/4.5	20
1N3038A	S	ZD			1W						56/4.5	10
1N3038B	S	ZD			1W						56/4.5	5
1N3039	S	ZD			1W						62/4	20
1N3039A	S	ZD			1W						62/4	10
1N3039B	S	ZD			1W						62/4	5
1N3040	S	ZD			1W						68/3.7	20
1N3040A	S	ZD			1W						68/3.7	10
1N3040B	S	ZD			1W						68/3.7	5
1N3041	S	ZD			1W						75/3.3	20
1N3041A	S	ZD			1W						75/3.3	10
1N3041B	S	ZD			1W						75/3.3	5
1N3042	S	ZD			1W						82/3	20
1N3042A	S	ZD			1W						82/3	10
1N3042B	S	ZD			1W						82/3	5
1N3043	S	ZD			1W						91/2.8	20
1N3043A	S	ZD			1W						91/2.8	10
1N3043B	S	ZD			1W						91/2.8	5
1N3044	S	ZD			1W						100/2	20
1N3044A	S	ZD			1W						100/2	10
1N3044B	S	ZD			1W						100/2	5
1N3045	S	ZD			1W						110/2.3	20
1N3045A	S	ZD			1W						110/2.3	10
1N3045B	S	ZD			1W						110/2.3	5
1N3046	S	ZD			1W						120/2	20
1N3046A	S	ZD			1W						120/2	10
1N3046B	S	ZD			1W						120/2	5
1N3047	S	ZD			1W						130/1.9	20
1N3047A	S	ZD			1W						130/1.9	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3047B	S	ZD			1W						130/1.9	5
1N3048	S	ZD			1W						150/1.7	20
1N3048A	S	ZD			1W						150/1.7	10
1N3048B	S	ZD			1W						150/1.7	5
1N3049	S	ZD			1W						160/1.6	20
1N3049A	S	ZD			1W						160/1.6	10
1N3049B	S	ZD			1W						160/1.6	5
1N3050	S	ZD			1W						180/1.4	20
1N3050A	S	ZD			1W						180/1.4	10
1N3050B	S	ZD			1W						180/1.4	5
1N3051	S	ZD			1W						200/1.2	20
1N3051A	S	ZD			1W						200/1.2	10
1N3051B	S	ZD			1W						200/1.2	5
1N3052	S	RE				12K	.1	200/	70/			
1N3053	S	RE				14K	.1	200/	75/			
1N3054	S	RE				16K	.1	200/	80/			
1N3055	S	RE				18K	.1	200/	85/			
1N3056	S	RE				20K	.1	200/	90/			
1N3057	S	RE				22K	.1	200/	95/			
1N3058	S	RE				24K	.1	200/	100/			
1N3059	S	RE				26K	.1	200/	105/			
1N3060	S	RE				28K	.1	200/	120/			
1N3061	S	RE				30K	.1	200/	125/			
1N3062	S	SD		1N4305		75		.1/50	1/20	2		
1N3063	S	SD		1N4305		75		.1/50	.85/10	2		
1N3064	S	SD		1N4454		75		.1/50	1/10	4		
1N3065	S	SD		1N4305		75		.1/50	1/20	2		
1N3066	S	SD		1N4305		75		.1/50	1/10	2		
1N3067	S	SD		1N4148		30		.1/20	1/5	2		
1N3068	S	SD		1N4148		30		.1/20	1/5	50		
1N3069	S	SD		1N4148		65		.1/50	1/50	50		
1N3070	S	SD	1N3070			200		.1/175	1/100	50		
1N3071	S	SD		1N3070		200		.1/175	1/100	50		
1N3072	S	RE		1N4001		50	.2	1/50	1.5/500			
1N3073	S	RE		1N4002		100	.2	1/100	1.5/500			
1N3074	S	RE		1N4003		150	.2	1/150	1.5/500			
1N3075	S	RE		1N4003		200	.2	1/200	1.5/500			
1N3076	S	RE		1N4004		250	.2	1/250	1.5/500			
1N3077	S	RE		1N4004		300	.2	1/300	1.5/500			
1N3078	S	RE		1N4004		350	.2	1/350	1.5/500			

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1N3079	S	RE		1N4004		400	.2	1/400	1.5/500			
1N3080	S	RE		1N4005		500	.2	1/500	1.5/500			
1N3081	S	RE		1N4005		600	.2	1/600	1.5/500			
1N3082	S	RE		1N4003		200	.5	200/200	1.2/200			
1N3083	S	RE		1N4004		400	.5	200/400	1.2/200			
1N3084	S	RE		1N4005		600	.5	200/600	1.2/200			
1N3085	S	RE				100	150	40M/	1.1/			
1N3086	S	RE				200	150	40M/	1.1/			
1N3087	S	RE				300	150	40M/	1.1/			
1N3088	S	RE				400	150	40M/	1.1/			
1N3089	S	RE				500	150	40M/	1.1/			
1N3090	S	RE				600	150	40M/	1.1/			
1N3091	S	RE				800	150	40M/	1.1/			
1N3092	G	RE				1K	150	40M/	1.1/			
1N3097	G	SD		1N4305		30		2/30	.5/10			
1N3098	S	ZD			1W						120/3	20
1N3098A	S	ZD			1W						120/3	10
1N3099	S	ZD			1W						150/3	20
1N3099A	S	ZD			1W						150/3	10
1N3100	S	ZD			1W						180/3	20
1N3100A	S	ZD			1W						180/3	10
1N3101	S	ZD			1W						220/3	20
1N3101A	S	ZD			1W						220/3	10
1N3106	S	RE		1N4006		800	.75	100/	1.6/750			
1N3107	S	RE				1.2K	.5	100/	3.2/			
1N3108	S	RE				800	1.5	100/	1.6/			
1N3109	S	RE				1.2K	.7	100/	3.2/			
1N3110	G	SD		1N4305		8		20/8	.45/5			
1N3112	S	ZD		1N4737A	1W						7.4/120	5
1N3121	G	SD		1N4305		50		3.5/50	.25/.1			
1N3122	G	SD		1N4305		20		4.5/20	.3/1			
1N3123	S	SD		1N4305		40		.1/40	1.5/10			
1N3124	S	SD		1N4151		40		.1/40	1/20			
1N3125	G	SD		1N4305		40		100/40	.4/5			
1N3139	S	RE				50	70	15M/	1.5/			
1N3140	S	RE				100	70	15M/	1.5/			
1N3141	S	RE				150	70	15M/	1.5/			
1N3142	S	RE				200	70	15M/	1.5/			
1N3144	G	SD		1N4305		20		20/	.3/1			
1N3145	G	SD		1N4305		65		25/	.45/10			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3146	G	SD		1N4154		20		100/	1/50			
1N3147	S	SD		1N4448		45			1/100			
1N3148	S	RD									8.5/10	
1N3154	S	RD			400						8.8/10	5
1N3154A	S	RD			400						8.8/10	5
1N3155	S	RD			400						8.8/10	5
1N3155A	S	RD			400						8.8/10	5
1N3156	S	RD			400						8.8/10	5
1N3156A	S	RD			400						8.8/10	5
1N3157	S	RD			400						8.8/10	5
1N3157A	S	RD			400						8.8/10	5
1N3159	G	SD		1N4305		15		100/10	.45/10	300		
1N3160	G	SD		1N4305		60		12/	.45/10			
1N3161	S	RE				50	240	16M/	1.3/			
1N3162	S	RE				100	240	16M/	1.3/			
1N3163	S	RE				150	240	16M/	1.3/			
1N3164	S	RE				200	240	16M/	1.3/			
1N3165	S	RE				250	240	16M/	1.3/			
1N3166	S	RE				300	240	16M/	1.3/			
1N3167	S	RE				350	240	16M/	1.3/			
1N3168	S	RE				400	240	16M/	1.3/			
1N3169	S	RE				500	240	16M/	1.3/			
1N3170	S	RE				600	240	16M/	1.3/			
1N3171	S	RE				700	240	16M/	1.9/			
1N3171A	S	RE				700	240	16M/	1.9/			
1N3172	S	RE				800	240	16M/	1.9/			
1N3172A	S	RE				800	240	16M/	1.9/			
1N3173	S	RE				900	240	16M/	1.9/			
1N3173A	S	RE				900	240	16M/	1.9/			
1N3174	S	RE				1K	240	16M/	1.9/			
1N3174A	S	RE				1K	240	16M/	1.9/			
1N3175	S	RE				1.2K	240	15M/	1.4/			
1N3176	S	RE				1.4K	240	15M/	1.4/			
1N3177	S	RE				1.6K	240	15M/	1.4/			
1N3179	S	SD		1N4938		240		10/200	1/100			
1N3180	S	SD		1N4938		130		5/100	1.5/500			
1N3181	S	ZD		1N4737	600						7.7/14	10
1N3190	S	RE		1N4004		400	1	5/400	1.1/1A			
1N3191	S	RE		1N4005		600	1	5/600	1.1/1A			
1N3192	S	RE		1N645		200		10/200	1/100			

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1N3193	S	RE		1N4003		200	.75	5/200	1.2/750			
1N3194	S	RE		1N4004		400	.75	5/200	1.2/750			
1N3195	S	RE		1N4005		600	.75	5/200	1.2/750			
1N3196	S	RE		1N4006		800	.75	5/200	1.2/750			
1N3197	G	SD		1N4148		30		50/10	.4/5	300		
1N3198	S	ZD			400						2.25/10	2
1N3199	S	RD			270						8.8/10	5
1N3200	S	RD			270						8.8/10	5
1N3201	S	RD			270						8.8/10	5
1N3202	S	RD			270						8.8/10	5
1N3203	G	SD		1N4305		25		50/25	.5/35	300		
1N3204	S	SD		1N4305		60		50/25	.4/35	300		
1N3206	S	SD		1N4531		80		30N/20	1/10	4		
1N3207	S	SD		1N4607		50		50N/20	1/150	6		
1N3208	S	RE				50	15	10M/	1.5/			
1N3209	S	RE				100	15	10M/	1.5/			
1N3210	S	RE				200	15	10M/	1.5/			
1N3211	S	RE				300	15	10M/	1.5/			
1N3212	S	RE				400	15	10M/	1.5/			
1N3213	S	RE				500	15	10M/	1.5/			
1N3214	S	RE				600	15	10M/	1.5/			
1N3215	S	SD		1N4152		80		10/50	.7/1			
1N3223	S	SD		1N4938		150		20/125	1.5/4	800		
1N3225	G	SD		1N4148		40		33/10	1/5	500		
1N3227	S	RE		1N4002		100	.5	250/100	3.3/500			
1N3228	S	RE		1N4003		200	.5	250/200	3.3/500			
1N3229	S	RE		1N4004		400	.5	250/400	3.3/500			
1N3230	S	RE		1N4005		600	.5	250/600	3.3/500			
1N3231	S	RE		1N4006		800	.5	250/800	3.3/500			
1N3232	S	RE		1N4007		1K	.5	250/1K	3.3/500			
1N3233	S	RE				1.2K	.5	250/	3.3/			
1N3234	S	RE				1.5K	.5	250/	3.3/			
1N3235	S	RE				1.8K	.5	250/	3.3/			
1N3236	S	RE				2K	.5	250/	3.3/			
1N3237	S	RE		1N4001		50	.75	250/50	2.2/750			
1N3238	S	RE		1N4002		100	.75	250/100	2.2/750			
1N3239	S	RE		1N4003		200	.75	250/200	2.2/750			
1N3240	S	RE		1N4004		400	.75	250/400	2.2/750			
1N3241	S	RE		1N4005		600	.75	250/600	2.2/750			
1N3242	S	RE		1N4006		800	.75	250/800	2.2/750			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R μA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3243	S	RE		1N4007		1K	.75	250/1K	2.2/750			
1N3244	S	RE				1.2K	.75		2.2/750			
1N3245	S	RE				1.5K	.75		2.2/750			
1N3246	S	RE		1N4001		50	1	250/50	1.1/1A			
1N3247	S	RE		1N4002		100	1	250/100	1.1/1A			
1N3248	S	RE		1N4003		200	1	250/200	1.1/1A			
1N3249	S	RE		1N4004		400	1	250/400	1.1/1A			
1N3250	S	RE		1N4005		600	1	250/600	1.1/1A			
1N3251	S	RE		1N4006		800	1	250/800	1.1/1A			
1N3252	S	RE		1N4007		1K	1	250/1K	1.1/1A			
1N3253	S	RE		1N4003		200	.75	200/200	1.2/750			
1N3254	S	RE		1N4004		400	.75	200/400	1.2/750			
1N3255	S	RE		1N4005		600	.75	200/600	1.2/750			
1N3256	S	RE		1N4006		800	.75	200/800	1.2/750			
1N3257	S	SD		1N4449		80		25N/50	1/30	3		
1N3258	S	SD		1N4448		80		25N/50	1/100	4		
1N3260	S	RE				50	160	12M/	1.6/			
1N3261	S	RE				100	160	12M/	1.6/			
1N3262	S	RE				150	160	12M/	1.6/			
1N3263	S	RE				200	160	12M/	1.6/			
1N3264	S	RE				250	160	12M/	1.6/			
1N3265	S	RE				300	160	12M/	1.6/			
1N3266	S	RE				350	160	12M/	1.6/			
1N3267	S	RE				400	160	12M/	1.6/			
1N3268	S	RE				500	160	12M/	1.6/			
1N3269	S	RE				600	160	12M/	1.6/			
1N3270	S	RE				700	160	12M/	1.6/			
1N3271	S	RE				800	160	12M/	1.6/			
1N3272	S	RE				900	160	12M/	1.6/			
1N3273	S	RE				1K	160	12M/	1.6/			
1N3274	S	RE				1.2K	160	12M/	1.6/			
1N3275	S	RE				1.4K	160	12M/	1.6/			
1N3276	S	RE				1.6K	160	12M/	1.6/			
1N3277	S	RE		1N4003		200	.75	5/200	1.3/750			
1N3278	S	RE		1N4004		400	.75	5/400	1.3/750			
1N3279	S	RE		1N4005		600	.75	5/600	1.3/750			
1N3280	S	RE		1N4006		800	.75	5/800	1.3/750			
1N3281	S	RE		1N4007		1K	.75	5/1K	1.3/750			
1N3282	S	RE		1N4007		1K	.1	1/1K	3.7/100			
1N3283	S	RE				1.5K	.1	1/	3.7/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3284	S	RE				2K	.1	1/	3.7/			
1N3285	S	RE				2.5K	.1	1/	3.7/			
1N3286	S	RE				3K	.1	1/	3.7/			
1N3287	G	SD				6		15/	.32/1			
1N3287W	G	SD				6		15/	.32/1			
1N3288	S	RE				100	100	24M/	1.5/			
1N3288A	S	RE				100	100	24M/	1.2/			
1N3289	S	RE				200	100	24M/	1.5/			
1N3289A	S	RE				200	100	24M/	1.2/			
1N3290	S	RE				300	100	24M/	1.5/			
1N3290A	S	RE				300	100	24M/	1.2/			
1N3291	S	RE				400	100	24M/	1.5/			
1N3291A	S	RE				400	100	24M/	1.2/			
1N3292	S	RE				500	100	21M/	1.5/			
1N3292A	S	RE				500	100	21M/	1.2/			
1N3292B	S	RE				500	100	21M/	1.5/			
1N3293	S	RE				600	100	17M/	1.5/			
1N3293A	S	RE				600	100	17M/	1.2/			
1N3294	S	RE				800	100	13M/	1.5/			
1N3294A	S	RE				800	100	13M/	1.2/			
1N3295	S	RE				1K	100	11M/	1.5/			
1N3295A	S	RE				1K	100	11M/	1.2/			
1N3296	S	RE				1.2K	100	9M/	1.5/			
1N3296A	S	RE				1.2K	100	9M/	1.2/			
1N3297	S	RE				1.4K	100	7M/	1.5/			
1N3297A	S	RE				1.4K	100	7M/	1.2/			
1N3298	S	SD		1N4608		70		.2/60	.9/500	200		
1N3298A	S	SD		1N4608		70		.2/60	.9/500	20		
1N3354	S	RE				10	3	20/	1.2/			
1N3355	S	RE				15	3	20/	1.2/			
1N3356	S	RE				25	3	10/	1.2/			
1N3357	S	RE				50	3	10/	1.2/			
1N3358	S	RE				75	3	10/	1.2/			
1N3359	S	RE				100	3	10/	1.2/			
1N3360	S	RE				150	3	10/	1.2/			
1N3361	S	RE				200	3	10/	1.2/			
1N3362	S	RE				300	3	10/	1.2/			
1N3363	S	RE				400	3	10/	1.2/			
1N3364	S	RE				500	3	10/	1.2/			
1N3365	S	RE				600	3	10/	1.2/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3366	S	RE				700	3	10/	1.2/			
1N3367	S	RE				800	3	10/	2/			
1N3368	S	RE				900	3	10/	2/			
1N3369	S	RE				1K	3	25/	2.5/			
1N3370	S	RE				1.2K	3	25/	2.5/			
1N3371	S	RE				1.5K	3	25/	2.5/			
1N3372	S	RE				10	20	315/	1/			
1N3373	S	RE				25	20	315/	1/			
1N3374	S	RE				50	20	315/	1/			
1N3375	S	RE				100	20	315/	1/			
1N3376	S	RE				150	20	315/	1/			
1N3377	S	RE				200	20	315/	1/			
1N3378	S	RE				300	20	315/	1/			
1N3379	S	RE				400	20	315/	1/			
1N3380	S	RE				500	20	315/	1/			
1N3381	S	SD				15		10/	1/500			
1N3382	S	SD				15		10/	1/500			
1N3383	S	SD				50		10/	1/500			
1N3384	S	SD				75		10/	1/500			
1N3385	S	SD				100		20/	1/500			
1N3386	S	SD				150		20/	1/500			
1N3387	S	SD				200		20/	1/500			
1N3388	S	SD				250		25/	1/500			
1N3389	S	SD				300		25/	1/500			
1N3390	S	SD				400		25/	1/500			
1N3391	S	SD				500		25/	1/500			
1N3392	S	ZD			500						1.5/50	10
1N3393	S	ZD			500						1.8/50	10
1N3394	S	ZD			500						2.2/50	10
1N3395	S	ZD			500						2.7/50	10
1N3396	S	ZD			500						3.3/30	10
1N3397	S	ZD			500						3.9/30	10
1N3398	S	ZD			500						4.7/30	10
1N3399	S	ZD			500						5.6/20	10
1N3400	S	ZD			500						6.8/20	10
1N3401	S	ZD			500						8.2/10	10
1N3402	S	ZD			500						10/10	10
1N3403	S	ZD			500						12/10	10
1N3404	S	ZD			500						15/10	10
1N3405	S	ZD			500						18/10	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R (V)	V_F (V)	@ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N3406	S	ZD			500								22/3	10
1N3407	S	ZD			500								27/3	10
1N3408	S	ZD			500								33/3	10
1N3409	S	ZD			500								39/1.5	10
1N3410	S	ZD			500								47/1.5	10
1N3411	S	ZD			500								6.2/1	10
1N3412	S	ZD			500								6.8/1	10
1N3413	S	ZD			500								7.5/1	10
1N3414	S	ZD			500								8.2/1	10
1N3415	S	ZD			500								10/1	10
1N3416	S	ZD			500								12/1	10
1N3417	S	ZD			500								15/1	10
1N3418	S	ZD			500								18/1	10
1N3419	S	ZD			500								22/1	10
1N3420	S	ZD			500								27/1	10
1N3421	S	ZD			500								30/1	10
1N3422	S	ZD			500								33/1	10
1N3423	S	ZD			500								39/1	10
1N3424	S	ZD			500								47/1	10
1N3425	S	ZD			500								56/1	10
1N3426	S	ZD			500								68/1	10
1N3427	S	ZD			500								82/1	10
1N3428	S	ZD			500								100/1	10
1N3429	S	ZD			500								120/1	10
1N3430	S	ZD			500								150/1	10
1N3431	S	ZD			500								180/1	10
1N3432	S	ZD			500								220/1	10
1N3433	S	ZD			500								82/25	10
1N3434	S	ZD			2W								10/25	10
1N3435	S	ZD			2W								12/25	10
1N3436	S	ZD			2W								15/25	10
1N3437	S	ZD			2W								18/25	10
1N3438	S	ZD			2W								22/7.5	10
1N3439	S	ZD			2W								27/7.5	10
1N3440	S	ZD			2W								33/7.5	10
1N3441	S	ZD			2W								39/7.5	10
1N3442	S	ZD			2W								47/7.5	10
1N3443	S	ZD			2W								6.2/2	10
1N3444	S	ZD			2W								6.8/2	10
1N3445	S	ZD			2W								8.2/2	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I_O (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3446	S	ZD			2W						10/2	10
1N3447	S	ZD			2W						12/2	10
1N3448	S	ZD			2W						15/2	10
1N3449	S	ZD			2W						18/2	10
1N3450	S	ZD			2W						22/2	10
1N3451	S	ZD			2W						27/2	10
1N3452	S	ZD			2W						30/2	10
1N3453	S	ZD			2W						33/2	10
1N3454	S	ZD			2W						39/2	10
1N3455	S	ZD			2W						47/2	10
1N3456	S	ZD			2W						56/2	10
1N3457	S	ZD			2W						68/2	10
1N3458	S	ZD			2W						82/2	10
1N3459	S	ZD			2W						100/2	10
1N3460	S	ZD			2W						120/2	10
1N3461	S	ZD			2W						150/2	10
1N3462	S	ZD			2W						180/2	10
1N3463	S	ZD			2W						220/2	10
1N3464	S	RE				12K	.1	.2/12K	24/60			
1N3465	G	SD		TID33		60		20/45	1/200			
1N3466	G	SD		TID33		40		15/30	1/200			
1N3467	G	SD		1N4446		18		15/15	.5/20	2		
1N3468	G	SD		1N4446		18		60/15	.5/20	2		
1N3469	G	SD		1N4608		35		15/35	1/600			
1N3470	G	SD		1N4608		35		30/35	1/600			
1N3471	S	SD		1N4148		40		20N/40	1/10	2		
1N3473	S	RE		1N4003		200	.75	500/200	1.4/750			
1N3474	S	RE		1N4004		400	.75	500/400	1.4/750			
1N3475	S	RE		1N4005		600	.75	500/600	1.4/750			
1N3476	S	RE		1N4006		800	.5	500/800	1.4/500			
1N3477	S	ZD			250						2.2/5	10
1N3477A	S	ZD			250						2.2/5	5
1N3478	S	SD		1N4003		200		10/200	1/500			
1N3479	S	SD		1N4004		400		10/400	1/500			
1N3480	S	SD		1N4005		600		10/600	1/500			
1N3483	G	SD		1N4305		8		30/8	.6/10			
1N3484	G	SD		1N4305		75		4/10	.45/10			
1N3485	S	SD		1N4938		175		25N/150	1/10	50		
1N3486	S	RE		1N4007		1K	.4	50/1K	2/400			
1N3487	S	RE				1.2K	.4	50/	2/400			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3491	S	RE				50	18	1M/	1.7/			
1N3492	S	RE				100	18	1M/	1.7/			
1N3493	S	RE				200	18	1M/	1.7/			
1N3494	S	RE				300	18	1M/	1.7/			
1N3495	S	RE				400	18	1M/	1.7/			
1N3496	S	RD			250						6.2/7.5	
1N3497	S	RD			250						6.2/7.5	
1N3498	S	RD			250						6.2/7.5	
1N3499	S	RD			250						6.2/7.5	
1N3500	S	RD			250						6.2/7.5	
1N3501	S	RD			250						6.35/7.5	
1N3502	S	RD			250						6.35/7.5	
1N3503	S	RD			250						6.35/7.5	
1N3504	S	RD			250						6.35/7.5	
1N3504A	S	RD			250						6.35/7.5	
1N3506	S	ZD	1N3506		400						3.3/20	5
1N3507	S	ZD	1N3507		400						3.6/20	5
1N3508	S	ZD	1N3508		400						3.9/20	5
1N3509	S	ZD	1N3509		400						4.3/20	5
1N3510	S	ZD	1N3510		400						4.7/20	5
1N3511	S	ZD	1N3511		400						5.1/20	5
1N3512	S	ZD	1N3512		400						5.6/20	5
1N3513	S	ZD	1N3513		400						6.2/20	5
1N3514	S	ZD	1N3514		400						6.8/20	5
1N3515	S	ZD	1N3515		400						7.5/10	5
1N3516	S	ZD	1N3516		400						8.2/10	5
1N3517	S	ZD	1N3517		400						9.1/10	5
1N3518	S	ZD	1N3518		400						10/10	5
1N3519	S	ZD	1N3519		400						11/10	5
1N3520	S	ZD	1N3520		400						12/10	5
1N3521	S	ZD	1N3521		400						13/10	5
1N3522	S	ZD	1N3522		400						15/5	5
1N3523	S	ZD	1N3523		400						16/5	5
1N3524	S	ZD	1N3524		400						18/5	5
1N3525	S	ZD	1N3525		400						20/5	5
1N3526	S	ZD	1N3526		400						22/5	5
1N3527	S	ZD	1N3527		400						24/5	5
1N3528	S	ZD	1N3528		400						27/4	5
1N3529	S	ZD	1N3529		400						30/4	5
1N3530	S	ZD	1N3530		400						33/3	5

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R μA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3531	S	ZD			400						36/3	5
1N3532	S	ZD			400						39/3	5
1N3533	S	ZD			400						43/2	5
1N3534	S	ZD			400						47/2	5
1N3535	S	SD		1N4938		200		1/150	.55/1			
1N3536	S	SD		1N457		70		25N/60	.62/1			
1N3537	S	ZD		1N4742	1W						12/25	10
1N3538	S	SD				150		2/150	2.3/2.5			
1N3544	S	RE		1N4002		100	.6	.2/100	1.5/500			
1N3545	S	RE		1N4003		200	.6	.2/200	1.5/500			
1N3546	S	RE		1N4004		300	.6	.2/300	1.5/500			
1N3547	S	RE		1N4004		400	.6	.2/400	1.5/500			
1N3548	S	RE		1N4005		500	.6	.2/500	1.5/500			
1N3549	S	RE		1N4005		600	.6	.2/600	1.5/500			
1N3550	S	SD		1N4938		180		200/180	1/50	1U		
1N3553	S	RD			250						6.3/7.5	3
1N3558	S	ZD		1N751A							10.3/15	3
1N3559	G	SD				24		20/	1/200			
1N3563	S	RE		1N4007		1K	.4	200/1K	1.2/400			
1N3564	G	SD		1N4448		15		20/10	1/40			
1N3565	S	SD				6		25M/	2/2A			
1N3566	S	RE				800	1	500/	2.2/1			
1N3567	S	SD		1N4448		75		.05/50	1/100	2		
1N3568	S	SD		1N4449		80		1/50	1/20	2		
1N3569	S	RE				100	3.5	400/	1.3/			
1N3570	S	RE				200	3.5	400/	1.3/			
1N3571	S	RE				300	3.5	400/	1.3/			
1N3572	S	RE				400	3.5	400/	1.3/			
1N3573	S	RE				500	3.5	400/	1.3/			
1N3574	S	RE				600	3.5	400/	1.3/			
1N3575	S	SD		1N483		60		.7N/50	.74/1			
1N3576	S	SD		1N484		125		.7N/125	.74/1			
1N3575	S	SD		1N485		175		.7N/175	.74/1			
1N3578	S	SD		1N645		225		.7N/225	.74/1			
1N3579	S	SD		1N647		275		.7N/275	.74/1			
1N3580	S	RD			750						11.7/7.5	
1N3580A	S	RD			750						11.7/7.5	
1N3580B	S	RD			750						11.7/7.5	
1N3581	S	RD			750						11.7/7.5	
1N3581A	S	RD			750						11.7/7.5	

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3581B	S	RD			750						11.7/7.5	
1N3582	S	RD			750						11.7/7.5	
1N3582A	S	RD			750						11.7/7.5	
1N3582B	S	RD			750						11.7/7.5	
1N3583	S	RD			750						11.7/7.5	
1N3583A	S	RD			750						11.7/7.5	
1N3583B	S	RD			750						11.7/7.5	
1N3584	S	RD			750						11.7/7.5	
1N3584A	S	RD			750						11.7/7.5	
1N3584B	S	RD			750						11.7/7.5	
1N3585	S	RE				50	400	25M/	1.2/			
1N3586	S	RE				100	400	25M/	1.2/			
1N3587	S	RE				200	400	25M/	1.2/			
1N3588	S	RE				300	400	25M/	1.2/			
1N3589	S	RE				400	400	25M/	1.2/			
1N3590	S	RE				500	400	25M/	1.2/			
1N3591	S	RE				600	400	25M/	1.2/			
1N3592	G	SD		1N4305		30		4/20	.35/2	70		
1N3593	S	SD		1N4531		40		25N/40	1/10			
1N3594	S	SD		1N4532		60		.1/50	1/50	6		
1N3595	S	SD		1N485		125		1N/125	1/200			
1N3596	S	SD		1N4449		20		.1/20	1/30	4		
1N3597	S	SD		1N4938		150		.1/150	1.2/400	300		
1N3598	S	SD		1N4152		75		.1/50	.85/10	4		
1N3599	S	SD		1N4938		200		.1/150	1/100	50		
1N3600	S	SD		1N4150		50		.1/50	1/200	4		
1N3601	S	SD		1N4149		100		.1/75	1/10	5		
1N3602	S	SD		1N4151		75		.1/50	1/20	5		
1N3603	S	SD		1N4151		50		.1/30	1/30	5		
1N3604	S	SD		1N4151		75		.05/50	1/50	4		
1N3605	S	SD		1N4152		40		.05/30	.55/.1	4		
1N3606	S	SD		1N4153		75		.05/50	.55/.1	4		
1N3607	S	SD		1N4151		75		.05/50	1/50	4		
1N3608	S	SD		1N4152		40		.05/30	.55/.1	4		
1N3609	S	SD		1N4153		75		.05/50	.55/.1	4		
1N3611	S	SD				200	2	10/	1/750			
1N3612	S	SD				400	2	10/	1/750			
1N3613	S	SD				600	2	10/	1/750			
1N3614	S	SD				800	2	10/	1/750			
1N3625	S	SD		1N4938		225		.5/200	1/40	500		

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3626	G	SD				50		1M/	.5/10			
1N3629	S	RE		1N4002		100	.75	10/70	1/750			
1N3630	S	RE		1N4003		200	.75	10/140	1/750			
1N3631	S	RE		1N4004		300	.75	10/210	1/750			
1N3632	S	RE		1N4004		400	.75	10/280	1/750			
1N3633	S	RE		1N4005		500	.75	10/350	1/750			
1N3634	S	RE		1N4005		600	.75	10/420	1/750			
1N3635	S	RE		1N4006		700	.75	10/490	1/750			
1N3636	S	RE		1N4006		800	.75	10/560	1/750			
1N3637	S	RE		1N4007		900	.75	10/630	1/750			
1N3638	S	RE		1N4007		1K	.75	10/700	1/750			
1N3639	S	RE		1N4003		200	.75	200/200	1.2/750			
1N3640	S	RE		1N4004		400	.75	200/400	1.2/750			
1N3641	S	RE		1N4005		600	.75	200/600	1.2/750			
1N3642	S	RE		1N4006		800	.75	200/800	1.2/750			
1N3643	S	SD				1K		5/	5/250			
1N3644	S	SD				1.5K		5/	5/250			
1N3645	S	SD				1K		5/	5/250			
1N3646	S	SD				2.5K		5/	5/250			
1N3647	S	SD				3K		5/	5/250			
1N3648	S	RE				10K	.35	500/	23/			
1N3649	S	RE				800	1	5/	1.1/1			
1N3650	S	RE				1K	1	5/	1.1/1			
1N3653	S	SD				100		25N/75	1/400	4		
1N3654	S	SD				100		25N/75	1/50	4		
1N3656	S	SD		1N4003		200	1	10/200	1.2/500			
1N3657	S	SD		1N4004		400	1	10/400	1.2/500			
1N3658	S	SD		1N4005		600	1	10/600	1.2/500			
1N3666	G	SD		1N4305		80		10/20	.4/5	300		
1N3666M	G	SD		1N4607		80		150/20	1/200			
1N3667	S	RE				500	1.5	1M/	1.2/			
1N3668	S	SD		1N4305		30		.1/15	1/5	150		
1N3669	S	SD		1N4607		70	.4	.25/	1.1/400	200		
1N3675	S	ZD		1N4736	750						6.8/19	20
1N3675A	S	ZD		1N4736	750						6.8/19	10
1N3675B	S	ZD		1N4736A	750						6.8/19	5
1N3676	S	ZD		1N4737	750						7.5/17	20
1N3676A	S	ZD		1N4737	750						7.5/17	10
1N3676B	S	ZD		1N4737A	750						7.5/17	5
1N3677	S	ZD		1N4738	750						8.2/15	20

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R (V)	V_F (V)	@ I_F (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3677A	S	ZD		1N4738	750								8.2/15	10
1N3677B	S	ZD		1N4738A	750								8.2/15	5
1N3678	S	ZD		1N4739	750								9.1/14	20
1N3678A	S	ZD		1N4739	750								9.1/14	10
1N3678B	S	ZD		1N4739A	750								9.1/14	5
1N3679	S	ZD		1N4740	750								10/13	20
1N3679A	S	ZD		1N4740	750								10/13	10
1N3679B	S	ZD		1N4740A	750								10/13	5
1N3680	S	ZD		1N4741	750								11/12	20
1N3680A	S	ZD		1N4741	750								11/12	10
1N3680B	S	ZD		1N4741A	750								11/12	5
1N3681	S	ZD		1N4742	750								12/11	20
1N3681A	S	ZD		1N4742	750								12/11	10
1N3681B	S	ZD		1N4742A	750								12/11	5
1N3682	S	ZD		1N4743	750								13/9.5	20
1N3682A	S	ZD		1N4743	750								13/9.5	10
1N3682B	S	ZD		1N4743A	750								13/9.5	5
1N3683	S	ZD		1N4744	750								15/8.5	20
1N3683A	S	ZD		1N4744	750								15/8.5	10
1N3683B	S	ZD		1N4744A	750								15/8.5	5
1N3684	S	ZD		1N4745	750								16/7.8	20
1N3684A	S	ZD		1N4745	750								16/7.8	10
1N3684B	S	ZD		1N4745A	750								16/7.8	5
1N3685	S	ZD		1N4746	750								18/7	20
1N3685A	S	ZD		1N4746	750								18/7	10
1N3685B	S	ZD		1N4746A	750								18/7	5
1N3686	S	ZD		1N4747	750								20/6.2	20
1N3686A	S	ZD		1N4747	750								20/6.2	10
1N3686B	S	ZD		1N4747A	750								20/6.2	5
1N3687	S	ZD		1N4748	750								22/5.6	20
1N3687A	S	ZD		1N4748	750								22/5.6	10
1N3687B	S	ZD		1N4748A	750								22/5.6	5
1N3688	S	ZD		1N4749	750								24/5.2	20
1N3688A	S	ZD		1N4749	750								24/5.2	10
1N3688B	S	ZD		1N4749A	750								24/5.2	5
1N3689	S	ZD		1N4750	750								27/4.6	20
1N3689A	S	ZD		1N4750	750								27/4.6	10
1N3689B	S	ZD		1N4750A	750								27/4.6	5
1N3690	S	ZD		1N4751	750								30/4.2	20
1N3690A	S	ZD		1N4751	750								30/4.2	10

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS						
					P_D (mW)	V_R (V)	I (A)	I_R µA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N3690B	S	ZD		1N4751A	750								30/4.2	5
1N3691	S	ZD		1N4752	750								33/3.8	20
1N3691A	S	ZD		1N4752	750								33/3.8	10
1N3691B	S	ZD		1N4752A	750								33/3.8	5
1N3692	S	ZD			750								36/3.4	20
1N3692A	S	ZD			750								36/3.4	10
1N3692B	S	ZD			750								36/3.4	5
1N3693	S	ZD			750								39/3.2	20
1N3693A	S	ZD			750								39/3.2	10
1N3693B	S	ZD			750								39/3.2	5
1N3694	S	ZD			750								43/3	20
1N3694A	S	ZD			750								43/3	10
1N3694B	S	ZD			750								43/3	5
1N3695	S	ZD			750								47/2.7	20
1N3695A	S	ZD			750								47/2.7	10
1N3695B	S	ZD			750								47/2.7	5
1N3696	S	ZD			750								51/2.5	20
1N3696A	S	ZD			750								51/2.5	10
1N3696B	S	ZD			750								51/2.5	5
1N3697	S	ZD			750								56/2.2	20
1N3697A	S	ZD			750								56/2.2	10
1N3697B	S	ZD			750								56/2.2	5
1N3698	S	ZD			750								62/2	20
1N3698A	S	ZD			750								62/2	10
1N3698B	S	ZD			750								62/2	5
1N3699	S	ZD			750								68/1.8	20
1N3699A	S	ZD			750								68/1.8	10
1N3699B	S	ZD			750								68/1.8	5
1N3700	S	ZD			750								75/1.7	20
1N3700A	S	ZD			750								75/1.7	10
1N3700B	S	ZD			750								75/1.7	5
1N3701	S	ZD			750								82/1.5	20
1N3701A	S	ZD			750								82/1.5	10
1N3701B	S	ZD			750								82/1.5	5
1N3702	S	ZD			750								91/1.4	20
1N3702A	S	ZD			750								91/1.4	10
1N3702B	S	ZD			750								91/1.4	5
1N3703	S	ZD			750								100/1.3	20
1N3703A	S	ZD			750								100/1.3	10
1N3703B	S	ZD			750								100/1.3	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3704	S	ZD			750						110/1.1	20
1N3704A	S	ZD			750						110/1.1	10
1N3704B	S	ZD			750						110/1.1	5
1N3705	S	ZD			750						120/1.0	20
1N3705A	S	ZD			750						120/1.0	10
1N3705B	S	ZD			750						120/1.0	5
1N3706	S	ZD			750						130/.95	20
1N3706A	S	ZD			750						130/.95	10
1N3706B	S	ZD			750						130/.95	5
1N3707	S	ZD			750						150/.85	20
1N3707A	S	ZD			750						150/.85	10
1N3707B	S	ZD			750						150/.85	5
1N3708	S	ZD			750						160/.8	20
1N3708A	S	ZD			750						160/.8	10
1N3708B	S	ZD			750						160/.8	5
1N3709	S	ZD			750						180/.68	20
1N3709A	S	ZD			750						180/.68	10
1N3709B	S	ZD			750						180/.68	5
1N3710	S	ZD			750						200/.65	20
1N3710A	S	ZD			750						200/.65	10
1N3710B	S	ZD			750						200/.65	5
1N3711	S	RE				6K	.15	25/	11/			
1N3722	S	SD		1N4531		50		.1/30	1/20	10		
1N3723	S	RE		1N4007		1K	.75	5/1K	2.2/750			
1N3724	S	RE				1.2K	.75	5/	2.2/			
1N3725	S	RE				1.4K	.75	5/	2.2/			
1N3726	S	RE				1.6K	.75	5/	2.2/			
1N3727	S	RE				1.8K	.75	5/	2.2/			
1N3728	S	SD		1N648		550		.1/400	1.2/400			
1N3729	S	SD		1N648		600		.1/500	1/5	500		
1N3730	S	SD		1N4608		80		.1/60	1/750	30		
1N3731	S	SD		1N4153		80		5/80	1/100	3		
1N3732	S	ZD		1N4733A	1W						5.1/40	5
1N3748	S	RE		1N4003		200	.5	5/200	1.5/500			
1N3749	S	RE		1N4004		400	.5	5/400	1.5/500			
1N3750	S	RE		1N4005		600	.5	5/600	1.5/500			
1N3751	S	RE		1N4006		800	.5	5/800	1.5/500			
1N3752	S	RE		1N4007		1K	.5	5/1K	1.5/500			
1N3753	G	SD		1N4148		55		5/55	1/150			
1N3754	S	RE		1N4002		100	.15	300/100	1.2/150			

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA @ V_R / (V)	V_F (V) @ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N3755	S	RE		1N4003		200	.15	300/200	1.2/150			
1N3756	S	RE		1N4004		400	.15	300/400	1.2/150			
1N3757	S	RE		1N4003		200	1	5/200	1/1A			
1N3758	S	RE		1N4004		400	1	5/400	1/1A			
1N3759	S	RE		1N4005		600	1	5/600	1/1A			
1N3760	S	RE		1N4006		800	1	5/800	1/1A			
1N3761	S	RE		1N4007		1K	1	5/1K	1/1A			
1N3762	S	RE				5.3K	.065	5/	12/			
1N3763	S	RD			1.5W						20/10	5
1N3764	S	RE				3K	.2	100/	6.5/			
1N3769	G	SD		1N4305		90		5/5	.5/25			
1N3773	G	SD		1N4305		25		4/3	.35/2	40		
1N3774	S	ZD			340						1.15/10	2
1N3775	S	RE				1.5K	3.3	100/	2.2/			
1N3777	S	SD		1N4148		40		.1/	1.1/10	4		
1N3779	S	RD			400						6.5/7.5	
1N3780	S	RD			400						6.5/7.5	
1N3781	S	RD			400						6.5/7.5	
1N3782	S	RD			400						6.5/7.5	
1N3783	S	RD			400						6.5/7.5	
1N3784	S	RD			400						6.5/7.5	
1N3785	S	ZD		1N4736	1.5W						6.8/55	20
1N3785A	S	ZD		1N4736	1.5W						6.8/55	10
1N3785B	S	ZD		1N4736A	1.5W						6.8/55	5
1N3786	S	ZD		1N4737	1.5W						7.5/50	20
1N3786A	S	ZD		1N4737	1.5W						7.5/50	10
1N3786B	S	ZD		1N4737A	1.5W						7.5/50	5
1N3787	S	ZD		1N4738	1.5W						8.2/46	20
1N3787A	S	ZD		1N4738	1.5W						8.2/46	10
1N3787B	S	ZD		1N4738A	1.5W						8.2/46	5
1N3788	S	ZD		1N4739	1.5W						9.1/41	20
1N3788A	S	ZD		1N4739	1.5W						9.1/41	10
1N3788B	S	ZD		1N4739A	1.5W						9.1/41	5
1N3789	S	ZD		1N4740	1.5W						10/37	20
1N3789A	S	ZD		1N4740	1.5W						10/37	10
1N3789B	S	ZD		1N4740A	1.5W						10/37	5
1N3790	S	ZD		1N4741	1.5W						11/34	20
1N3790A	S	ZD		1N4741	1.5W						11/34	10
1N3790B	S	ZD		1N4741A	1.5W						11/34	5
1N3791	S	ZD		1N4742	1.5W						12/31	20

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R µA @ V_R / (V)	V_F (V) @ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N3791A	S	ZD		1N4742	1.5W						12/31	10
1N3791B	S	ZD		1N4742A	1.5W						12/31	5
1N3792	S	ZD		1N4743	1.5W						13/29	20
1N3792A	S	ZD		1N4743	1.5W						13/29	10
1N3792B	S	ZD		1N4743A	1.5W						13/29	5
1N3793	S	ZD		1N4744	1.5W						15/25	20
1N3793A	S	ZD		1N4744	1.5W						15/25	10
1N3793B	S	ZD		1N4744A	1.5W						15/25	5
1N3794	S	ZD		1N4745	1.5W						16/23	20
1N3794A	S	ZD		1N4745	1.5W						16/23	10
1N3794B	S	ZD		1N4745A	1.5W						16/23	5
1N3795	S	ZD		1N4746	1.5W						18/21	20
1N3795A	S	ZD		1N4746	1.5W						18/21	10
1N3795B	S	ZD		1N4746A	1.5W						18/21	5
1N3796	S	ZD		1N4747	1.5W						20/19	20
1N3796A	S	ZD		1N4747	1.5W						20/19	10
1N3796B	S	ZD		1N4747A	1.5W						20/19	5
1N3797	S	ZD		1N4748	1.5W						22/17	20
1N3797A	S	ZD		1N4748	1.5W						22/17	10
1N3797B	S	ZD		1N4748A	1.5W						22/17	5
1N3798	S	ZD		1N4749	1.5W						24/16	20
1N3798A	S	ZD		1N4749	1.5W						24/16	10
1N3798B	S	ZD		1N4749A	1.5W						24/16	5
1N3799	S	ZD		1N4750	1.5W						27/14	20
1N3799A	S	ZD		1N4750	1.5W						27/14	10
1N3799B	S	ZD		1N4750A	1.5W						27/14	5
1N3800	S	ZD		1N4751	1.5W						30/12	20
1N3800A	S	ZD		1N4751	1.5W						30/12	10
1N3800B	S	ZD		1N4751A	1.5W						30/12	5
1N3801	S	ZD		1N4752	1.5W						33/11	20
1N3801A	S	ZD		1N4752	1.5W						33/11	10
1N3801B	S	ZD		1N4752A	1.5W						33/11	5
1N3802	S	ZD			1.5W						36/10	20
1N3802A	S	ZD			1.5W						36/10	10
1N3802B	S	ZD			1.5W						36/10	5
1N3803	S	ZD			1.5W						39/10	20
1N3803A	S	ZD			1.5W						39/10	10
1N3803B	S	ZD			1.5W						39/10	5
1N3804	S	ZD			1.5W						43/9	20
1N3804A	S	ZD			1.5W						43/9	10

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3804B	S	ZD			1.5W						43/9	5
1N3805	S	ZD			1.5W						47/8	20
1N3805A	S	ZD			1.5W						47/8	10
1N3805B	S	ZD			1.5W						47/8	5
1N3806	S	ZD			1.5W						51/7.4	20
1N3806A	S	ZD			1.5W						51/7.4	10
1N3806B	S	ZD			1.5W						51/7.4	5
1N3807	S	ZD			1.5W						56/6.7	20
1N3807A	S	ZD			1.5W						56/6.7	10
1N3807B	S	ZD			1.5W						56/6.7	5
1N3808	S	ZD			1.5W						62/6	20
1N3808A	S	ZD			1.5W						62/6	10
1N3808B	S	ZD			1.5W						62/6	5
1N3809	S	ZD			1.5W						68/5.5	20
1N3809A	S	ZD			1.5W						68/5.5	10
1N3809B	S	ZD			1.5W						68/5.5	5
1N3810	S	ZD			1.5W						75/5	20
1N3810A	S	ZD			1.5W						75/5	10
1N3810B	S	ZD			1.5W						75/5	5
1N3811	S	ZD			1.5W						82/4.5	20
1N3811A	S	ZD			1.5W						82/4.5	10
1N3811B	S	ZD			1.5W						82/4.5	5
1N3812	S	ZD			1.5W						91/4.1	20
1N3812A	S	ZD			1.5W						91/4.1	10
1N3812B	S	ZD			1.5W						91/4.1	5
1N3813	S	ZD			1.5W						100/3.7	20
1N3813A	S	ZD			1.5W						100/3.7	10
1N3813B	S	ZD			1.5W						100/3.7	5
1N3814	S	ZD			1.5W						110/3.4	20
1N3814A	S	ZD			1.5W						110/3.4	10
1N3814B	S	ZD			1.5W						110/3.4	5
1N3815	S	ZD			1.5W						120/3.1	20
1N3815A	S	ZD			1.5W						120/3.1	10
1N3815B	S	ZD			1.5W						120/3.1	5
1N3816	S	ZD			1.5W						130/2.9	20
1N3816A	S	ZD			1.5W						130/2.9	10
1N3816B	S	ZD			1.5W						130/2.9	5
1N3817	S	ZD			1.5W						150/2.5	20
1N3817A	S	ZD			1.5W						150/2.5	10
1N3817B	S	ZD			1.5W						150/2.5	5

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N3818	S	ZD			1.5W						160/2.3	20
1N3818A	S	ZD			1.5W						160/2.3	10
1N3818B	S	ZD			1.5W						160/2.3	5
1N3819	S	ZD			1.5W						180/2.1	20
1N3819A	S	ZD			1.5W						180/2.1	10
1N3819B	S	ZD			1.5W						180/2.1	5
1N3820	S	ZD			1.5W						200/1.9	20
1N3820A	S	ZD			1.5W						200/1.9	10
1N3820B	S	ZD			1.5W						200/1.9	5
1N3821	S	ZD		1N4728	1W						3.3/76	10
1N3821A	S	ZD		1N4728A	1W						3.3/76	5
1N3822	S	ZD		1N4729	1W						3.6/69	10
1N3822A	S	ZD		1N4729A	1W						3.6/69	5
1N3823	S	ZD		1N4730	1W						3.9/64	10
1N3823A	S	ZD		1N4730A	1W						3.9/64	5
1N3824	S	ZD		1N4731	1W						4.3/58	10
1N3824A	S	ZD		1N4731A	1W						4.3/58	5
1N3825	S	ZD		1N4732	1W						4.7/53	10
1N3825A	S	ZD		1N4732A	1W						4.7/53	5
1N3826	S	ZD		1N4733	1W						5.1/49	10
1N3826A	S	ZD		1N4733A	1W						5.1/49	5
1N3827	S	ZD		1N4734	1W						5.6/45	10
1N3827A	S	ZD		1N4734A	1W						5.6/45	5
1N3828	S	ZD		1N4735	1W						6.2/41	10
1N3828A	S	ZD		1N4735A	1W						6.2/41	5
1N3829	S	ZD		1N4736	1W						6.8/37	10
1N3829A	S	ZD		1N4736A	1W						6.8/37	5
1N3830	S	ZD		1N4737	1W						7.5/34	10
1N3830A	S	ZD		1N4737A	1W						7.5/34	5
1N3864	S	SD		1N458		125		1N/125	1.5/200	900		
1N3865	S	SD		1N4148		80		15/50	1/100	500		
1N3866	S	RE		1N4003		200	1	.01/200	1.1/1A			
1N3867	S	RE		1N4004		400	1	.01/400	1.1/1A			
1N3868	S	RE		1N4005		600	1	.01/600	1.1/1A			
1N3869	S	RE		1N4007		1K	.5	10/1K	3/500			
1N3870	S	RE				1.5K	.5	10/1.5K	3/500			
1N3871	S	RE				2.5K	.25	10/2.5K	6/250			
1N3872	S	SD		TID33		90		.1/75	1/150	15		
1N3873	S	SD		TID33		50		.1/50	.95/150	4		
1N3894	S	SD		1N647		400		.2/400	1/400			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N3895	S	SD		1N647		350		.5/350	1/200			
1N3896	S	ZD			250						.77/50	5
1N3897	S	ZD			250						1.5/30	5
1N3898	S	ZD			250						2/20	5
1N3929	S	SD				1K		10/	2/1A			
1N3930	S	SD				1.5K		10/	2/1A			
1N3931	S	SD				2K		10/	2/1A			
1N3932	S	SD				1.5K		10/	2/1A			
1N3933	S	SD				3K		10/	2/1A			
1N3934	S	RE				1.2K	1	400/	2.5/			
1N3938	S	RE				200	2	400/	1.1/			
1N3939	S	RE				400	2	200/	1.1/			
1N3940	S	RE				600	2	200/	1.1/			
1N3941	S	RE				800	2	200/	1.5/			
1N3942	S	RE				1K	2	200/	1.5/			
1N3943	S	SD		1N4001		3	.75	10/1	3.5/300			
1N3944	G	SD		1N4305		15		2.5/1.5	.75/10	12		
1N3950	S	ZD			1.5W						20/19	5
1N3951	S	ZD			1.5W						25/15	5
1N3952	S	SD		1N4938		150		25N/130	.74/10			
1N3953	G	SD		1N4148		40		50/40	.5/35	300		
1N3954	S	SD		1N4150		50		.1/50	1/200	4		
1N3956	S	SD		1N4305		40		.05/40	.55/.1	2		
1N3957	S	SD				1K	4	10/	1/			
1N3958	S	RE				100	3.5	400/	1.3/	3U		
1N3958C	S	RE				100	3.5	400/	1.3/	1U		
1N3959	S	RE				200	3.5	400/	1.3/	3U		
1N3959C	S	RE				200	3.5	400/	1.3/	1U		
1N3960	S	RE				300	3.5	400/	1.3/	3U		
1N3960C	S	RE				300	3.5	400/	1.3/	1U		
1N3961	S	RE				400	3.5	400/	1.3/	3U		
1N3961C	S	RE				400	3.5	400/	1.3/	1U		
1N3962	S	RE				500	3.5	400/	1.3/	3U		
1N3962C	S	RE				500	3.5	400/	1.3/	1U		
1N3963	S	RE				600	3.5	400/	1.3/	3U		
1N3963C	S	RE				600	3.5	400/	1.3/	1U		
1N3981	S	SD				200	4	10/200	1/900			
1N3982	S	SD				400	4	10/400	1/900			
1N3983	S	SD				600	4	10/600	1/900			
1N3987	S	RE				700	6	900/	1.4/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N3988	S	RE				800	6	800/	1.4/			
1N3989	S	RE				900	6	700/	1.4/			
1N3990	S	RE				1K	6	600/	1.4/			
1N3991	G	SD		1N4305		35		1M/10	.55/30			
1N3992	S	SD				4K	1	5/4K	5/250			
1N4001	S	RE	1N4001			50	1	10/50	1.1/1			
1N4002	S	RE	1N4002			100	1	10/100	1.1/1			
1N4003	S	RE	1N4003			200	1	10/200	1.1/1			
1N4004	S	RE	1N4004			400	1	10/400	1.1/1			
1N4005	S	RE	1N4005			600	1	10/600	1.1/1			
1N4006	S	RE	1N4006			800	1	10/800	1.1/1			
1N4007	S	RE	1N4007			1K	1	10/1K	1.1/1			
1N4008	G	SD		1N4305		12		100/10	.5/10	70		
1N4009	S	SD		1N4154		25		100/25	1/30	4		
1N4010	S	RD			400						6.2/7.5	5
1N4011	S	RE		1N4007		1K	.5	200/1K	1.1/500			
1N4043	S	SD		1N4154		25		.1/25	1/30	2		
1N4057	S	RD			1.5W						12.4/10	
1N4057A	S	RD			1.5W						12.4/10	
1N4058	S	RD			1.5W						14.6/10	
1N4058A	S	RD			1.5W						14.6/10	
1N4059	S	RD			1.5W						16.8/10	
1N4059A	S	RD			1.5W						16.8/10	
1N4060	S	RD			1.5W						18.5/10	
1N4060A	S	RD			1.5W						18.5/10	
1N4061	S	RD			1.5W						21/10	
1N4061A	S	RD			1.5W						21/10	
1N4062	S	RD			1.5W						23/10	
1N4062A	S	RD			1.5W						23/10	
1N4063	S	RD			1.5W						27/10	
1N4063A	S	RD			1.5W						27/10	
1N4064	S	RD			1.5W						30/10	
1N4064A	S	RD			1.5W						30/10	
1N4065	S	RD			1.5W						33/10	
1N4065A	S	RD			1.5W						33/10	
1N4066	S	RD			1.5W						37/7.5	
1N4066A	S	RD			1.5W						37/7.5	
1N4067	S	RD			1.5W						43/7.5	
1N4067A	S	RD			1.5W						43/7.5	
1N4068	S	RD			1.5W						47/7.5	

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA @ / V_R (V)	V_F (V) @ / I_F (mA)	t_{rr} (ns)	V_Z (V) @ / I_Z (mA)	TOL %
1N4068A	S	RD			1.5W						47/7.5	
1N4069	S	RD			2W						51/7.5	
1N4069A	S	RD			2W						51/7.5	
1N4070	S	RD			2W						56/7.5	
1N4070A	S	RD			2W						56/7.5	
1N4071	S	RD			2W						62/7.5	
1N4071A	S	RD			2W						62/7.5	
1N4072	S	RD			2W						68/5	
1N4072A	S	RD			2W						68/5	
1N4073	S	RD			2W						75/5	
1N4073A	S	RD			2W						75/5	
1N4074	S	RD			2W						82/5	
1N4074A	S	RD			2W						82/5	
1N4075	S	RD			2W						87/5	
1N4075A	S	RD			2W						87/5	
1N4076	S	RD			2W						91/5	
1N4076A	S	RD			2W						91/5	
1N4077	S	RD			2W						100/5	
1N4077A	S	RD			2W						100/5	
1N4078	S	RD			2W						105/2.5	
1N4078A	S	RD			2W						105/2.5	
1N4079	S	RD			2W						110/2.5	
1N4079A	S	RD			2W						110/2.5	
1N4080	S	RD			2W						120/2.5	
1N4080A	S	RD			2W						120/2.5	
1N4086	S	SD		TID33		70		.25/70	1/200	200		
1N4087	S	SD		TID33		50		.09/50	.98/30			
1N4088	G	SD		1N4148		30		200/20	1/100			
1N4089	S	RE				400	1.1	200/	1.2/			
1N4092	S	SD						1/	1/5			
1N4093	S	SD				50		1M/	1/5			
1N4094	S	RD			1W						9.6/10	
1N4095	S	ZD		1N751	275						5/5	10
1N4099	S	ZD	1N4099		250						6.8/.25	5
1N4100	S	ZD	1N4100		250						7.5/.25	5
1N4101	S	ZD	1N4101		250						8.2/.25	5
1N4102	S	ZD	1N4102		250						8.7/.25	5
1N4103	S	ZD	1N4103		250						9.1/.25	5
1N4104	S	ZD	1N4104		250						10/.25	5
1N4105	S	ZD	1N4105		250						11/.25	5

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1N4106	S	ZD	1N4106		250						12/.25	5
1N4107	S	ZD			250						13/.25	5
1N4108	S	ZD			250						14/.25	5
1N4109	S	ZD			250						15/.25	5
1N4110	S	ZD			250						16/.25	5
1N4111	S	ZD			250						17/.25	5
1N4112	S	ZD			250						18/.25	5
1N4113	S	ZD			250						19/.25	5
1N4114	S	ZD			250						20/.25	5
1N4115	S	ZD			250						22/.25	5
1N4116	S	ZD			250						24/.25	5
1N4117	S	ZD			250						25/.25	5
1N4118	S	ZD			250						27/.25	5
1N4119	S	ZD			250						28/.25	5
1N4120	S	ZD			250						30/.25	5
1N4121	S	ZD			250						33/.25	5
1N4122	S	ZD			250						36/.25	5
1N4123	S	ZD			250						39/.25	5
1N4124	S	ZD			250						43/.25	5
1N4125	S	ZD			250						47/.25	5
1N4126	S	ZD			250						51/.25	5
1N4127	S	ZD			250						56/.25	5
1N4128	S	ZD			250						60/.25	5
1N4129	S	ZD			250						62/.25	5
1N4130	S	ZD			250						68/.25	5
1N4131	S	ZD			250						75/.25	5
1N4132	S	ZD			250						82/.25	5
1N4133	S	ZD			250						87/.25	5
1N4134	S	ZD			250						91/.25	5
1N4135	S	ZD			250						100/.25	5
1N4139	S	RE				50	3	100/	1/			
1N4140	S	RE				100	3	100/	1/			
1N4141	S	RE				200	3	100/	1/			
1N4142	S	RE				400	3	100/	1/			
1N4143	S	RE				600	3	100/	1/			
1N4144	S	RE				800	3	100/	1/			
1N4145	S	RE				1K	3	100/	1/			
1N4146	S	RE				2K	3	100/	1/			
1N4147	S	SD	1N4147			30		.1/30	1/30	10		
1N4148	S	SD	1N4148			75		25N/20	1/10	4		

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS PD (mW)	RATINGS VR (V)	RATINGS I (A)	CHARACTERISTICS IR @ VR µA / (V)	CHARACTERISTICS VF @ IF (V) / (mA)	CHARACTERISTICS trr (ns)	CHARACTERISTICS VZ @ IZ (V) / (mA)	TOL %
1N4149	S	SD	1N4149			75		25N/20	1/10	4		
1N4150	S	SD	1N4150			50		.1/50	1/200	6		
1N4151	S	SD	1N4151			75		50N/50	1/50	2		
1N4152	S	SD	1N4152			40		50N/30	.88/20	2		
1N4153	S	SD	1N4153			75		50N/50	.88/20	2		
1N4154	S	SD	1N4154			35		.1/25	1/300	4		
1N4155	S	SD		1N647		400		.1/400	1/100	10U		
1N4158	S	ZD		1N4736	1W						6.8/37	20
1N4158A	S	ZD		1N4736	1W						6.8/37	10
1N4158B	S	ZD		1N4736A	1W						6.8/37	5
1N4159	S	ZD		1N4737	1W						7.5/34	20
1N4159A	S	ZD		1N4737	1W						7.5/34	10
1N4159B	S	ZD		1N4737A	1W						7.5/34	5
1N4160	S	ZD		1N4738	1W						8.2/31	20
1N4160A	S	ZD		1N4738	1W						8.2/31	10
1N4160B	S	ZD		1N4738A	1W						8.2/31	5
1N4161	S	ZD		1N4739	1W						9.1/28	20
1N4161A	S	ZD		1N4739	1W						9.1/28	10
1N4161B	S	ZD		1N4739A	1W						9.1/28	5
1N4162	S	ZD		1N4740	1W						10/25	20
1N4162A	S	ZD		1N4740	1W						10/25	10
1N4162B	S	ZD		1N4740A	1W						10/25	5
1N4163	S	ZD		1N4741	1W						11/23	20
1N4163A	S	ZD		1N4741	1W						11/23	10
1N4163B	S	ZD		1N4741A	1W						11/23	5
1N4164	S	ZD		1N4742	1W						12/21	20
1N4164A	S	ZD		1N4742	1W						12/21	10
1N4164B	S	ZD		1N4742A	1W						12/21	5
1N4165	S	ZD		1N4743	1W						13/19	20
1N4165A	S	ZD		1N4743	1W						13/19	10
1N4165B	S	ZD		1N4743A	1W						13/19	5
1N4166	S	ZD		1N4744	1W						15/17	20
1N4166A	S	ZD		1N4744	1W						15/17	10
1N4166B	S	ZD		1N4744A	1W						15/17	5
1N4167	S	ZD		1N4745	1W						16/16	20
1N4167A	S	ZD		1N4745	1W						16/16	10
1N4167B	S	ZD		1N4745A	1W						16/16	5
1N4168	S	ZD		1N4746	1W						18/14	20
1N4168A	S	ZD		1N4746	1W						18/14	10
1N4168B	S	ZD		1N4746A	1W						18/14	5

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA / @ V_R (V)	V_F (V) / @ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N4169	S	ZD		1N4747	1W						20/13	20
1N4169A	S	ZD		1N4747	1W						20/13	10
1N4169B	S	ZD		1N4747A	1W						20/13	5
1N4170	S	ZD		1N4748	1W						22/12	20
1N4170A	S	ZD		1N4748	1W						22/12	10
1N4170B	S	ZD		1N4748A	1W						22/12	5
1N4171	S	ZD		1N4749	1W						24/11	20
1N4171A	S	ZD		1N4749	1W						24/11	10
1N4171B	S	ZD		1N4749A	1W						24/11	5
1N4172	S	ZD		1N4750	1W						27/9.5	20
1N4172A	S	ZD		1N4750	1W						27/9.5	10
1N4172B	S	ZD		1N4750A	1W						27/9.5	5
1N4173	S	ZD		1N4751	1W						30/8.5	20
1N4173A	S	ZD		1N4751	1W						30/8.5	10
1N4173B	S	ZD		1N4751A	1W						30/8.5	5
1N4174	S	ZD		1N4752	1W						33/7.5	20
1N4174A	S	ZD		1N4752	1W						33/7.5	10
1N4174B	S	ZD		1N4752A	1W						33/7.5	5
1N4175	S	ZD			1W						36/7	20
1N4175A	S	ZD			1W						36/7	10
1N4175B	S	ZD			1W						36/7	5
1N4176	S	ZD			1W						39/6.5	20
1N4176A	S	ZD			1W						39/6.5	10
1N4176B	S	ZD			1W						39/6.5	5
1N4177	S	ZD			1W						43/6	20
1N4177A	S	ZD			1W						43/6	10
1N4177B	S	ZD			1W						43/6	5
1N4178	S	ZD			1W						47/5.5	20
1N4178A	S	ZD			1W						47/5.5	10
1N4178B	S	ZD			1W						47/5.5	5
1N4179	S	ZD			1W						51/5	20
1N4179A	S	ZD			1W						51/5	10
1N4179B	S	ZD			1W						51/5	5
1N4180	S	ZD			1W						56/4.5	20
1N4180A	S	ZD			1W						56/4.5	10
1N4180B	S	ZD			1W						56/4.5	5
1N4181	S	ZD			1W						62/4	20
1N4181A	S	ZD			1W						62/4	10
1N4181B	S	ZD			1W						62/4	5
1N4182	S	ZD			1W						68/3.7	20

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4182A	S	ZD			1W						68/3.7	10
1N4182B	S	ZD			1W						68/3.7	5
1N4183	S	ZD			1W						75/3.3	20
1N4183A	S	ZD			1W						75/3.3	10
1N4183B	S	ZD			1W						75/3.3	5
1N4184	S	ZD			1W						82/3	20
1N4184A	S	ZD			1W						82/3	10
1N4184B	S	ZD			1W						82/3	5
1N4185	S	ZD			1W						91/2.8	20
1N4185A	S	ZD			1W						91/2.8	10
1N4185B	S	ZD			1W						91/2.8	5
1N4186	S	ZD			1W						100/2.5	20
1N4186A	S	ZD			1W						100/2.5	10
1N4186B	S	ZD			1W						100/2.5	5
1N4187	S	ZD			1W						110/2.3	20
1N4187A	S	ZD			1W						110/2.3	10
1N4187B	S	ZD			1W						110/2.3	5
1N4188	S	ZD			1W						120/2	20
1N4188A	S	ZD			1W						120/2	10
1N4188B	S	ZD			1W						120/2	5
1N4189	S	ZD			1W						130/1.9	20
1N4189A	S	ZD			1W						130/1.9	10
1N4189B	S	ZD			1W						130/1.9	5
1N4190	S	ZD			1W						150/1.7	20
1N4190A	S	ZD			1W						150/1.7	10
1N4190B	S	ZD			1W						150/1.7	5
1N4191	S	ZD			1W						160/1.6	20
1N4191A	S	ZD			1W						160/1.6	10
1N4191B	S	ZD			1W						160/1.6	5
1N4192	S	ZD			1W						180/1.4	20
1N4192A	S	ZD			1W						180/1.4	10
1N4192B	S	ZD			1W						180/1.4	5
1N4193	S	ZD			1W						200/1.2	20
1N4193A	S	ZD			1W						200/1.2	10
1N4193B	S	ZD			1W						200/1.2	5
1N4242	S	SD				40		.1N/	1/20	2		
1N4243	S	SD				40		.1N/	1/10	2		
1N4244	S	SD				10		.1/	1/20	.75		
1N4245	S	RE		1N4003		200	1	1/200	1.2/1			
1N4246	S	RE		1N4004		400	1	1/400	1.2/1			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N4247	S	RE		1N4005		600	1	1/600	1.2/1			
1N4248	S	RE		1N4006		800	1	1/800	1.2/1			
1N4249	S	RE		1N4007		1K	1	1/1K	1.2/1			
1N4250	S	RE		1N4006		800	.5	1/800	1.2/1			
1N4251	S	RE		1N4007		1K	.5	1/1K	1.2/1			
1N4252	S	RE				1.2K	.5	50/				
1N4253	S	RE				1.5K	.5	50/				
1N4254	S	RE				1.5K	.25	50/	4.8/			
1N4255	S	RE				2K	.25	50/	4.8/			
1N4256	S	RE				2.5K	.25	50/	4.8/			
1N4257	S	RE				3K	.25	50/	4.8/			
1N4295	S	RD			400						10/10	
1N4295A	S	RD			400						10/10	
1N4296	S	RD			1W						10/20	
1N4296A	S	RD			1W						10/20	
1N4305	S	SD	1N4305			75		.1/50	.57/.25	2		
1N4306	S	SD		1N4151		75		50N/50	1/50	2		
1N4307	S	SD		1N4151		75		50N/50	1/50	2		
1N4308	S	SD		1N4150		100		.1/75	1/200	2		
1N4309	S	SD		1N4608		50		.1/30	1/400	2		
1N4310	S	SD		1N4608		75		.1/50	1/400	2		
1N4311	S	SD		1N4607		100		.1/75	1/300	2		
1N4312	S	SD		TID32		150		.1/100	1/200	2		
1N4313	S	SD		1N4151		100		.1/75	1/100	4		
1N4314	S	SD		1N4150		100		.1/75	1/200	2		
1N4315	S	SD		1N4608		50		.1/30	1/400	2		
1N4316	S	SD		1N4608		75		.1/50	1/400	2		
1N4317	S	SD		1N4607		100		.1/75	1/300	2		
1N4318	S	SD		TID32		150		.1/100	1/200	2		
1N4319	S	SD		1N4151		75		.1/50	1/100	4		
1N4322	S	SD		1N4150		50		.1/50	1/200	6		
1N4323	S	ZD		1N4736	1W						6.8/37	20
1N4323A	S	ZD		1N4736	1W						6.8/37	10
1N4323B	S	ZD		1N4736A	1W						6.8/37	5
1N4324	S	ZD		1N4737	1W						7.5/34	20
1N4324A	S	ZD		1N4737	1W						7.5/34	10
1N4324B	S	ZD		1N4737A	1W						7.5/34	5
1N4325	S	ZD		1N4738	1W						8.2/31	20
1N4325A	S	ZD		1N4738	1W						8.2/31	10
1N4325B	S	ZD		1N4738A	1W						8.2/31	5

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4326	S	ZD		1N4739	1W						9.1/28	20
1N4326A	S	ZD		1N4739	1W						9.1/28	10
1N4326B	S	ZD		1N4739A	1W						9.1/28	5
1N4327	S	ZD		1N4740	1W						10/25	20
1N4327A	S	ZD		1N4740	1W						10/25	10
1N4327B	S	ZD		1N4740A	1W						10/25	5
1N4328	S	ZD		1N4741	1W						11/23	20
1N4328A	S	ZD		1N4741	1W						11/23	10
1N4328B	S	ZD		1N4741A	1W						11/23	5
1N4329	S	ZD		1N4742	1W						12/21	20
1N4329A	S	ZD		1N4742	1W						12/21	10
1N4329B	S	ZD		1N4742A	1W						12/21	5
1N4330	S	ZD		1N4743	1W						13/19	20
1N4330A	S	ZD		1N4743	1W						13/19	10
1N4330B	S	ZD		1N4743A	1W						13/19	5
1N4331	S	ZD		1N4744	1W						15/17	20
1N4331A	S	ZD		1N4744	1W						15/17	10
1N4331B	S	ZD		1N4744A	1W						15/17	5
1N4332	S	ZD		1N4745	1W						16/16	20
1N4332A	S	ZD		1N4745	1W						16/16	10
1N4332B	S	ZD		1N4745A	1W						16/16	5
1N4333	S	ZD		1N4746	1W						18/14	20
1N4333A	S	ZD		1N4746	1W						18/14	10
1N4333B	S	ZD		1N4746A	1W						18/14	5
1N4334	S	ZD		1N4747	1W						20/13	20
1N4334A	S	ZD		1N4747	1W						20/13	10
1N4334B	S	ZD		1N4747A	1W						20/13	5
1N4335	S	ZD		1N4748	1W						22/12	20
1N4335A	S	ZD		1N4748	1W						22/12	10
1N4335B	S	ZD		1N4748A	1W						22/12	5
1N4336	S	ZD		1N4749	1W						24/11	20
1N4336A	S	ZD		1N4749	1W						24/11	10
1N4336B	S	ZD		1N4749A	1W						24/11	5
1N4337	S	ZD		1N4750	1W						27/9.5	20
1N4337A	S	ZD		1N4750	1W						27/9.5	10
1N4337B	S	ZD		1N4750A	1W						27/9.5	5
1N4338	S	ZD		1N4751	1W						30/8.5	20
1N4338A	S	ZD		1N4751	1W						30/8.5	10
1N4338B	S	ZD		1N4751A	1W						30/8.5	5
1N4339	S	ZD		1N4752	1W						33/7.5	20

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS						
					P_D (mW)	V_R (V)	I (A)	I_R µA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4339A	S	ZD		1N4752	1W								33/7.5	10
1N4339B	S	ZD		1N4752A	1W								33/7.5	5
1N4340	S	ZD			1W								36/7	20
1N4340A	S	ZD			1W								36/7	10
1N4340B	S	ZD			1W								36/7	5
1N4341	S	ZD			1W								39/6.5	20
1N4341A	S	ZD			1W								39/6.5	10
1N4341B	S	ZD			1W								39/6.5	5
1N4342	S	ZD			1W								43/6	20
1N4342A	S	ZD			1W								43/6	10
1N4342B	S	ZD			1W								43/6	5
1N4343	S	ZD			1W								47/5.5	20
1N4343A	S	ZD			1W								47/5.5	10
1N4343B	S	ZD			1W								47/5.5	5
1N4344	S	ZD			1W								51/5	20
1N4344A	S	ZD			1W								51/5	10
1N4344B	S	ZD			1W								51/5	5
1N4345	S	ZD			1W								56/4.5	20
1N4345A	S	ZD			1W								56/4.5	10
1N4345B	S	ZD			1W								56/4.5	5
1N4346	S	ZD			1W								62/4	20
1N4346A	S	ZD			1W								62/4	10
1N4346B	S	ZD			1W								62/4	5
1N4347	S	ZD			1W								68/3.7	20
1N4347A	S	ZD			1W								68/3.7	10
1N4347B	S	ZD			1W								68/3.7	5
1N4348	S	ZD			1W								75/3.3	20
1N4348A	S	ZD			1W								75/3.3	10
1N4348B	S	ZD			1W								75/3.3	5
1N4349	S	ZD			1W								82/3	20
1N4349A	S	ZD			1W								82/3	10
1N4349B	S	ZD			1W								82/3	5
1N4350	S	ZD			1W								91/2.8	20
1N4350A	S	ZD			1W								91/2.8	10
1N4350B	S	ZD			1W								91/2.8	5
1N4351	S	ZD			1W								100/2.5	20
1N4351A	S	ZD			1W								100/2.5	10
1N4351B	S	ZD			1W								100/2.5	5
1N4352	S	ZD			1W								110/2.3	20
1N4352A	S	ZD			1W								110/2.3	10

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	CHARACTERISTICS TOL %
1N4352B	S	ZD			1W						110/2.3	5
1N4353	S	ZD			1W						120/2	20
1N4353A	S	ZD			1W						120/2	10
1N4353B	S	ZD			1W						120/2	5
1N4354	S	ZD			1W						130/1.9	20
1N4354A	S	ZD			1W						130/1.9	10
1N4354B	S	ZD			1W						130/1.9	5
1N4355	S	ZD			1W						150/1.7	20
1N4355A	S	ZD			1W						150/1.7	10
1N4355B	S	ZD			1W						150/1.7	5
1N4356	S	ZD			1W						160/1.6	20
1N4356A	S	ZD			1W						160/1.6	10
1N4356B	S	ZD			1W						160/1.6	5
1N4357	S	ZD			1W						180/1.4	20
1N4357A	S	ZD			1W						180/1.4	10
1N4357B	S	ZD			1W						180/1.4	5
1N4358	S	ZD			1W						200/1.2	20
1N4358A	S	ZD			1W						200/1.2	10
1N4358B	S	ZD			1W						200/1.2	5
1N4360	S	ZD			250						2.4/10	5
1N4361	S	RE		1N4007		900	.5	500/900	1.3/500			
1N4362	S	SD		1N484		100		10N/50	.9/100			
1N4363	S	SD		1N4938		150		.1/120	1/200	40		
1N4364	S	RE		TID382		100	.75	100/100	1.5/750			
1N4365	S	RE		TID383		200	.75	100/200	1.5/750			
1N4366	S	RE		TID384		300	.75	100/300	1.5/750			
1N4367	S	RE		TID384		400	.75	100/400	1.5/750			
1N4368	S	RE		TID385		500	.75	100/500	1.5/750			
1N4369	S	RE		TID385		600	.75	100/600	1.5/750			
1N4370	S	ZD			400						2.4/20	10
1N4370A	S	ZD			400						2.4/20	5
1N4371	S	ZD			400						2.7/20	10
1N4371A	S	ZD			400						2.7/20	5
1N4372	S	ZD			400						3.0/20	10
1N4372A	S	ZD			400						3.0/20	5
1N4373	S	SD		1N4531		100		25N/20	1/10	4		
1N4374	S	RE				1.5K	.75	100/	1.7/			
1N4375	S	SD		1N4153		60		10N/10	1/20	6		
1N4376	S	SD		TID701		20		.1/10	1.1/50	.75		
1N4377	S	RE				25K	.75	100/	30/			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N4380	S	SD				50		50/50	1.4/570	1.8		
1N4381	G	SD				25		.1M/	.35/2	100		
1N4382	S	SD				55		.1/	1/300	6.5		
1N4383	S	RE		TID383		200	1	275/200	1.3/1A			
1N4384	S	RE		TID384		400	1	250/400	1.3/1A			
1N4385	S	RE		TID385		600	1	225/600	1.3/1A			
1N4389	S	SD		1N4148		5		100/5	1/2			
1N4390	S	SD		TID701		20		.2/5	1/5	.5		
1N4391	S	SD		TID701		20		.2/5	1/2	.5		
1N4392	S	SD		TID701		15		1/5	1/2	.5		
1N4400	S	ZD		1N4736	1W						6.8/37	20
1N4400A	S	ZD		1N4736	1W						6.8/37	10
1N4400B	S	ZD		1N4736A	1W						6.8/37	5
1N4401	S	ZD		1N4737	1W						7.5/34	20
1N4401A	S	ZD		1N4737	1W						7.5/34	10
1N4401B	S	ZD		1N4737A	1W						7.5/34	5
1N4402	S	ZD		1N4738	1W						8.2/31	20
1N4402A	S	ZD		1N4738	1W						8.2/31	10
1N4402B	S	ZD		1N4738A	1W						8.2/31	5
1N4403	S	ZD		1N4739	1W						9.1/28	20
1N4403A	S	ZD		1N4739	1W						9.1/28	10
1N4403B	S	ZD		1N4739A	1W						9.1/28	5
1N4404	S	ZD		1N4740	1W						10/25	20
1N4404A	S	ZD		1N4740	1W						10/25	10
1N4404B	S	ZD		1N4740A	1W						10/25	5
1N4405	S	ZD		1N4741	1W						11/23	20
1N4405A	S	ZD		1N4741	1W						11/23	10
1N4405B	S	ZD		1N4741A	1W						11/23	5
1N4406	S	ZD		1N4742	1W						12/21	20
1N4406A	S	ZD		1N4742	1W						12/21	10
1N4406B	S	ZD		1N4742A	1W						12/21	5
1N4407	S	ZD		1N4743	1W						13/19	20
1N4407A	S	ZD		1N4743	1W						13/19	10
1N4407B	S	ZD		1N4743A	1W						13/19	5
1N4408	S	ZD		1N4744	1W						15/17	20
1N4408A	S	ZD		1N4744	1W						15/17	10
1N4408B	S	ZD		1N4744A	1W						15/17	5
1N4409	S	ZD		1N4745	1W						16/19	20
1N4410	S	ZD		1N4746	1W						18/14	20
1N4410A	S	ZD		1N4746	1W						18/14	10

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4410B	S	ZD		1N4746A	1W						18/14	5
1N4411	S	ZD		1N4747	1W						20/13	20
1N4411A	S	ZD		1N4747	1W						20/13	10
1N4411B	S	ZD		1N4747A	1W						20/13	5
1N4412	S	ZD		1N4748	1W						22/12	20
1N4412A	S	ZD		1N4748	1W						22/12	10
1N4412B	S	ZD		1N4748A	1W						22/12	5
1N4413	S	ZD		1N4749	1W						24/11	20
1N4413A	S	ZD		1N4749	1W						24/11	10
1N4413B	S	ZD		1N4749A	1W						24/11	5
1N4414	S	ZD		1N4750	1W						27/9.5	20
1N4414A	S	ZD		1N4750	1W						27/9.5	10
1N4414B	S	ZD		1N4750A	1W						27/9.5	5
1N4415	S	ZD		1N4751	1W						30/8.5	20
1N4416	S	ZD		1N4752	1W						33/7.5	20
1N4416A	S	ZD		1N4752	1W						33/7.5	10
1N4416B	S	ZD		1N4752A	1W						33/7.5	5
1N4417	S	ZD			1W						36/7	20
1N4417A	S	ZD			1W						36/7	10
1N4417B	S	ZD			1W						36/7	5
1N4418	S	ZD			1W						39/6.5	20
1N4418A	S	ZD			1W						39/6.5	10
1N4418B	S	ZD			1W						39/6.5	5
1N4419	S	ZD			1W						43/6	20
1N4419A	S	ZD			1W						43/6	10
1N4419B	S	ZD			1W						43/6	5
1N4420	S	ZD			1W						47/5.5	20
1N4420A	S	ZD			1W						47/5.5	10
1N4420B	S	ZD			1W						47/5.5	5
1N4421	S	ZD			1W						51/5	20
1N4422	S	ZD			1W						56/4.5	20
1N4422A	S	ZD			1W						56/4.5	10
1N4422B	S	ZD			1W						56/4.5	5
1N4423	S	ZD			1W						62/4	20
1N4423A	S	ZD			1W						62/4	10
1N4423B	S	ZD			1W						62/4	5
1N4424	S	ZD			1W						68/3.7	20
1N4424A	S	ZD			1W						68/3.7	10
1N4424B	S	ZD			1W						68/3.7	5
1N4425	S	ZD			1W						75/3.3	20

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4425A	S	ZD			1W						75/3.3	10
1N4425B	S	ZD			1W						75/3.3	5
1N4426	S	ZD			1W						82/3	20
1N4426A	S	ZD			1W						82/3	10
1N4426B	S	ZD			1W						82/3	5
1N4427	S	ZD			1W						91/2.8	20
1N4428	S	ZD			1W						100/2.5	20
1N4428A	S	ZD			1W						100/2.5	10
1N4428B	S	ZD			1W						100/2.5	5
1N4429	S	ZD			1W						110/2.3	20
1N4429A	S	ZD			1W						110/2.3	10
1N4429B	S	ZD			1W						110/2.3	5
1N4430	S	ZD			1W						120/2	20
1N4430A	S	ZD			1W						120/2	10
1N4430B	S	ZD			1W						120/2	5
1N4431	S	ZD			1W						130/1.9	20
1N4431A	S	ZD			1W						130/1.9	10
1N4431B	S	ZD			1W						130/1.9	5
1N4432	S	ZD			1W						150/1.7	20
1N4432A	S	ZD			1W						150/1.7	10
1N4432B	S	ZD			1W						150/1.7	5
1N4433	S	ZD			1W						160/1.6	20
1N4434	S	ZD			1W						180/1.4	20
1N4434A	S	ZD			1W						180/1.4	10
1N4434B	S	ZD			1W						180/1.4	5
1N4435	S	ZD			1W						200/1.2	20
1N4435A	S	ZD			1W						200/1.2	10
1N4435B	S	ZD			1W						200/1.2	5
1N4436	S	RE				200	10	1M/	1.2/			
1N4437	S	RE				400	10	1M/	1.2/			
1N4438	S	RE				600	10	1M/	1/			
1N4439	S	RE				800	10	1M/	1.2/			
1N4440	S	RE				1K	10	1M/	1.2/			
1N4441	S	RE				1.5K	.025	1/	4/			
1N4442	S	SD				30		1N/	1/100	1		
1N4443	S	SD				50		2N/	1/100	.6		
1N4444	S	SD	1N4444			70		50N/50	1/100	7		
1N4445	S	SD		1N4151		100		50N/75	1/100	4		
1N4446	S	SD	1N4446			75		25N/20	1/20	4		
1N4447	S	SD	1N4447			75		25N/20	1/20	4		

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4448	S	SD	1N4448			75		25N/20	.72/5	4		
1N4449	S	SD	1N4449			75		25N/20	.73/5	4		
1N4451	S	SD		1N4151		40		50N/30	.87/100	10		
1N4450	S	SD		1N4150		40		50N/30	.92/100	4		
1N4452	S	SD		1N4608		30		50N/30	1/600	20		
1N4453	S	SD		1N4448		20		50N/20	.92/100			
1N4454	S	SD	1N4454			75		.1/50	1/10	2		
1N4455	S	SD		1N4305		50		.1/20	.7/5			
1N4456	S	SD		1N4150		35		.2/30	1/150	1.5		
1N4457	S	SD		1N4150		50		.2/40	1/200	1.5		
1N4458	S	RE				800	5	500/	1.5/			
1N4459	S	RE				1K	5	500/	1.5/			
1N4460	S	ZD		1N4735A	1.5W						6.2/40	5
1N4461	S	ZD		1N4736A	1.5W						6.8/37	5
1N4462	S	ZD		1N4737A	1.5W						7.5/34	5
1N4463	S	ZD		1N4738A	1.5W						8.2/31	5
1N4464	S	ZD		1N4739A	1.5W						9.1/28	5
1N4465	S	ZD		1N4740A	1.5W						10/25	5
1N4466	S	ZD		1N4741A	1.5W						11/23	5
1N4467	S	ZD		1N4742A	1.5W						12/21	5
1N4468	S	ZD		1N4743A	1.5W						13/19	5
1N4469	S	ZD		1N4744A	1.5W						15/17	5
1N4470	S	ZD		1N4745A	1.5W						16/16	5
1N4471	S	ZD		1N4746A	1.5W						18/14	5
1N4472	S	ZD		1N4747A	1.5W						20/13	5
1N4473	S	ZD		1N4748A	1.5W						22/12	5
1N4474	S	ZD		1N4749A	1.5W						24/11	5
1N4475	S	ZD		1N4750A	1.5W						27/9.5	5
1N4476	S	ZD		1N4751A	1.5W						30/8.5	5
1N4477	S	ZD		1N4752A	1.5W						33/7.5	5
1N4478	S	ZD			1.5W						36/7	5
1N4479	S	ZD			1.5W						39/6.5	5
1N4480	S	ZD			1.5W						43/6	5
1N4481	S	ZD			1.5W						47/5.5	5
1N4482	S	ZD			1.5W						51/5	5
1N4483	S	ZD			1.5W						56/4.5	5
1N4484	S	ZD			1.5W						62/4	5
1N4485	S	ZD			1.5W						68/3.7	5
1N4486	S	ZD			1.5W						75/3.3	5
1N4487	S	ZD			1.5W						82/3	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4488	S	ZD			1.5W						91/2.8	5
1N4489	S	ZD			1.5W						100/2.5	5
1N4490	S	ZD			1.5W						110/2.3	5
1N4491	S	ZD			1.5W						120/2	5
1N4492	S	ZD			1.5W						130/1.9	5
1N4493	S	ZD			1.5W						150/1.7	5
1N4494	S	ZD			1.5W						160/1.6	5
1N4495	S	ZD			1.5W						180/1.4	5
1N4496	S	ZD			1.5W						200/1.2	5
1N4497	S	RE				1.6K	.75	100/	3/			
1N4498	S	RE				3K	.75	100/	5/			
1N4499	S	ZD		1N4735A	1W						6.2/7.5	5
1N4500	S	SD		1N4607		100		.1/75	1/300	4		
1N4502	G	SD		1N4305		20		10/6	.3/3			
1N4505	S	RE				6K	.1	100/	8.5/			
1N4506	S	RE				200	12		1.4/			
1N4507	S	RE				400	12		1.4/			
1N4508	S	RE				600	12		1.4/			
1N4509	S	RE				800	12	2M/	1.4/			
1N4510	S	RE				1K	12		1.4/			
1N4511	S	RE				1.2K	12		1.4/			
1N4512	S	SD				10		10N/	.77/5			
1N4513	S	RE				2K	.25	100/	4.5/			
1N4514	S	RE				800	1.1	100/	1/			
1N4517	S	RE				200	2	100/	1.2/			
1N4523	G	SD		1N4305		15		30/10	.5/10	8		
1N4524	G	SD		1N4305		10		12/6	.65/10	3		
1N4531	S	SD	1N4531			75		25N/20	1/10	4		
1N4532	S	SD	1N4532			75		.1/50	1/10	2		
1N4533	S	SD	1N4533			40		50N/30	.88/20	2		
1N4534	S	SD	1N4534			75		50N/50	.88/20	2		
1N4535	S	ZD			500						3.45/5	5
1N4536	S	SD	1N4536			35		.1/25	1/30	2		
1N4537	S	RE				1.5K	3		1.8/.3			
1N4538	S	RE				2K	3		1.8/.3			
1N4539	S	RE				2.5K	3		1.8/.3			
1N4540	S	RE				3K	3		1.8/.3			
1N4541	S	SD		1N645		225		20N/225	1/400			
1N4542	S	SD		1N647		400		20N/400	1/400			
1N4543	S	SD		1N648		600		20N/600	1/400			

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4544	S	SD		1N649		800		20N/800	1/400			
1N4545	S	SD				1K		20N/1K	1/400			
1N4546	S	RE				25K	1	100/	30/			
1N4547	S	SD		1N4151		25		10N/25	1/25			
1N4548	S	SD		1N4536		35		.1/25	1/30	4		
1N4565	S	RD			400						6.4/.5	5
1N4565A	S	RD			400						6.4/.5	5
1N4566	S	RD			400						6.4/.5	5
1N4566A	S	RD			400						6.4/.5	5
1N4567	S	RD			400						6.4/.5	5
1N4567A	S	RD			400						6.4/.5	5
1N4568	S	RD			400						6.4/.5	5
1N4568A	S	RD			400						6.4/.5	5
1N4569	S	RD			400						6.4/.5	5
1N4569A	S	RD			400						6.4/.5	5
1N4570	S	RD			400						6.4/1	5
1N4570A	S	RD			400						6.4/1	5
1N4571	S	RD			400						6.4/1	5
1N4571A	S	RD			400						6.4/1	5
1N4572	S	RD			400						6.4/1	5
1N4572A	S	RD			400						6.4/1	5
1N4573	S	RD			400						6.4/1	5
1N4573A	S	RD			400						6.4/1	5
1N4574	S	RD			400						6.4/1	5
1N4574A	S	RD			400						6.4/1	5
1N4575	S	RD			400						6.4/2	5
1N4575A	S	RD			400						6.4/2	5
1N4576	S	RD			400						6.4/2	5
1N4576A	S	RD			400						6.4/2	5
1N4577	S	RD			400						6.4/2	5
1N4577A	S	RD			400						6.4/2	5
1N4578	S	RD			400						6.4/2	5
1N4578A	S	RD			400						6.4/2	5
1N4579	S	RD			400						6.4/2	5
1N4579A	S	RD			400						6.4/2	5
1N4580	S	RD			400						6.4/4	5
1N4580A	S	RD			400						6.4/4	5
1N4581	S	RD			400						6.4/4	5
1N4581A	S	RD			400						6.4/4	5
1N4582	S	RD			400						6.4/4	5

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TEXAS INSTRUMENTS
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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4582A	S	RD			400						6.4/4	5
1N4583	S	RD			400						6.4/4	5
1N4583A	S	RD			400						6.4/4	5
1N4584	S	RD			400						6.4/4	5
1N4584A	S	RD			400						6.4/4	5
1N4585	S	RE		TID387		800	1	2/800	1.3/1A			
1N4586	S	RE		TID387		1K	1	2/1K	1.3/1A			
1N4596	S	RE				1.4K			1.3/3.5			
1N4597	S	RE				5K	.025		5/			
1N4606	S	SD	1N4606			85		.25/70	1/200	6		
1N4607	S	SD	1N4607			85		.25/70	.95/250	10		
1N4608	S	SD	1N4608			85		.25/70	.96/350	10		
1N4610	S	SD		1N4150		80		.1/55	1.1/300	2		
1N4611	S	RD			250						6.6/2	
1N4611A	S	RD			250						6.6/2	
1N4611B	S	RD			250						6.6/2	
1N4611C	S	RD			250						6.6/2	
1N4612	S	RD			250						6.6/5	
1N4612A	S	RD			250						6.6/5	
1N4612B	S	RD			250						6.6/5	
1N4612C	S	RD			250						6.6/5	
1N4613	S	RD			250						6.6/10	
1N4613A	S	RD			250						6.6/10	
1N4613B	S	RD			250						6.6/10	
1N4613C	S	RD			250						6.6/10	
1N4614	S	ZD			250						1.8/.25	5
1N4615	S	ZD			250						2/.25	5
1N4616	S	ZD			250						2.2/.25	5
1N4617	S	ZD			250						2.4/.25	5
1N4618	S	ZD			250						2.7/.25	5
1N4619	S	ZD			250						3/.25	5
1N4620	S	ZD			250						3.3/.25	5
1N4621	S	ZD			250						3.6/.25	5
1N4622	S	ZD			250						3.9/.25	5
1N4623	S	ZD			250						4.3/.25	5
1N4624	S	ZD			250						4.7/.25	5
1N4625	S	ZD			250						5.1/.25	5
1N4626	S	ZD			250						5.6/.25	5
1N4627	S	ZD			250						6.2/.25	5
1N4628	S	ZD		1N4736A	600						6.8/19	5

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4629	S	ZD		1N4737A	600						7.5/17	5
1N4630	S	ZD		1N4738A	600						8.2/15	5
1N4631	S	ZD		1N4739A	600						9.1/14	5
1N4632	S	ZD		1N4740A	600						10/13	5
1N4633	S	ZD		1N4741A	600						11/12	5
1N4634	S	ZD		1N4742A	600						12/11	5
1N4635	S	ZD		1N4743A	600						13/9.5	5
1N4636	S	ZD		1N4744A	600						15/8.5	5
1N4637	S	ZD		1N4745A	600						16/7.8	5
1N4638	S	ZD		1N4746A	600						18/7	5
1N4639	S	ZD		1N4747A	600						20/6.2	5
1N4640	S	ZD		1N4748A	600						22/6	5
1N4641	S	ZD		1N4749A	600						24/5.2	5
1N4642	S	ZD		1N4750A	600						27/4.6	5
1N4643	S	ZD		1N4751A	600						30/4.2	5
1N4644	S	ZD		1N4752A	600						33/3.8	5
1N4645	S	ZD			600						36/3.4	5
1N4646	S	ZD			600						39/3.2	5
1N4647	S	ZD			600						43/3	5
1N4648	S	ZD			600						47/2.7	5
1N4649	S	ZD		1N4728A	1W						3.3/76	5
1N4650	S	ZD		1N4729A	1W						3.6/69	5
1N4651	S	ZD		1N4730A	1W						3.9/64	5
1N4652	S	ZD		1N4731A	1W						4.3/58	5
1N4653	S	ZD		1N4732A	1W						4.7/53	5
1N4654	S	ZD		1N4733A	1W						5.1/49	5
1N4655	S	ZD		1N4734A	1W						5.6/45	5
1N4656	S	ZD		1N4735A	1W						6.2/41	5
1N4657	S	ZD		1N4736A	1W						6.8/37	5
1N4658	S	ZD		1N4737A	1W						7.5/34	5
1N4659	S	ZD		1N4738A	1W						8.2/31	5
1N4660	S	ZD		1N4739A	1W						9.1/28	5
1N4661	S	ZD		1N4740A	1W						10/25	5
1N4662	S	ZD		1N4741A	1W						11/23	5
1N4663	S	ZD		1N4742A	1W						12/21	5
1N4664	S	ZD		1N4743A	1W						13/19	5
1N4665	S	ZD		1N4744A	1W						15/17	5
1N4666	S	ZD		1N4745A	1W						16/16	5
1N4667	S	ZD		1N4746A	1W						18/14	5
1N4668	S	ZD		1N4747A	1W						20/13	5

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N4669	S	ZD		1N4748A	1W								22/12	5
1N4670	S	ZD		1N4749A	1W								24/11	5
1N4671	S	ZD		1N4750A	1W								27/9.5	5
1N4672	S	ZD		1N4751A	1W								30/8.5	5
1N4673	S	ZD		1N4752A	1W								33/7.5	5
1N4674	S	ZD			1W								36/7	5
1N4675	S	ZD			1W								39/6.5	5
1N4676	S	ZD			1W								43/6	5
1N4677	S	ZD			1W								47/5.5	5
1N4678	S	ZD			250								1.8/.05	5
1N4679	S	ZD			250								2/.05	5
1N4680	S	ZD			250								2.2/.05	5
1N4681	S	ZD			250								2.4/.05	5
1N4682	S	ZD			250								2.7/.05	5
1N4683	S	ZD			250								3/.05	5
1N4684	S	ZD			250								3.3/.05	5
1N4685	S	ZD			250								3.6/.05	5
1N4686	S	ZD			250								3.9/.05	5
1N4687	S	ZD			250								4.3/.05	5
1N4688	S	ZD			250								4.7/.05	5
1N4689	S	ZD			250								5.1/.05	5
1N4690	S	ZD			250								5.6/.05	5
1N4691	S	ZD			250								6.2/.05	5
1N4692	S	ZD			250								6.8/.05	5
1N4693	S	ZD			250								7.5/.05	5
1N4694	S	ZD			250								8.2/.05	5
1N4695	S	ZD			250								8.7/.05	5
1N4696	S	ZD			250								9.1/.05	5
1N4697	S	ZD			250								10/.05	5
1N4698	S	ZD			250								11/.05	5
1N4699	S	ZD			250								12/.05	5
1N4700	S	ZD			250								13/.05	5
1N4701	S	ZD			250								14/.05	5
1N4702	S	ZD			250								15/.05	5
1N4703	S	ZD			250								16/.05	5
1N4704	S	ZD			250								17/.05	5
1N4705	S	ZD			250								18/.05	5
1N4706	S	ZD			250								19/.05	5
1N4707	S	ZD			250								20/.05	5
1N4708	S	ZD			250								22/.05	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N4709	S	ZD			250						24/.05	5
1N4710	S	ZD			250						25/.05	5
1N4711	S	ZD			250						27/.05	5
1N4712	S	ZD			250						28/.05	5
1N4713	S	ZD			250						30/.05	5
1N4714	S	ZD			250						33/.05	5
1N4715	S	ZD			250						36/.05	5
1N4716	S	ZD			250						39/.05	5
1N4717	S	ZD			250						40/.05	5
1N4718	S	SD		1N4608		50		50/50	1.2/750	180		
1N4719	S	RE				50	3	1M/	1/			
1N4720	S	RE				100	3	1M/	1/			
1N4721	S	RE				200	3	1M/	1/			
1N4722	S	RE				400	3	1M/	1/			
1N4723	S	RE				600	3	1M/	1/			
1N4724	S	RE				800	3	1M/	1/			
1N4725	S	RE				1K	3	1M/	1/			
1N4726	S	SD		1N4727		30		.1/20	.85/10			
1N4727	S	SD	1N4727			30		.1/20	.85/10			
1N4728	S	ZD	1N4728		1W						3.3/76	10
1N4728A	S	ZD	1N4728A		1W						3.3/76	5
1N4729	S	ZD	1N4729		1W						3.6/69	10
1N4729A	S	ZD	1N4729A		1W						3.6/69	5
1N4730	S	ZD	1N4730		1W						3.9/64	10
1N4730A	S	ZD	1N4730A		1W						3.9/64	5
1N4731	S	ZD	1N4731		1W						4.3/58	10
1N4731A	S	ZD	1N4731A		1W						4.3/58	5
1N4732	S	ZD	1N4732		1W						4.7/53	10
1N4732A	S	ZD	1N4732A		1W						4.7/53	5
1N4733	S	ZD	1N4733		1W						5.1/49	10
1N4733A	S	ZD	1N4733A		1W						5.1/49	5
1N4734	S	ZD	1N4734		1W						5.6/45	10
1N4734A	S	ZD	1N4734A		1W						5.6/45	5
1N4735	S	ZD	1N4735		1W						6.2/41	10
1N4735A	S	ZD	1N4735A		1W						6.2/41	5
1N4736	S	ZD	1N4736		1W						6.8/37	10
1N4736A	S	ZD	1N4736A		1W						6.8/37	5
1N4737	S	ZD	1N4737		1W						7.5/34	10
1N4737A	S	ZD	1N4737A		1W						7.5/34	5
1N4738	S	ZD	1N4738		1W						8.2/31	10

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4738A	S	ZD	1N4738A		1W								8.2/31	5
1N4739	S	ZD	1N4739		1W								9.1/28	10
1N4739A	S	ZD	1N4739A		1W								9.1/28	5
1N4740	S	ZD	1N4740		1W								10/25	10
1N4740A	S	ZD	1N4740A		1W								10/25	5
1N4741	S	ZD	1N4741		1W								11/23	10
1N4741A	S	ZD	1N4741A		1W								11/23	5
1N4742	S	ZD	1N4742		1W								12/21	10
1N4742A	S	ZD	1N4742A		1W								12/21	5
1N4743	S	ZD	1N4743		1W								13/19	10
1N4743A	S	ZD	1N4743A		1W								13/19	5
1N4744	S	ZD	1N4744		1W								15/17	10
1N4744A	S	ZD	1N4744A		1W								15/17	5
1N4745	S	ZD	1N4745		1W								16/15	10
1N4745A	S	ZD	1N4745A		1W								16/15	5
1N4746	S	ZD	1N4746		1W								18/14	10
1N4746A	S	ZD	1N4746A		1W								18/14	5
1N4747	S	ZD	1N4747		1W								20/12	10
1N4747A	S	ZD	1N4747A		1W								20/12	5
1N4748	S	ZD	1N4748		1W								22/11	10
1N4748A	S	ZD	1N4748A		1W								22/11	5
1N4749	S	ZD	1N4749		1W								24/10	10
1N4749A	S	ZD	1N4749A		1W								24/10	5
1N4750	S	ZD	1N4750		1W								27/9.5	10
1N4750A	S	ZD	1N4750A		1W								27/9.5	5
1N4751	S	ZD	1N4751		1W								30/8.5	10
1N4751A	S	ZD	1N4751A		1W								30/8.5	5
1N4752	S	ZD	1N4752		1W								33/7.5	10
1N4752A	S	ZD	1N4752A		1W								33/7.5	5
1N4753	S	ZD			1W								36/7	10
1N4753A	S	ZD			1W								36/7	5
1N4754	S	ZD			1W								39/6.5	10
1N4754A	S	ZD			1W								39/6.5	5
1N4755	S	ZD			1W								43/6	10
1N4755A	S	ZD			1W								43/6	5
1N4756	S	ZD			1W								47/5.5	10
1N4756A	S	ZD			1W								47/5.5	5
1N4757	S	ZD			1W								51/5	10
1N4757A	S	ZD			1W								51/5	5
1N4758	S	ZD			1W								56/4.5	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA / @ V_R (V)	V_F (V) / @ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N4758A	S	ZD			1W						56/4.5	5
1N4759	S	ZD			1W						62/4	10
1N4759A	S	ZD			1W						62/4	5
1N4760	S	ZD			1W						68/3.7	10
1N4760A	S	ZD			1W						68/3.7	5
1N4761	S	ZD			1W						75/3.3	10
1N4761A	S	ZD			1W						75/3.3	5
1N4762	S	ZD			1W						82/3	10
1N4762A	S	ZD			1W						82/3	5
1N4763	S	ZD			1W						91/2.8	10
1N4763A	S	ZD			1W						91/2.8	5
1N4764	S	ZD			1W						100/2.5	10
1N4764A	S	ZD			1W						100/2.5	5
1N4765	S	RD									9.1/.5	
1N4765A	S	RD									9.1/.5	
1N4765B	S	RD									9.1/.5	
1N4766	S	RD									9.1/.5	
1N4766A	S	RD									9.1/.5	
1N4766B	S	RD									9.1/.5	
1N4767	S	RD									9.1/.5	
1N4767A	S	RD									9.1/.5	
1N4767B	S	RD									9.1/.5	
1N4768	S	RD									9.1/.5	
1N4768A	S	RD									9.1/.5	
1N4768B	S	RD									9.1/.5	
1N4769	S	RD									9.1/.5	
1N4769A	S	RD									9.1/.5	
1N4769B	S	RD									9.1/.5	
1N4770	S	RD									9.1/1	
1N4770A	S	RD									9.1/1	
1N4770B	S	RD									9.1/1	
1N4771	S	RD									9.1/1	
1N4771A	S	RD									9.1/1	
1N4771B	S	RD									9.1/1	
1N4772	S	RD									9.1/1	
1N4772A	S	RD									9.1/1	
1N4772B	S	RD									9.1/1	
1N4773	S	RD									9.1/1	
1N4773A	S	RD									9.1/1	
1N4773B	S	RD									9.1/1	

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R ● V_R µA / (V)	V_F ● I_F (V) / (mA)	t_{rr} (ns)	V_Z ● I_Z (V) / (mA)	TOL %
1N4774	S	RD									9.1/1	
1N4774A	S	RD									9.1/1	
1N4774B	S	RD									9.1/1	
1N4775	S	RD									8.5/.5	
1N4775A	S	RD									8.5/.5	
1N4775B	S	RD									8.5/.5	
1N4776	S	RD									8.5/.5	
1N4776A	S	RD									8.5/.5	
1N4776B	S	RD									8.5/.5	
1N4777	S	RD									8.5/.5	
1N4777A	S	RD									8.5/.5	
1N4777B	S	RD									8.5/.5	
1N4778	S	RD									8.5/.5	
1N4778A	S	RD									8.5/.5	
1N4778B	S	RD									8.5/.5	
1N4779	S	RD									8.5/.5	
1N4779A	S	RD									8.5/.5	
1N4779B	S	RD									8.5/.5	
1N4780	S	RD									8.5/1	
1N4780A	S	RD									8.5/1	
1N4780B	S	RD									8.5/1	
1N4781	S	RD									8.5/1	
1N4781A	S	RD									8.5/1	
1N4781B	S	RD									8.5/1	
1N4782	S	RD									8.5/1	
1N4782A	S	RD									8.5/1	
1N4782B	S	RD									8.5/1	
1N4783	S	RD									8.5/1	
1N4783A	S	RD									8.5/1	
1N4783B	S	RD									8.5/1	
1N4784	S	RD									8.5/1	
1N4784A	S	RD									8.5/1	
1N4784B	S	RD									8.5/1	
1N4816	S	RE				50	1.5	250/	1.3/			
1N4817	S	RE				100	1.5	250/	1.3/			
1N4818	S	RE				200	1.5	250/	1.3/			
1N4819	S	RE				300	1.5	250/	1.3/			
1N4820	S	RE				400	1.5	250/	1.3/			
1N4821	S	RE				500	1.5	250/	1.3/			
1N4822	S	RE				600	1.5	250/	1.3/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4823	S	RE				100	1	1M/	1.2/	100		
1N4824	S	RE				200	1	1M/	1.2/	100		
1N4825	S	RE				400	1	1M/	1.2/	100		
1N4826	S	RE				600	1	1M/	1.2/	100		
1N4827	G	SD		1N4448		30		15/10	1/40	200		
1N4828	S	SD				20		.1/	1.1/100			
1N4829	S	SD				20		.1/	1.8/100			
1N4830	S	SD				20		.1/	2.6/100			
1N4831	S	ZD		1N4739	1.2W						9.1/28	20
1N4831A	S	ZD		1N4739	1.2W						9.1/28	10
1N4831B	S	ZD		1N4739A	1.2W						9.1/28	5
1N4832	S	ZD		1N4740	1.2W						10/25	20
1N4832A	S	ZD		1N4740	1.2W						10/25	10
1N4832B	S	ZD		1N4740A	1.2W						10/25	5
1N4833	S	ZD		1N4741	1.2W						11/23	20
1N4833A	S	ZD		1N4741	1.2W						11/23	10
1N4833B	S	ZD		1N4741A	1.2W						11/23	5
1N4834	S	ZD		1N4742	1.2W						12/21	20
1N4834A	S	ZD		1N4742	1.2W						12/21	10
1N4834B	S	ZD		1N4742A	1.2W						12/21	5
1N4835	S	ZD		1N4743	1.2W						13/19	20
1N4835A	S	ZD		1N4743	1.2W						13/19	10
1N4835B	S	ZD		1N4743A	1.2W						13/19	5
1N4836	S	ZD		1N4744	1.2W						15/17	20
1N4836A	S	ZD		1N4744	1.2W						15/17	10
1N4836B	S	ZD		1N4744A	1.2W						15/17	5
1N4837	S	ZD		1N4745	1.2W						16/16	20
1N4837A	S	ZD		1N4745	1.2W						16/16	10
1N4837B	S	ZD		1N4745A	1.2W						16/16	5
1N4838	S	ZD		1N4746	1.2W						18/14	20
1N4838A	S	ZD		1N4746	1.2W						18/14	10
1N4838B	S	ZD		1N4746A	1.2W						18/14	5
1N4839	S	ZD		1N4747	1.2W						20/19	20
1N4839A	S	ZD		1N4747	1.2W						20/19	10
1N4839B	S	ZD		1N4747A	1.2W						20/19	5
1N4840	S	ZD		1N4748	1.2W						22/11	20
1N4840A	S	ZD		1N4748	1.2W						22/11	10
1N4840B	S	ZD		1N4748A	1.2W						22/11	5
1N4841	S	ZD		1N4749	1.2W						24/11	20
1N4841A	S	ZD		1N4749	1.2W						24/11	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4841B	S	ZD		1N4749A	1.2W								24/11	5
1N4842	S	ZD		1N4750	1.2W								27/9.3	20
1N4842A	S	ZD		1N4750	1.2W								27/9.3	10
1N4842B	S	ZD		1N4750A	1.2W								27/9.3	5
1N4843	S	ZD		1N4751	1.2W								30/8.3	20
1N4843A	S	ZD		1N4751	1.2W								30/8.3	10
1N4843B	S	ZD		1N4751A	1.2W								30/8.3	5
1N4844	S	ZD		1N4752	1.2W								33/7.5	20
1N4844A	S	ZD		1N4752	1.2W								33/7.5	10
1N4844B	S	ZD		1N4752A	1.2W								33/7.5	5
1N4845	S	ZD			1.2W								36/7	20
1N4845A	S	ZD			1.2W								36/7	10
1N4845B	S	ZD			1.2W								36/7	5
1N4846	S	ZD			1.2W								39/6.5	20
1N4846A	S	ZD			1.2W								39/6.5	10
1N4846B	S	ZD			1.2W								39/6.5	5
1N4847	S	ZD			1.2W								43/5.8	20
1N4847A	S	ZD			1.2W								43/5.8	10
1N4847B	S	ZD			1.2W								43/5.8	5
1N4848	S	ZD			1.2W								47/5.3	20
1N4848A	S	ZD			1.2W								47/5.3	10
1N4848B	S	ZD			1.2W								47/5.3	5
1N4849	S	ZD			1.2W								51/5	20
1N4849A	S	ZD			1.2W								51/5	10
1N4849B	S	ZD			1.2W								51/5	5
1N4850	S	ZD			1.2W								56/4.5	20
1N4850A	S	ZD			1.2W								56/4.5	10
1N4850B	S	ZD			1.2W								56/4.5	5
1N4851	S	ZD			1.2W								62/4	20
1N4851A	S	ZD			1.2W								62/4	10
1N4851B	S	ZD			1.2W								62/4	5
1N4852	S	ZD			1.2W								68/3.7	20
1N4852A	S	ZD			1.2W								68/3.7	10
1N4852B	S	ZD			1.2W								68/3.7	5
1N4853	S	ZD			1.2W								75/3.3	20
1N4853A	S	ZD			1.2W								75/3.3	10
1N4853B	S	ZD			1.2W								75/3.3	5
1N4854	S	ZD			1.2W								82/3	20
1N4854A	S	ZD			1.2W								82/3	10
1N4854B	S	ZD			1.2W								82/3	5

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4855	S	ZD			1.2W						91/2.8	20
1N4855A	S	ZD			1.2W						91/2.8	10
1N4855B	S	ZD			1.2W						91/2.8	5
1N4856	S	ZD			1.2W						100/2.5	20
1N4856A	S	ZD			1.2W						100/2.5	10
1N4856B	S	ZD			1.2W						100/2.5	5
1N4857	S	ZD			1.2W						110/2.3	20
1N4857A	S	ZD			1.2W						110/2.3	10
1N4857B	S	ZD			1.2W						110/2.3	5
1N4858	S	ZD			1.2W						120/1.2	20
1N4858A	S	ZD			1.2W						120/1.2	10
1N4858B	S	ZD			1.2W						120/1.2	5
1N4859	S	ZD			1.2W						130/1.9	20
1N4859A	S	ZD			1.2W						130/1.9	10
1N4859B	S	ZD			1.2W						130/1.9	5
1N4860	S	ZD			1.2W						150/1.7	20
1N4860A	S	ZD			1.2W						150/1.7	10
1N4860B	S	ZD			1.2W						150/1.7	5
1N4861	S	SD		1N457		50		2N/30	1.2/100	1U		
1N4862	S	SD		1N457		50		5N/30	1.1/100	1U		
1N4863	S	SD		1N4444		50		50N/30	1.2/100	7		
1N4864	S	SD		1N4151		125		.1/80	1.1/100	4		
1N4865	S	RE				1.5K	1.25	600/	2.4/			
1N4866	S	RE				2.5K	1.25	600/	3.6/			
1N4867	S	RE				3K	1.25	600/	4.8/			
1N4868	S	RE				5K	1.25	600/	8.4/			
1N4869	S	RE				7.5K	1.25	600/	12/			
1N4870	S	RE				10K	1.25	600/	16/			
1N4871	S	RE				12K	1.25	600/	18/			
1N4872	S	RE				15K	1.25	600/	23/			
1N4873	S	RE				20K	1.25	600/	30/			
1N4874	S	RE				25K	1.25	600/	38/			
1N4875	S	RE				30K	1.25	600/	46/			
1N4876	S	RE				40K	1.25	600/	60/			
1N4877	S	RE				50K	1.25	600/	76/			
1N4878	S	RE				100	100	5M/	1.3/			
1N4879	S	RE				100	160	10M/	1.3/			
1N4880	S	RE				100	250	10M/	1.2/			
1N4887	S	RE				75K	1.25	600/	115/			
1N4888	S	SD		TID777		12		50N/	1/20	.5		

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N4890	S	RD			400								6.35/7.5	5
1N4890A	S	RD			400								6.35/7.5	5
1N4891	S	RD			400								6.35/7.5	5
1N4891A	S	RD			400								6.35/7.5	5
1N4892	S	RD			400								6.35/7.5	5
1N4892A	S	RD			400								6.35/7.5	5
1N4893	S	RD			400								6.35/7.5	5
1N4893A	S	RD			400								6.35/7.5	5
1N4894	S	RD			400								6.35/7.5	5
1N4894A	S	RD			400								6.35/7.5	5
1N4895	S	RD			400								6.35/7.5	5
1N4895A	S	RD			400								6.35/7.5	5
1N4896	S	RD			400								12.8/.5	5
1N4896A	S	RD			400								12.8/.5	5
1N4897	S	RD			400								12.8/.5	5
1N4897A	S	RD			400								12.8/.5	5
1N4898	S	RD			400								12.8/.5	5
1N4898A	S	RD			400								12.8/.5	5
1N4899	S	RD			400								12.8/.5	5
1N4899A	S	RD			400								12.8/.5	5
1N4900	S	RD			400								12.8/1	5
1N4900A	S	RD			400								12.8/1	5
1N4901	S	RD			400								12.8/1	5
1N4901A	S	RD			400								12.8/1	5
1N4902	S	RD			400								12.8/1	5
1N4902A	S	RD			400								12.8/1	5
1N4903	S	RD			400								12.8/1	5
1N4903A	S	RD			400								12.8/1	5
1N4904	S	RD			400								12.8/2	5
1N4904A	S	RD			400								12.8/2	5
1N4905	S	RD			400								12.8/2	5
1N4905A	S	RD			400								12.8/2	5
1N4906	S	RD			400								12.8/2	5
1N4906A	S	RD			400								12.8/2	5
1N4907	S	RD			400								12.8/2	5
1N4907A	S	RD			400								12.8/2	5
1N4908	S	RD			400								12.8/4	5
1N4908A	S	RD			400								12.8/4	5
1N4909	S	RD			400								12.8/4	5
1N4909A	S	RD			400								12.8/4	5

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N4910	S	RD			400						12.8/4	5
1N4910A	S	RD			400						12.8/4	5
1N4911	S	RD			400						12.8/4	5
1N4911A	S	RD			400						12.8/4	5
1N4912	S	RD			400						12.8/7.5	5
1N4912A	S	RD			400						12.8/7.5	5
1N4913	S	RD			400						12.8/7.5	5
1N4913A	S	RD			400						12.8/7.5	5
1N4914	S	RD			400						12.8/7.5	5
1N4914A	S	RD			400						12.8/7.5	5
1N4915	S	RD			400						12.8/7.5	5
1N4915A	S	RD			400						12.8/7.5	5
1N4916	S	RD			400						19.2/.5	5
1N4916A	S	RD			400						19.2/.5	5
1N4917	S	RD			400						19.2/.5	5
1N4917A	S	RD			400						19.2/.5	5
1N4918	S	RD			400						19.2/.5	5
1N4918A	S	RD			400						19.2/.5	5
1N4919	S	RD			400						19.2/1	5
1N4919A	S	RD			400						19.2/1	5
1N4920	S	RD			400						19.2/1	5
1N4920A	S	RD			400						19.2/1	5
1N4921	S	RD			400						19.2/1	5
1N4921A	S	RD			400						19.2/1	5
1N4922	S	RD			400						19.2/2	5
1N4922A	S	RD			400						19.2/2	5
1N4923	S	RD			400						19.2/2	5
1N4923A	S	RD			400						19.2/2	5
1N4924	S	RD			400						19.2/2	5
1N4924A	S	RD			400						19.2/2	5
1N4925	S	RD			400						19.2/4	5
1N4925A	S	RD			400						19.2/4	5
1N4926	S	RD			400						19.2/4	5
1N4926A	S	RD			400						19.2/4	5
1N4927	S	RD			400						19.2/4	5
1N4927A	S	RD			400						19.2/4	5
1N4928	S	RD			400						19.2/4	5
1N4928A	S	RD			400						19.2/4	5
1N4929	S	RD			400						19.2/7.5	5
1N4929A	S	RD			400						19.2/7.5	5

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA / @ V_R (V)	V_F (V) / @ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N4930	S	RD			400						19.2/7.5	5
1N4930A	S	RD			400						19.2/7.5	5
1N4931	S	RD			400						19.2/7.5	5
1N4931A	S	RD			400						19.2/7.5	5
1N4932	S	RD			400						19.2/7.5	5
1N4932A	S	RD			400						19.2/7.5	5
1N4933	S	RE				50	1	300/	1.2/	200		
1N4934	S	RE				100	1	300/	1.2/	200		
1N4935	S	RE				200	1	300/	1.2/	200		
1N4936	S	RE				400	1	300/	1.2/	200		
1N4937	S	RE				600	1	300/	1.2/	200		
1N4938	S	SD	1N4938			200		.1/175	1/100	50		
1N4942	S	SD				200	1	500/	1.5/3	150		
1N4943	S	SD				300	1	500/	1.5/3	150		
1N4944	S	SD				400	1	500/	1.5/3	150		
1N4945	S	SD				500	1	500/	1.5/3	150		
1N4946	S	SD				600	1	500/	1.5/3	250		
1N4947	S	SD				800	1	500/	1.5/3	300		
1N4948	S	SD				1K	1	500/	1.5/3	500		
1N4949	S	SD		TID701		35		50N/30	1/150	.3		
1N4950	S	SD		1N4150		25		100/25	1/300	4		
1N4951	S	SD		1N4607		20		.1/20	.85/1			
1N4952	S	SD		1N4607		50		.1/20	.85/1			
1N4953	S	SD		TID701		30		.5/30	1/100	1		
1N4997	S	RE				50	3		1/2			
1N4998	S	RE				100	3		1/2			
1N4999	S	RE				200	3		1/2			
1N5000	S	RE				400	3	2M/	1/			
1N5001	S	RE				600	3	1M/	1/			
1N5002	S	RE				800	3	1M/	1/			
1N5003	S	RE				1K	3	1M/	1/			
1N5004	S	RE				100	1	1M/	1.3/	120		
1N5005	S	RE				200	1	1M/	1.3/	120		
1N5006	S	RE				400	1	1M/	1.3/	120		
1N5007	S	RE				600	1	1M/	1.3/	120		
1N5053	S	RE				800	1.5	500/	1.3/			
1N5054	S	RE				1K	1.5	500/	1.3/			
1N5055	S	RE				100	1	250/	1.4/	200		
1N5056	S	RE				200	1	250/	1.4/	200		
1N5057	S	RE				300	.8	250/	1.4/	400		

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5058	S	RE				400	.8	250/	1.4/	800		
1N5059	S	RE		TID383		200	1	300/200	1.2/1A			
1N5060	S	RE		TID384		400	1	300/400	1.2/1A			
1N5061	S	RE		TID385		600	1	200/600	1.2/1A			
1N5062	S	RE		TID386		800	1	200/800	1.2/1A			
1N5170	S	RE				15	2	25/	1.2/			
1N5171	S	RE				50	2	25/	1.2/			
1N5172	S	RE				100	2	25/	1.2/			
1N5173	S	RE				300	2	25/	1.2/			
1N5174	S	RE				400	2	25/	1.2/			
1N5175	S	RE				500	2	25/	1.2/			
1N5176	S	RE				600	2	25/	1.2/			
1N5177	S	RE				800	2	25/	1.2/			
1N5178	S	RE				1K	2	25/	1.2/			
1N5179	S	SD				30		50N/	3.7/100			
1N5180	S	RE				100	4	5/				
1N5181	S	RE				4K	.6	20/				
1N5182	S	RE				5K	.6	20/				
1N5183	S	RE				7.5K	.6	20/				
1N5184	S	RE				10K	.6	20/				
1N5185	S	RE				50	3	100/	1.1/			
1N5185A	S	RE				50	4	22/	1.1/			
1N5186	S	RE				100	3	100/	1.1/			
1N5186A	S	RE				100	4	22/	1.1/			
1N5187	S	RE				200	3	100/	1.1/			
1N5187A	S	RE				200	4	22/	1.1/			
1N5188	S	RE				400	3	100/	1.1/			
1N5188A	S	RE				400	4	22/	1.1/			
1N5189	S	RE				500	3	100/	1.1/			
1N5189A	S	RE				500	4	22/	1.1/			
1N5190	S	RE				600	3	100/	1.1/			
1N5190A	S	RE				600	4	22/	1.1/			
1N5194	S	SD		1N483		80		25N/70	1/100			
1N5195	S	SD		1N485		200		25N/180	1/100			
1N5196	S	SD		1N486		250		25N/225	1/100			
1N5197	S	RE				50	2	100/	1.2/			
1N5198	S	RE				100	2	100/	1.2/			
1N5199	S	RE				200	2	100/	1.2/			
1N5200	S	RE				400	2	100/	1.2/			
1N5201	S	RE				600	2	100/	1.2/			

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	CHARACTERISTICS V_F @ I_F (V) / (mA)	CHARACTERISTICS t_{rr} (ns)	CHARACTERISTICS V_Z @ I_Z (V) / (mA)	TOL %
1N5206	S	RE				400	2	3/	1.2/			
1N5207	S	RE				400	4	5/	1.2/			
1N5208	S	SD		1N457		70		25N/175	1/20			
1N5209	S	SD		1N458		150		25N/125	1/7			
1N5210	S	SD		1N459		200		25N/175	1.2/3			
1N5211	S	RE		TID383		200	1	200/200	1.2/1A			
1N5212	S	RE		TID384		400	1	200/400	1.2/1A			
1N5213	S	RE		TID385		600	1	200/600	1.2/1A			
1N5214	S	RE		TID386		800	.75	200/800	1.2/1A			
1N5215	S	RE		TID383		200	1	200/200	1.2/1A			
1N5216	S	RE		TID384		400	1	200/400	1.2/1A			
1N5217	S	RE		TID385		600	1	200/600	1.2/1A			
1N5218	S	RE		TID386		800	.75	200/800	1.2/1A			
1N5219	S	SD		TID701		30		50N/20	1/50	2		
1N5220	S	SD		TID701		30		50N/20	1.2/50	2		
1N5221	S	ZD			500						2.4/20	20
1N5221A	S	ZD			500						2.4/20	10
1N5221B	S	ZD			500						2.4/20	5
1N5222	S	ZD			500						2.5/20	20
1N5222A	S	ZD			500						2.5/20	10
1N5222B	S	ZD			500						2.5/20	5
1N5223	S	ZD			500						2.7/20	20
1N5223A	S	ZD			500						2.7/20	10
1N5223B	S	ZD			500						2.7/20	5
1N5224	S	ZD			500						2.8/20	20
1N5224A	S	ZD			500						2.8/20	10
1N5224B	S	ZD			500						2.8/20	5
1N5225	S	ZD			500						3/20	20
1N5225A	S	ZD			500						3/20	10
1N5225B	S	ZD			500						3/20	5
1N5226	S	ZD	1N5226		500						3.3/20	20
1N5226A	S	ZD	1N5226A		500						3.3/20	10
1N5226B	S	ZD	1N5226B		500						3.3/20	5
1N5227	S	ZD	1N5227		500						3.6/20	20
1N5227A	S	ZD	1N5227A		500						3.6/20	10
1N5227B	S	ZD	1N5227B		500						3.6/20	5
1N5228	S	ZD	1N5228		500						3.9/20	20
1N5228A	S	ZD	1N5228A		500						3.9/20	10
1N5228B	S	ZD	1N5228B		500						3.9/20	5
1N5229	S	ZD	1N5229		500						4.3/20	20

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DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS			CHARACTERISTICS				
					P_D (mW)	V_R (V)	I (A)	I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5229A	S	ZD	1N5229A		500						4.3/20	10
1N5229B	S	ZD	1N5229B		500						4.3/20	5
1N5230	S	ZD	1N5230		500						4.7/20	20
1N5230A	S	ZD	1N5230A		500						4.7/20	10
1N5230B	S	ZD	1N5230B		500						4.7/20	5
1N5231	S	ZD	1N5231		500						5.1/20	20
1N5231A	S	ZD	1N5231A		500						5.1/20	10
1N5231B	S	ZD	1N5231B		500						5.1/20	5
1N5232	S	ZD	1N5232		500						5.6/20	20
1N5232A	S	ZD	1N5232A		500						5.6/20	10
1N5232B	S	ZD	1N5232B		500						5.6/20	5
1N5233	S	ZD	1N5233		500						6/20	20
1N5233A	S	ZD	1N5233A		500						6/20	10
1N5233B	S	ZD	1N5233B		500						6/20	5
1N5234	S	ZD	1N5234		500						6.2/20	20
1N5234A	S	ZD	1N5234A		500						6.2/20	10
1N5234B	S	ZD	1N5234B		500						6.2/20	5
1N5235	S	ZD	1N5235		500						6.8/20	20
1N5235A	S	ZD	1N5235A		500						6.8/20	10
1N5235B	S	ZD	1N5235B		500						6.8/20	5
1N5236	S	ZD	1N5236		500						7.5/20	20
1N5236A	S	ZD	1N5236A		500						7.5/20	10
1N5236B	S	ZD	1N5236B		500						7.5/20	5
1N5237	S	ZD	1N5237		500						8.2/20	20
1N5237A	S	ZD	1N5237A		500						8.2/20	10
1N5237B	S	ZD	1N5237B		500						8.2/20	5
1N5238	S	ZD	1N5238		500						8.7/20	20
1N5238A	S	ZD	1N5238A		500						8.7/20	10
1N5238B	S	ZD	1N5238B		500						8.7/20	5
1N5239	S	ZD	1N5239		500						9.1/20	20
1N5239A	S	ZD	1N5239A		500						9.1/20	10
1N5239B	S	ZD	1N5239B		500						9.1/20	5
1N5240	S	ZD	1N5240		500						10/20	20
1N5240A	S	ZD	1N5240A		500						10/20	10
1N5240B	S	ZD	1N5240B		500						10/20	5
1N5241	S	ZD	1N5241		500						11/20	20
1N5241A	S	ZD	1N5241A		500						11/20	10
1N5241B	S	ZD	1N5241B		500						11/20	5
1N5242	S	ZD	1N5242		500						12/20	20
1N5242A	S	ZD	1N5242A		500						12/20	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA @ V_R / (V)	V_F (V) @ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N5242B	S	ZD	1N5242B		500						12/20	5
1N5243	S	ZD	1N5243		500						13/9.5	20
1N5243A	S	ZD	1N5243A		500						13/9.5	10
1N5243B	S	ZD	1N5243B		500						13/9.5	5
1N5244	S	ZD	1N5244		500						14/9	20
1N5244A	S	ZD	1N5244A		500						14/9	10
1N5244B	S	ZD	1N5244B		500						14/9	5
1N5245	S	ZD	1N5245		500						15/8.5	20
1N5245A	S	ZD	1N5245A		500						15/8.5	10
1N5245B	S	ZD	1N5245B		500						15/8.5	5
1N5246	S	ZD	1N5246		500						16/7.8	20
1N5246A	S	ZD	1N5246A		500						16/7.8	10
1N5246B	S	ZD	1N5246B		500						16/7.8	5
1N5247	S	ZD	1N5247		500						17/7.4	20
1N5247A	S	ZD	1N5247A		500						17/7.4	10
1N5247B	S	ZD	1N5247B		500						17/7.4	5
1N5248	S	ZD	1N5248		500						18/7	20
1N5248A	S	ZD	1N5248A		500						18/7	10
1N5248B	S	ZD	1N5248B		500						18/7	5
1N5249	S	ZD	1N5249		500						19/6.6	20
1N5249A	S	ZD	1N5249A		500						19/6.6	10
1N5249B	S	ZD	1N5249B		500						19/6.6	5
1N5250	S	ZD	1N5250		500						20/6.2	20
1N5250A	S	ZD	1N5250A		500						20/6.2	10
1N5250B	S	ZD	1N5250B		500						20/6.2	5
1N5251	S	ZD	1N5251		500						22/5.6	20
1N5251A	S	ZD	1N5251A		500						22/5.6	10
1N5251B	S	ZD	1N5251B		500						22/5.6	5
1N5252	S	ZD	1N5252		500						24/5.2	20
1N5252A	S	ZD	1N5252A		500						24/5.2	10
1N5252B	S	ZD	1N5252B		500						24/5.2	5
1N5253	S	ZD	1N5253		500						25/5	20
1N5253A	S	ZD	1N5253A		500						25/5	10
1N5253B	S	ZD	1N5253B		500						25/5	5
1N5254	S	ZD	1N5254		500						27/4.6	20
1N5254A	S	ZD	1N5254A		500						27/4.6	10
1N5254B	S	ZD	1N5254B		500						27/4.6	5
1N5255	S	ZD	1N5255		500						28/4.5	20
1N5255A	S	ZD	1N5255A		500						28/4.5	10
1N5255B	S	ZD	1N5255B		500						28/4.5	5

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5284	S	RD			600							
1N5285	S	RD			600							
1N5286	S	RD			600							
1N5287	S	RD			600							
1N5288	S	RD			600							
1N5289	S	RD			600							
1N5290	S	RD			600							
1N5291	S	RD			600							
1N5292	S	RD			600							
1N5293	S	RD			600							
1N5294	S	RD			600							
1N5295	S	RD			600							
1N5296	S	RD			600							
1N5297	S	RD			600							
1N5298	S	RD			600							
1N5300	S	RD			600							
1N5301	S	RD			600							
1N5302	S	RD			600							
1N5303	S	RD			600							
1N5304	S	RD			600							
1N5305	S	RD			600							
1N5306	S	RD			600							
1N5307	S	RD			600							
1N5308	S	RD			600							
1N5309	S	RD			600							
1N5310	S	RD			600							
1N5311	S	RD			600							
1N5312	S	RD			600							
1N5313	S	RD			600							
1N5315	S	SD		1N4153		100		50N/50	1/200	4		
1N5316	S	SD		1N4153		100		50N/50	1/100	4		
1N5317	S	SD		1N4150		80		.1/55	1.3/500	4		
1N5318	S	SD		1N4150		75		.1/50	1/200	4		
1N5319	S	SD		1N4305		40		100/25	1/100	4		
1N5314	S	RD			600							
1N5320	S	RE				100	1	100/100	1.1/1A	250		
1N5324	S	RE				15K	.01	25/	24/			
1N5326	S	RE				100	12					
1N5329	S	RE				1.6K	.135	150/				
1N5330	S	RE				1.6K	.54	150/				

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA @ V_R / (V)	V_F (V) @ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N5242B	S	ZD	1N5242B		500						12/20	5
1N5243	S	ZD	1N5243		500						13/9.5	20
1N5243A	S	ZD	1N5243A		500						13/9.5	10
1N5243B	S	ZD	1N5243B		500						13/9.5	5
1N5244	S	ZD	1N5244		500						14/9	20
1N5244A	S	ZD	1N5244A		500						14/9	10
1N5244B	S	ZD	1N5244B		500						14/9	5
1N5245	S	ZD	1N5245		500						15/8.5	20
1N5245A	S	ZD	1N5245A		500						15/8.5	10
1N5245B	S	ZD	1N5245B		500						15/8.5	5
1N5246	S	ZD	1N5246		500						16/7.8	20
1N5246A	S	ZD	1N5246A		500						16/7.8	10
1N5246B	S	ZD	1N5246B		500						16/7.8	5
1N5247	S	ZD	1N5247		500						17/7.4	20
1N5247A	S	ZD	1N5247A		500						17/7.4	10
1N5247B	S	ZD	1N5247B		500						17/7.4	5
1N5248	S	ZD	1N5248		500						18/7	20
1N5248A	S	ZD	1N5248A		500						18/7	10
1N5248B	S	ZD	1N5248B		500						18/7	5
1N5249	S	ZD	1N5249		500						19/6.6	20
1N5249A	S	ZD	1N5249A		500						19/6.6	10
1N5249B	S	ZD	1N5249B		500						19/6.6	5
1N5250	S	ZD	1N5250		500						20/6.2	20
1N5250A	S	ZD	1N5250A		500						20/6.2	10
1N5250B	S	ZD	1N5250B		500						20/6.2	5
1N5251	S	ZD	1N5251		500						22/5.6	20
1N5251A	S	ZD	1N5251A		500						22/5.6	10
1N5251B	S	ZD	1N5251B		500						22/5.6	5
1N5252	S	ZD	1N5252		500						24/5.2	20
1N5252A	S	ZD	1N5252A		500						24/5.2	10
1N5252B	S	ZD	1N5252B		500						24/5.2	5
1N5253	S	ZD	1N5253		500						25/5	20
1N5253A	S	ZD	1N5253A		500						25/5	10
1N5253B	S	ZD	1N5253B		500						25/5	5
1N5254	S	ZD	1N5254		500						27/4.6	20
1N5254A	S	ZD	1N5254A		500						27/4.6	10
1N5254B	S	ZD	1N5254B		500						27/4.6	5
1N5255	S	ZD	1N5255		500						28/4.5	20
1N5255A	S	ZD	1N5255A		500						28/4.5	10
1N5255B	S	ZD	1N5255B		500						28/4.5	5

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5256	S	ZD	1N5256		500								30/4.2	20
1N5256A	S	ZD	1N5256A		500								30/4.2	10
1N5256B	S	ZD	1N5256B		500								30/4.2	5
1N5257	S	ZD	1N5257		500								33/3.8	20
1N5257A	S	ZD	1N5257A		500								33/3.8	10
1N5257B	S	ZD	1N5257B		500								33/3.8	5
1N5258	S	ZD			500								36/3.4	20
1N5258A	S	ZD			500								36/3.4	10
1N5258B	S	ZD			500								36/3.4	5
1N5259	S	ZD			500								39/3.2	20
1N5259A	S	ZD			500								39/3.2	10
1N5259B	S	ZD			500								39/3.2	5
1N5260	S	ZD			500								43/3	20
1N5260A	S	ZD			500								43/3	10
1N5260B	S	ZD			500								43/3	5
1N5261	S	ZD			500								47/2.7	20
1N5261A	S	ZD			500								47/2.7	10
1N5261B	S	ZD			500								47/2.7	5
1N5262	S	ZD			500								51/2.5	20
1N5262A	S	ZD			500								51/2.5	10
1N5262B	S	ZD			500								51/2.5	5
1N5263	S	ZD			500								56/2.2	20
1N5263A	S	ZD			500								56/2.2	10
1N5263B	S	ZD			500								56/2.2	5
1N5264	S	ZD			500								60/2.1	20
1N5264A	S	ZD			500								60/2.1	10
1N5264B	S	ZD			500								60/2.1	5
1N5265	S	ZD			500								62/2	20
1N5265A	S	ZD			500								62/2	10
1N5265B	S	ZD			500								62/2	5
1N5266	S	ZD			500								68/1.8	20
1N5266A	S	ZD			500								68/1.8	10
1N5266B	S	ZD			500								68/1.8	5
1N5267	S	ZD			500								75/1.7	20
1N5267A	S	ZD			500								75/1.7	10
1N5267B	S	ZD			500								75/1.7	5
1N5268	S	ZD			500								82/1.5	20
1N5268A	S	ZD			500								82/1.5	10
1N5268B	S	ZD			500								82/1.5	5
1N5269	S	ZD			500								87/1.4	20

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5269A	S	ZD			500						87/1.4	10
1N5269B	S	ZD			500						87/1.4	5
1N5270	S	ZD			500						91/1.4	20
1N5270A	S	ZD			500						91/1.4	10
1N5270B	S	ZD			500						91/1.4	5
1N5271	S	ZD			500						100/1.3	20
1N5271A	S	ZD			500						100/1.3	10
1N5271B	S	ZD			500						100/1.3	5
1N5272	S	ZD			500						110/1.1	20
1N5272A	S	ZD			500						110/1.1	10
1N5272B	S	ZD			500						110/1.1	5
1N5273	S	ZD			500						120/1	20
1N5273A	S	ZD			500						120/1	10
1N5273B	S	ZD			500						120/1	5
1N5274	S	ZD			500						130/.95	20
1N5274A	S	ZD			500						130/.95	10
1N5274B	S	ZD			500						130/.95	5
1N5275	S	ZD			500						140/.9	20
1N5275A	S	ZD			500						140/.9	10
1N5275B	S	ZD			500						140/.9	5
1N5276	S	ZD			500						150/.85	20
1N5276A	S	ZD			500						150/.85	10
1N5276B	S	ZD			500						150/.85	5
1N5277	S	ZD			500						160/.80	20
1N5277A	S	ZD			500						160/.80	10
1N5277B	S	ZD			500						160/.80	5
1N5278	S	ZD			500						170/.74	20
1N5278A	S	ZD			500						170/.74	10
1N5278B	S	ZD			500						170/.74	5
1N5279	S	ZD			500						180/.68	20
1N5279A	S	ZD			500						180/.68	10
1N5279B	S	ZD			500						180/.68	5
1N5280	S	ZD			500						190/.66	20
1N5280A	S	ZD			500						190/.66	10
1N5280B	S	ZD			500						190/.66	5
1N5281	S	ZD			500						200/.65	20
1N5281A	S	ZD			500						200/.65	10
1N5281B	S	ZD			500						200/.65	5
1N5282	S	SD		1N4150		80		.1/55	1.3/500	4		
1N5283	S	RD			600							

DIODE INTERCHANGEABILITY

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5284	S	RD			600							
1N5285	S	RD			600							
1N5286	S	RD			600							
1N5287	S	RD			600							
1N5288	S	RD			600							
1N5289	S	RD			600							
1N5290	S	RD			600							
1N5291	S	RD			600							
1N5292	S	RD			600							
1N5293	S	RD			600							
1N5294	S	RD			600							
1N5295	S	RD			600							
1N5296	S	RD			600							
1N5297	S	RD			600							
1N5298	S	RD			600							
1N5300	S	RD			600							
1N5301	S	RD			600							
1N5302	S	RD			600							
1N5303	S	RD			600							
1N5304	S	RD			600							
1N5305	S	RD			600							
1N5306	S	RD			600							
1N5307	S	RD			600							
1N5308	S	RD			600							
1N5309	S	RD			600							
1N5310	S	RD			600							
1N5311	S	RD			600							
1N5312	S	RD			600							
1N5313	S	RD			600							
1N5315	S	SD		1N4153		100		50N/50	1/200	4		
1N5316	S	SD		1N4153		100		50N/50	1/100	4		
1N5317	S	SD		1N4150		80		.1/55	1.3/500	4		
1N5318	S	SD		1N4150		75		.1/50	1/200	4		
1N5319	S	SD		1N4305		40		100/25	1/100	4		
1N5314	S	RD			600							
1N5320	S	RE				100	1	100/100	1.1/1A	250		
1N5324	S	RE				15K	.01	25/	24/			
1N5326	S	RE				100	12					
1N5329	S	RE				1.6K	.135	150/				
1N5330	S	RE				1.6K	.54	150/				

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5331	S	RE				1.2K	12					
1N5332	S	RE				1.2K	35					
1N5389	S	RE				40K	.1	100/	80/			
1N5391	S	RE				50	1.5	300/	1.4/			
1N5392	S	RE				100	1.5	300/	1.4/			
1N5393	S	RE				200	1.5	300/	1.4/			
1N5394	S	RE				300	1.5	300/	1.4/			
1N5395	S	RE				400	1.5	300/	1.4/			
1N5396	S	RE				500	1.5	300/	1.4/			
1N5397	S	RE				600	1.5	300/	1.4/			
1N5398	S	RE				800	1.5	300/	1.4/			
1N5399	S	RE				1K	1.5	300/	1.4/			
1N5400	S	RE				50	3	500/	1.2/			
1N5401	S	RE				100	3	500/	1.2/			
1N5402	S	RE				200	3	500/	1.2/			
1N5403	S	RE				300	3	500/	1.2/			
1N5404	S	RE				400	3	500/	1.2/			
1N5405	S	RE				500	3	500/	1.2/			
1N5406	S	RE				600	3	500/	1.2/			
1N5407	S	RE				800	3	500/	1.2/			
1N5408	S	RE				1K	3	500/	1.2/			
1N5412	S	SD		1N4305		30		.1/30	.5/.1	2		
1N5413	S	SD		1N4305		80		.1/80	.5/.1	2		
1N5414	S	SD		1N4305		75		.1/75	.5/.1	2		
1N5415	S	RE				50		1/	1.1/3A	150		
1N5416	S	RE				100		1/	1.1/3A	150		
1N5417	S	RE				200		1/	1.1/3A	150		
1N5418	S	RE				400		1/	1.1/3A	150		
1N5419	S	RE				500		1/	1.1/3A	250		
1N5420	S	RE				600		1/	1.1/3A	400		
1N5426	S	SD				25		1/6	1/40	.1		
1N5427	S	SD		1N4148		75		.1/50	1/10	4		
1N5428	S	SD		1N4938		200		.1/175	1/100	5		
1N5429	S	SD		1N485		200		5N/125	1/200			
1N5430	S	SD		1N4150		75		.1/50	1/200	4		
1N5431	S	SD		1N4608		80		.1/55	1/500	4		
1N5432	S	SD		TID777		20		50N/10	1/50	.75		
1N5477	S	RE				6K	1	350/	.6/			
1N5478	S	RE				7.2K	1	350/	.6/			
1N5479	S	RE				8.4K	1	350/	.6/			

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA / @ V_R (V)	V_F (V) / @ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N5480	S	RE				9.6K	1	350/	.6/			
1N5481	S	RE				12K	1	350/	.6/			
1N5482	S	RE				2.4K	1	350/	1/			
1N5483	S	RE				3.6K	1	350/	1/			
1N5484	S	RE				4.8K	1	350/	1/			
1N5485	S	RE				6K	1	350/	1/			
1N5518	S	ZD			400						3.3/20	20
1N5518A	S	ZD			400						3.3/20	10
1N5518B	S	ZD			400						3.3/20	5
1N5518C	S	ZD			400						3.3/20	2
1N5518D	S	ZD			400						3.3/20	1
1N5519	S	ZD			400						3.6/20	20
1N5519A	S	ZD			400						3.6/20	10
1N5519B	S	ZD			400						3.6/20	5
1N5519C	S	ZD			400						3.6/20	2
1N5519D	S	ZD			400						3.6/20	1
1N5520	S	ZD			400						3.9/20	20
1N5520A	S	ZD			400						3.9/20	10
1N5520B	S	ZD			400						3.9/20	5
1N5520C	S	ZD			400						3.9/20	2
1N5520D	S	ZD			400						3.9/20	1
1N5521	S	ZD			400						4.3/20	20
1N5521A	S	ZD			400						4.3/20	10
1N5521B	S	ZD			400						4.3/20	5
1N5521C	S	ZD			400						4.3/20	2
1N5521D	S	ZD			400						4.3/20	1
1N5522	S	ZD			400						4.7/10	20
1N5522A	S	ZD			400						4.7/10	10
1N5522B	S	ZD			400						4.7/10	5
1N5522C	S	ZD			400						4.7/10	2
1N5522D	S	ZD			400						4.7/10	1
1N5523	S	ZD			400						5.1/5	20
1N5523A	S	ZD			400						5.1/5	10
1N5523B	S	ZD			400						5.1/5	5
1N5523C	S	ZD			400						5.1/5	2
1N5523D	S	ZD			400						5.1/5	1
1N5524	S	ZD			400						5.6/3	20
1N5524A	S	ZD			400						5.6/3	10
1N5524B	S	ZD			400						5.6/3	5
1N5524C	S	ZD			400						5.6/3	2

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N5524D	S	ZD			400								5.6/3	1
1N5525	S	ZD			400								6.2/1	20
1N5525A	S	ZD			400								6.2/1	10
1N5525B	S	ZD			400								6.2/1	5
1N5525C	S	ZD			400								6.2/1	2
1N5525D	S	ZD			400								6.2/1	1
1N5526	S	ZD			400								6.8/1	20
1N5526A	S	ZD			400								6.8/1	10
1N5526B	S	ZD			400								6.8/1	5
1N5526C	S	ZD			400								6.8/1	2
1N5526D	S	ZD			400								6.8/1	1
1N5527	S	ZD			400								7.5/1	20
1N5527A	S	ZD			400								7.5/1	10
1N5527B	S	ZD			400								7.5/1	5
1N5527C	S	ZD			400								7.5/1	2
1N5527D	S	ZD			400								7.5/1	1
1N5528	S	ZD			400								8.2/1	20
1N5528A	S	ZD			400								8.2/1	10
1N5528B	S	ZD			400								8.2/1	5
1N5528C	S	ZD			400								8.2/1	2
1N5528D	S	ZD			400								8.2/1	1
1N5529	S	ZD			400								9.1/1	20
1N5529A	S	ZD			400								9.1/1	10
1N5529B	S	ZD			400								9.1/1	5
1N5529C	S	ZD			400								9.1/1	2
1N5529D	S	ZD			400								9.1/1	1
1N5530	S	ZD			400								10/1	20
1N5530A	S	ZD			400								10/1	10
1N5530B	S	ZD			400								10/1	5
1N5530C	S	ZD			400								10/1	2
1N5530D	S	ZD			400								10/1	1
1N5531	S	ZD			400								11/1	20
1N5531A	S	ZD			400								11/1	10
1N5531B	S	ZD			400								11/1	5
1N5531C	S	ZD			400								11/1	2
1N5531D	S	ZD			400								11/1	1
1N5532	S	ZD			400								12/1	20
1N5532A	S	ZD			400								12/1	10
1N5532B	S	ZD			400								12/1	5
1N5532C	S	ZD			400								12/1	2

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R μA	@ V_R / (V)	V_F (V)	@ I_F / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5532D	S	ZD			400								12/1	1
1N5533	S	ZD			400								13/1	20
1N5533A	S	ZD			400								13/1	10
1N5533B	S	ZD			400								13/1	5
1N5533C	S	ZD			400								13/1	2
1N5533D	S	ZD			400								13/1	1
1N5534	S	ZD			400								14/1	20
1N5534A	S	ZD			400								14/1	10
1N5534B	S	ZD			400								14/1	5
1N5534C	S	ZD			400								14/1	2
1N5534D	S	ZD			400								14/1	1
1N5535	S	ZD			400								15/1	20
1N5535A	S	ZD			400								15/1	10
1N5535B	S	ZD			400								15/1	5
1N5535C	S	ZD			400								15/1	2
1N5535D	S	ZD			400								15/1	1
1N5536	S	ZD			400								16/1	20
1N5536A	S	ZD			400								16/1	10
1N5536B	S	ZD			400								16/1	5
1N5536C	S	ZD			400								16/1	2
1N5536D	S	ZD			400								16/1	1
1N5537	S	ZD			400								17/1	20
1N5537A	S	ZD			400								17/1	10
1N5537B	S	ZD			400								17/1	5
1N5537C	S	ZD			400								17/1	2
1N5537D	S	ZD			400								17/1	1
1N5538	S	ZD			400								18/1	20
1N5538A	S	ZD			400								18/1	10
1N5538B	S	ZD			400								18/1	5
1N5538C	S	ZD			400								18/1	2
1N5538D	S	ZD			400								18/1	1
1N5539	S	ZD			400								19/1	20
1N5539A	S	ZD			400								19/1	10
1N5539B	S	ZD			400								19/1	5
1N5539C	S	ZD			400								19/1	2
1N5539D	S	ZD			400								19/1	1
1N5540	S	ZD			400								20/1	20
1N5540A	S	ZD			400								20/1	10
1N5540B	S	ZD			400								20/1	5
1N5540C	S	ZD			400								20/1	2

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5540D	S	ZD			400						20/1	1
1N5541	S	ZD			400						22/1	20
1N5541A	S	ZD			400						22/1	10
1N5541B	S	ZD			400						22/1	5
1N5541C	S	ZD			400						22/1	2
1N5541D	S	ZD			400						22/1	1
1N5542	S	ZD			400						24/1	20
1N5542A	S	ZD			400						24/1	10
1N5542B	S	ZD			400						24/1	5
1N5542C	S	ZD			400						24/1	2
1N5542D	S	ZD			400						24/1	1
1N5543	S	ZD			400						25/1	20
1N5543A	S	ZD			400						25/1	10
1N5543B	S	ZD			400						25/1	5
1N5543C	S	ZD			400						25/1	2
1N5543D	S	ZD			400						25/1	1
1N5544	S	ZD			400						28/1	20
1N5544A	S	ZD			400						28/1	10
1N5544B	S	ZD			400						28/1	5
1N5544C	S	ZD			400						28/1	2
1N5544D	S	ZD			400						28/1	1
1N5545	S	ZD			400						30/1	20
1N5545A	S	ZD			400						30/1	10
1N5545B	S	ZD			400						30/1	5
1N5545C	S	ZD			400						30/1	2
1N5545D	S	ZD			400						30/1	1
1N5546	S	ZD			400						33/1	20
1N5546A	S	ZD			400						33/1	10
1N5546B	S	ZD			400						33/1	5
1N5546C	S	ZD			400						33/1	2
1N5546D	S	ZD			400						33/1	1
1N5550	S	RE				200	3	25/1		2U		
1N5551	S	RE				400	3	25/1		2U		
1N5552	S	RE				600	3	25/1		2U		
1N5553	S	RE				800	3	25/1		2U		
1N5554	S	RE				1K	3	25/1		2U		
1N5555	S	TS			1W	21.5		5/				
1N5556	S	TS			1W	28.5		5/				
1N5557	S	TS			1W	34.5		5/				
1N5558	S	TS			1W	124		5/				

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	RATINGS V_R (V)	RATINGS I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5559	S	ZD		1N4736	1W						6.8/37	20
1N5559A	S	ZD		1N4736	1W						6.8/37	10
1N5559B	S	ZD		1N4736A	1W						6.8/37	5
1N5560	S	ZD		1N4737	1W						7.5/34	20
1N5560A	S	ZD		1N4737	1W						7.5/34	10
1N5560B	S	ZD		1N4737A	1W						7.5/34	5
1N5561	S	ZD		1N4738	1W						8.2/31	20
1N5561A	S	ZD		1N4738	1W						8.2/31	10
1N5561B	S	ZD		1N4738A	1W						8.2/31	5
1N5562	S	ZD		1N4739	1W						9.1/28	20
1N5562A	S	ZD		1N4739	1W						9.1/28	10
1N5562B	S	ZD		1N4739A	1W						9.1/28	5
1N5563	S	ZD		1N4740	1W						10/25	20
1N5563A	S	ZD		1N4740	1W						10/25	10
1N5563B	S	ZD		1N4740A	1W						10/25	5
1N5564	S	ZD		1N4741	1W						11/23	20
1N5564A	S	ZD		1N4741	1W						11/23	10
1N5564B	S	ZD		1N4741A	1W						11/23	5
1N5565	S	ZD		1N4742	1W						12/21	20
1N5565A	S	ZD		1N4742	1W						12/21	10
1N5565B	S	ZD		1N4742A	1W						12/21	5
1N5566	S	ZD		1N4743	1W						13/19	20
1N5566A	S	ZD		1N4743	1W						13/19	10
1N5566B	S	ZD		1N4743A	1W						13/19	5
1N5567	S	ZD		1N4744	1W						15/17	20
1N5567A	S	ZD		1N4744	1W						15/17	10
1N5567B	S	ZD		1N4744A	1W						15/17	5
1N5568	S	ZD		1N4745	1W						16/15	20
1N5568A	S	ZD		1N4745	1W						16/15	10
1N5568B	S	ZD		1N4745A	1W						16/15	5
1N5569	S	ZD		1N4746	1W						18/14	20
1N5569A	S	ZD		1N4746	1W						18/14	10
1N5569B	S	ZD		1N4746A	1W						18/14	5
1N5570	S	ZD		1N4747	1W						20/12	20
1N5570A	S	ZD		1N4747	1W						20/12	10
1N5570B	S	ZD		1N4747A	1W						20/12	5
1N5571	S	ZD		1N4748	1W						22/11	20
1N5571A	S	ZD		1N4748	1W						22/11	10
1N5571B	S	ZD		1N4748A	1W						22/11	5
1N5572	S	ZD		1N4749	1W						24/10	20

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5572A	S	ZD		1N4749	1W						24/10	10
1N5572B	S	ZD		1N4749A	1W						24/10	5
1N5573	S	ZD		1N4750	1W						27/9.5	20
1N5573A	S	ZD		1N4750	1W						27/9.5	10
1N5573B	S	ZD		1N4750A	1W						27/9.5	5
1N5574	S	ZD		1N4751	1W						30/8.5	20
1N5574A	S	ZD		1N4751	1W						30/8.5	10
1N5574B	S	ZD		1N4751A	1W						30/8.5	5
1N5575	S	ZD		1N4752	1W						33/7.5	20
1N5575A	S	ZD		1N4752	1W						33/7.5	10
1N5575B	S	ZD		1N4752A	1W						33/7.5	5
1N5576	S	ZD			1W						36/7	20
1N5576A	S	ZD			1W						36/7	10
1N5576B	S	ZD			1W						36/7	5
1N5577	S	ZD			1W						39/6.5	20
1N5577A	S	ZD			1W						39/6.5	10
1N5577B	S	ZD			1W						39/6.5	5
1N5578	S	ZD			1W						43/6	20
1N5578A	S	ZD			1W						43/6	10
1N5578B	S	ZD			1W						43/6	5
1N5579	S	ZD			1W						47/5.5	20
1N5579A	S	ZD			1W						47/5.5	10
1N5579B	S	ZD			1W						47/5.5	5
1N5580	S	ZD			1W						51/5	20
1N5580A	S	ZD			1W						51/5	10
1N5580B	S	ZD			1W						51/5	5
1N5581	S	ZD			1W						56/4.5	20
1N5581A	S	ZD			1W						56/4.5	10
1N5581B	S	ZD			1W						56/4.5	5
1N5582	S	ZD			1W						62/4	20
1N5582A	S	ZD			1W						62/4	10
1N5582B	S	ZD			1W						62/4	5
1N5583	S	ZD			1W						68/3.7	20
1N5583A	S	ZD			1W						68/3.7	10
1N5583B	S	ZD			1W						68/3.7	5
1N5584	S	ZD			1W						75/3.3	20
1N5584A	S	ZD			1W						75/3.3	10
1N5584B	S	ZD			1W						75/3.3	5
1N5585	S	ZD			1W						82/3	20
1N5585A	S	ZD			1W						82/3	10

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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA / @ V_R (V)	V_F (V) / @ I_F (mA)	t_{rr} (ns)	V_Z (V) / @ I_Z (mA)	TOL %
1N5585B	S	ZD			1W						82/3	5
1N5586	S	ZD			1W						91/2.8	20
1N5586A	S	ZD			1W						91/2.8	10
1N5586B	S	ZD			1W						91/2.8	5
1N5587	S	ZD			1W						100/2.5	20
1N5587A	S	ZD			1W						100/2.5	10
1N5587B	S	ZD			1W						100/2.5	5
1N5588	S	ZD			1W						110/2.3	20
1N5588A	S	ZD			1W						110/2.3	10
1N5588B	S	ZD			1W						110/2.3	5
1N5589	S	ZD			1W						120/2	20
1N5589A	S	ZD			1W						120/2	10
1N5589B	S	ZD			1W						120/2	5
1N5590	S	ZD			1W						130/1.9	20
1N5590A	S	ZD			1W						130/1.9	10
1N5590B	S	ZD			1W						130/1.9	5
1N5591	S	ZD			1W						150/1.7	20
1N5591A	S	ZD			1W						150/1.7	10
1N5591B	S	ZD			1W						150/1.7	5
1N5592	S	ZD			1W						160/1.6	20
1N5592A	S	ZD			1W						160/1.6	10
1N5592B	S	ZD			1W						160/1.6	5
1N5593	S	ZD			1W						180/1.4	20
1N5593A	S	ZD			1W						180/1.4	10
1N5593B	S	ZD			1W						180/1.4	5
1N5594	S	ZD			1W						200/1.2	20
1N5594A	S	ZD			1W						200/1.2	10
1N5594B	S	ZD			1W						200/1.2	5
1N5595	S	RE				5K	1.15	300/	7.4/			
1N5596	S	RE				7.5K	.87	300/	11/			
1N5597	S	RE				10K	.7	300/	14/			
1N5598	S	RE				15K	.47	300/	23/			
1N5599	S	RE				2.5K	2.1	750/	3.7/			
1N5600	S	RE				5K	1.4	750/	7.4/			
1N5601	S	RE				7.5K	.92	750/	11/			
1N5602	S	RE				2.5K	4.6	1M/	5/			
1N5603	S	RE				5K	3.3	1M/	9/			
1N5604	S	RE				7.5K	2.3	1M/	12/			
1N5605	S	SD		1N457		70		25N/60	1/20			
1N5606	S	SD		1N458		150		25N/125	1/7			

TEXAS INSTRUMENTS
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TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5607	S	SD		1N4938		200		25N/175	1/3	300		
1N5608	S	SD		1N4938		120		50N/50	1/100	300		
1N5609	S	SD		1N4938		120		5/100	1/6	300		
1N5614	S	RE		TID383		200	1	2.5/200	1.2/1A	2U		
1N5615	S	RE				200	1	2.5/	1.2/	150		
1N5616	S	RE		TID384		400	1	2.5/400	1.2/1A	2U		
1N5617	S	RE				400	1	2.5/	1.2/	150		
1N5618	S	RE		TID385		600	1	2.5/600	1.2/1A	2U		
1N5619	S	RE				600	1	2.5/	1.2/	250		
1N5620	S	RE		TID386		800	1	2.5/800	1.2/1A	2U		
1N5621	S	RE				800	1	2.5/	1.2/	350		
1N5622	S	RE		TID387		1K	1	2.5/1K	1.2/1A	2U		
1N5623	S	RE				1K	1	2.5/	1.2/	500		
1N5624	S	RE				200	3	300/	.95/			
1N5625	S	RE				400	3	300/	.95/			
1N5626	S	RE				600	3	300/	.95/			
1N5627	S	RE				800	3	300/	.95/			
1N5667A	S	ZD			250						2/1	10
1N5668A	S	ZD			250						2.2/1	10
1N5669A	S	ZD			250						2.4/1	10
1N5670A	S	ZD			250						2.7/1	10
1N5671A	S	ZD			250						3/1	10
1N5672A	S	ZD			250						3.3/1	10
1N5673A	S	ZD			250						3.6/1	10
1N5674A	S	ZD			250						3.9/1	10
1N5675A	S	ZD			250						4.3/1	10
1N5676A	S	ZD			250						4.7/1	10
1N5677A	S	ZD			250						5.1/1	10
1N5678A	S	ZD			250						5.6/1	10
1N5679	S	RE		TID381		50	1	10/50	1.1/1A			
1N5680	S	RE		TID382		100	1	10/100	1.1/1A			
1N5711	S	SD		1N4446		55		.2/50	1/15			
1N5712	S	SD		1N4446		16		.1/15	1/35			
1N5713	S	SD		1N4446		12		.1/8	1/20			
1N5719	S	SD		1N484		150		1/100	1/100			
1N5720	S	SD		1N4448		30		.5/20	1/50	10		
1N5721	S	SD		1N4448		15		.5/10	1/50	10		
1N5726	S	SD		1N4608		60		.2/50	1.1/500	10		
1N5727	S	SD		1N4608		50		1/30	1.1/500	10		
1N5728B	S	ZD			400						4.7/10	5

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R µA @ V_R / (V)	V_F (V) @ I_F / (mA)	t_{rr} (ns)	V_Z (V) @ I_Z / (mA)	TOL %
1N5728C	S	ZD			400						4.7/10	2
1N5728D	S	ZD			400						4.7/10	1
1N5729B	S	ZD			400						5.1/10	5
1N5729C	S	ZD			400						5.1/10	2
1N5729D	S	ZD			400						5.1/10	1
1N5730B	S	ZD			400						5.6/10	5
1N5730C	S	ZD			400						5.6/10	2
1N5730D	S	ZD			400						5.6/10	1
1N5731B	S	ZD			400						6.2/10	5
1N5731C	S	ZD			400						6.2/10	2
1N5731D	S	ZD			400						6.2/10	1
1N5732B	S	ZD			400						6.8/10	5
1N5732C	S	ZD			400						6.8/10	2
1N5732D	S	ZD			400						6.8/10	1
1N5733B	S	ZD			400						7.5/10	5
1N5733C	S	ZD			400						7.5/10	2
1N5733D	S	ZD			400						7.5/10	1
1N5734B	S	ZD			400						8.2/10	5
1N5734C	S	ZD			400						8.2/10	2
1N5734D	S	ZD			400						8.2/10	1
1N5735B	S	ZD			400						9.1/10	5
1N5735C	S	ZD			400						9.1/10	2
1N5735D	S	ZD			400						9.1/10	1
1N5736B	S	ZD			400						10/10	5
1N5736C	S	ZD			400						10/10	2
1N5736D	S	ZD			400						10/10	1
1N5737B	S	ZD			400						11/5	5
1N5737C	S	ZD			400						11/5	2
1N5737D	S	ZD			400						11/5	1
1N5738B	S	ZD			400						12/5	5
1N5738C	S	ZD			400						12/5	2
1N5738D	S	ZD			400						12/5	1
1N5739B	S	ZD			400						13/5	5
1N5739C	S	ZD			400						13/5	2
1N5739D	S	ZD			400						13/5	1
1N5740B	S	ZD			400						15/5	5
1N5740C	S	ZD			400						15/5	2
1N5740D	S	ZD			400						15/5	1
1N5741B	S	ZD			400						16/5	5
1N5741C	S	ZD			400						16/5	2

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R μA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5741D	S	ZD			400						16/5	1
1N5742B	S	ZD			400						18/5	5
1N5742C	S	ZD			400						18/5	2
1N5742D	S	ZD			400						18/5	1
1N5743B	S	ZD			400						20/5	5
1N5743C	S	ZD			400						20/5	2
1N5743D	S	ZD			400						20/5	1
1N5744B	S	ZD			400						22/5	5
1N5744C	S	ZD			400						22/5	2
1N5744D	S	ZD			400						22/5	1
1N5745B	S	ZD			400						24/5	5
1N5745C	S	ZD			400						24/5	2
1N5745D	S	ZD			400						24/5	1
1N5746B	S	ZD			400						27/2	5
1N5746C	S	ZD			400						27/2	2
1N5746D	S	ZD			400						27/2	1
1N5747B	S	ZD			400						30/2	5
1N5747C	S	ZD			400						30/2	2
1N5747D	S	ZD			400						30/2	1
1N5748B	S	ZD			400						33/2	5
1N5748C	S	ZD			400						33/2	2
1N5748D	S	ZD			400						33/2	1
1N5749B	S	ZD			400						36/2	5
1N5749C	S	ZD			400						36/2	2
1N5749D	S	ZD			400						36/2	1
1N5750B	S	ZD			400						39/2	5
1N5750C	S	ZD			400						39/2	2
1N5750D	S	ZD			400						39/2	1
1N5751B	S	ZD			400						43/2	5
1N5751C	S	ZD			400						43/2	2
1N5751D	S	ZD			400						43/2	1
1N5752B	S	ZD			400						47/2	5
1N5752C	S	ZD			400						47/2	2
1N5752D	S	ZD			400						47/2	1
1N5753B	S	ZD			400						51/2	5
1N5753C	S	ZD			400						51/2	2
1N5753D	S	ZD			400						51/2	1
1N5754B	S	ZD			400						56/2	5
1N5754C	S	ZD			400						56/2	2
1N5754D	S	ZD			400						56/2	1

TYPE NUMBER	MATERIAL	CLASSIFICATION	TI REPLACEMENT	FOR NEW DESIGN	RATINGS P_D (mW)	V_R (V)	I (A)	CHARACTERISTICS I_R @ V_R µA / (V)	V_F @ I_F (V) / (mA)	t_{rr} (ns)	V_Z @ I_Z (V) / (mA)	TOL %
1N5755B	S	ZD			400						62/2	5
1N5755C	S	ZD			400						62/2	2
1N5755D	S	ZD			400						62/2	1
1N5756B	S	ZD			400						68/2	5
1N5756C	S	ZD			400						68/2	2
1N5756D	S	ZD			400						68/2	1
1N5757B	S	ZD			400						75/2	5
1N5757C	S	ZD			400						75/2	2
1N5757D	S	ZD			400						75/2	1
1N5766	S	SD				110		20/100	1.7/30A	400		
1N5767	S	SD				100		1/50	1/100			

Diode Data Sheets

TYPE 1N251
SILICON SWITCHING DIODE

BULLETIN NO. DL-S 739094, SEPTEMBER 1966—REVISED MARCH 1973

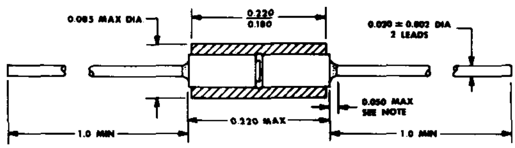
MEDIUM-SPEED SWITCHING DIODE

- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY COLOR BAND



DIMENSIONS ARE IN INCHES

NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

REGISTERED BODY DIMENSIONS*

LENGTH	0.300 MAX.
DIAMETER	0.105 MAX.

*absolute maximum ratings

$V_{RM(wkg)}$	Working Peak Reverse Voltage at 125°C Free-Air Temperature	30 V
I_O	Average Rectified Forward Current at (or below) 25°C Free-Air Temperature (See Notes 1 and 2)	75 mA
I_O	Average Rectified Forward Current at 125°C Free-Air Temperature (See Notes 1 and 3)	30 mA
$I_{FM(surge)}$	Peak Surge Current, One Second, at 125°C Free-Air Temperature (See Note 4)	125 mA
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 5)	150 mW
$T_{A(opr)}$	Operating Free-Air Temperature Range	–55°C to 150°C
T_{stg}	Storage Temperature Range	–55°C to 150°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	40		V
$*I_R$	Static Reverse Current	$V_R = 20$ V		20	μA
		$V_R = 10$ V		0.1	μA
		$V_R = 10$ V, $T_A = 125°C$		10	μA
$*V_F$	Static Forward Voltage	$I_F = 5$ mA		1	V

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_{rr}	Reverse Recovery Time	256-JAN, $I_F = 5$ mA, $V_R = 10$ V, $R_L = 1\ k\Omega$, $C_L = 10$ pF, $i_{rr} = 0.5$ mA		150	ns

NOTES: 1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load.
2. Derate linearly to 30 mA at 125°C free-air temperature.
3. Derate linearly to 0 at 150°C free-air temperature.
4. These values apply for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
5. Derate linearly to 150°C free-air temperature at the rate of 1.2 mW/°C.

*Indicates JEDEC registered data

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BULLETIN NO. DL-S 7111508, SEPTEMBER 1971

$V_{RM(wkg)}$ . . . 25 to 185 Volts

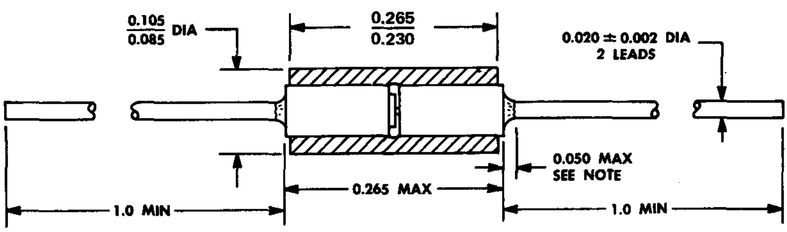
- Rugged Double-Plug Construction
- Low Reverse Current

description and mechanical data

The glass-passivated silicon chip combines extremely low reverse current with a high degree of stability. True glass passivation and the absence of an organic coating ensure protection of the junction from contaminants and moisture.

Double-plug construction affords integral positive contacts by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard. Gold-plated leads are available on request.

FALLS WITHIN JEDEC DO-7 DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES

NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

REGISTERED BODY DIMENSIONS*

	1N456 THRU 1N459 1N461 THRU 1N464	1N456A THRU 1N459A 1N461A THRU 1N464A	1N482 THRU 1N485 1N482A THRU 1N485A 1N482B THRU 1N485B
LENGTH	0.265 MAX	0.265 MAX	0.300 MAX
DIAMETER	0.105 MAX	0.140 MAX	0.105 MAX

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TEXAS INSTRUMENTS
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*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

TYPE	V_{RM} Peak Reverse Voltage	$V_{RM(wkg)}$ Working Peak Reverse Voltage	I_O Average Rectified Forward Current @ $T_A \leq 25°C$ (See Notes 1 and 2)	I_F Steady State Forward Current @ $T_A \leq 25°C$ (See Note 2)	$I_{FM(surge)}$ Peak Surge Current 1 s (See Note 3)	$I_{FM(surge)}$ Peak Surge Current 2 µs (See Note 4)	P Continuous Power Dissipation $T_A \leq 25°C$ (See Note 5)	T_{stg} Storage Temperature Range
1N456	30 V	25 V	90 mA	135 mA	0.7 A	1.2 A	200 mW	−80°C to 200°C
1N456A			200 mA	—	1.5 A	—	500 mW	
1N457	70 V	60 V	75 mA	110 mA	0.6 A	1.0 A	200 mW	
1N457A			200 mA	—	1.5 A	—	500 mW	
1N458	150 V	125 V	55 mA	80 mA	0.5 A	0.8 A	200 mW	
1N458A			200 mA	—	1.5 A	—	500 mW	
1N459	200 V	175 V	40 mA	60 mA	0.4 A	0.7 A	200 mW	
1N459A			200 mA	—	1.5 A	—	500 mW	
1N461	30 V	25 V	60 mA	90 mA	0.55 A	0.9 A	200 mW	
1N461A			200 mA	—	1.5 A	—	500 mW	
1N462	70 V	60 V	50 mA	75 mA	0.5 A	0.8 A	200 mW	
1N462A			200 mA	—	1.5 A	—	500 mW	
1N463	200 V	175 V	30 mA	50 mA	0.4 A	0.7 A	200 mW	
1N463A			200 mA	—	1.5 A	—	500 mW	
1N464	150 V	125 V	40 mA	60 mA	0.4 A	0.7 A	200 mW	
1N464A			200 mA	—	1.5 A	—	500 mW	

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

TYPE	V_{RM} Peak Reverse Voltage	$V_{RM(wkg)}$ Working Peak Reverse Voltage	I_O Average Rectified Forward Current @ $T_A \leq 25°C$ (See Notes 1 and 2)	$I_{FM(rep)}$ Repetitive Peak Forward Current (See Note 6)	$I_{FM(surge)}$ Peak Surge Current (See Note 7)	P Continuous Power Dissipation (See Note 5)	T_{stg} Storage Temperature Range
1N482	40 V	36 V	100 mA	400 mA	1 A	250 mW	−65°C to 200°C
1N482A			200 mA	650 mA	2 A		
1N482B			200 mA	650 mA	2 A		
1N483	80 V	70 V	100 mA	400 mA	1 A		
1N483A			200 mA	650 mA	2 A		
1N483B			200 mA	650 mA	2 A		
1N484	150 V	130 V	100 mA	400 mA	1 A		
1N484A			200 mA	650 mA	2 A		
1N484B			200 mA	650 mA	2 A		
1N485	200 V	180 V	100 mA	400 mA	1 A		
1N485A			200 mA	650 mA	2 A		
1N485B			200 mA	650 mA	2 A		

NOTES: 1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load.
2. For operation above 25°C free-air temperature refer to Forward Current Derating Curve Figure 1.
3. These values apply for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
4. These values apply for 2-µs pulses, duty cycle ≤ 1%, with the device at nonoperating thermal equilibrium immediately prior to the surge.
5. For operation above 25°C free-air temperature refer to Dissipation Derating Curve Figure 2.
6. These values apply for a 4-ms square-wave pulse, duty cycle ≤ 25%.
7. These values apply for a 1/10-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.

*JEDEC registered data

TYPES 1N456 THRU 1N459, 1N461 THRU 1N464, 1N482 THRU 1N485, AND SUFFIX VERSIONS SILICON GENERAL PURPOSE DIODES

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

CHARACTERISTICS					TEST VOLTAGE AND CURRENT	
PARAMETER	$V_{(BR)}$ Reverse Breakdown Voltage	I_R Static Reverse Current		V_F Static Forward Voltage		
TEST CONDITIONS	I_R = 100 μA	T_A = 25°C	T_A = 150°C		V_R FOR TESTING I_R	I_F FOR TESTING V_F
LIMITS	MIN	MAX	MAX	MAX		
1N456 1N456A	30 V				25 V	40 mA 100 mA
1N457 1N457A	70 V	25 nA	5 μA		60 V	20 mA 100 mA
1N458 1N458A	150 V				125 V	7 mA 100 mA
1N459 1N459A	200 V			1.0 V	175 V	3 mA 100 mA
1N461 1N461A	30 V				25 V	15 mA 100 mA
1N462 1N462A	70 V	500 nA	30 μA		60 V	5 mA 100 mA
1N463 1N463A	200 V				175 V	1 mA 100 mA
1N464 1N464A	150 V				125 V	3 mA 100 mA
1N482 1N482A 1N482B	40 V	250 nA 25 nA 25 nA	30 μA 15 μA 5 μA	1.1 V 1.0 V 1.0 V	30 V	100 mA
1N483 1N483A 1N483B	80 V	250 nA 25 nA 25 nA	30 μA 15 μA 5 μA	1.1 V 1.0 V 1.0 V	60 V	100 mA
1N484 1N484A 1N484B	150 V	250 nA 25 nA 25 nA	30 μA 15 μA 5 μA	1.1 V 1.0 V 1.0 V	125 V	100 mA
1N485 1N485A 1N485B	200 V	250 nA 25 nA 25 nA	30 μA 15 μA 5 μA	1.1 V 1.0 V 1.0 V	175 V	100 mA

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*JEDEC registered data

THERMAL INFORMATION

FORWARD CURRENT DERATING CURVE

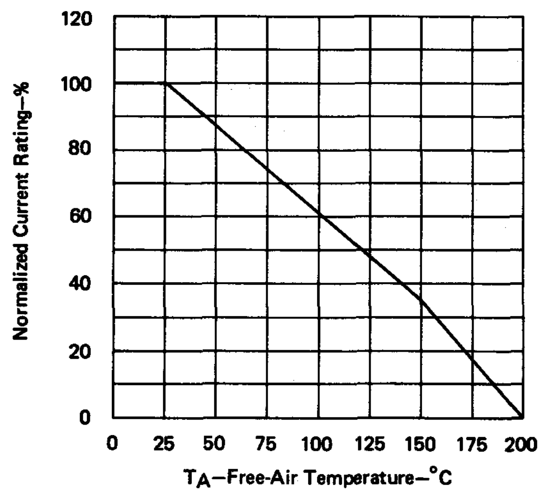


FIGURE 1

DISSIPATION DERATING CURVE

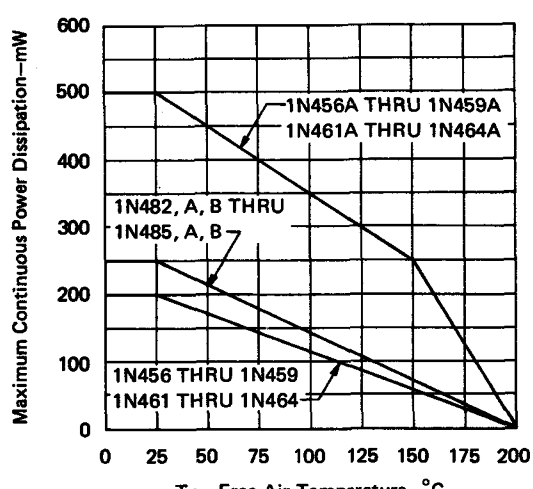


FIGURE 2

BULLETIN NO. DL-S 739121, SEPTEMBER 1966—REVISED MARCH 1973

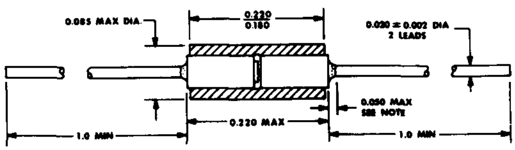
MEDIUM-SPEED SWITCHING DIODES

- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY COLOR BAND



DIMENSIONS ARE IN INCHES

NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		1N625	1N626	1N627	1N628	1N629	UNIT
$^*V_{RM(wkg)}$	Working Peak Reverse Voltage	20	35	75	125	175	V
$^*I_O$	Average Rectified Forward Current at (or below) 25°C Free-Air Temperature (See Notes 1 and 2)	20					mA
$^*I_O$	Average Rectified Forward Current at 100°C Free-Air Temperature (See Notes 1 and 3)	5					mA
$I_{FM(surge)}$	Peak Surge Current, One Second (See Note 4)	300					mA
$^*P$	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 5)	200					mW
$^*T_{A(opr)}$	Operating Free-Air Temperature Range	−80 to 150					°C
T_{stg}	Storage Temperature Range	−80 to 200					°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	1N625		1N626		1N627		1N628		1N629		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	30		50		100		150		200		V
I_R	Static Reverse Current	V_R = Rated $V_{RM(wkg)}$		1		1		1		1		1	μA
		V_R = Rated $V_{RM(wkg)}$, $T_A = 100°C$		30		30		30		30		30	μA
V_F	Static Forward Voltage	$I_F = 4$ mA		1.5		1.5		1.5		1.5		1.5	V

*switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	1N625	1N626	1N627	1N628	1N629	UNIT	LIMIT
t_{rr} Reverse Recovery Time	256-JAN, $I_F = 30$ mA, $V_R = 35$ V, $R_L = 25\ k\Omega$, $C_L = 20$ pF, Recovery to 400 kΩ	1	1	1	1	1	μs	MAX

NOTES: 1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load.
2. Derate linearly to 5 mA at 100°C free-air temperature.
3. Derate linearly to 0 at 150°C free-air temperature.
4. This value applies for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
5. Derate linearly to 150°C free-air temperature at the rate of 1.6 mW/°C.

*Indicates JEDEC registered data

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TYPE 1N643
SILICON SWITCHING DIODE

BULLETIN NO. DL-S 739459, NOVEMBER 1966—REVISED MARCH 1973

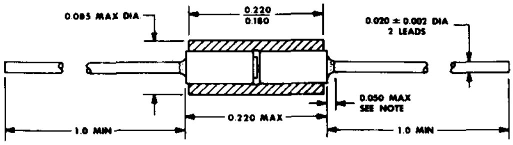
MEDIUM-SPEED SWITCHING DIODE

- **Rugged Double-Plug Construction**

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY COLOR BAND



DIMENSIONS ARE IN INCHES

NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

REGISTERED BODY DIMENSIONS*

LENGTH	0.265 MAX
DIAMETER	0.140 MAX

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

*$V_{RM(wkg)}$	Working Peak Reverse Voltage	175 V
*I_O	Average Rectified Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	40 mA
*$I_{FM(surge)}$	Peak Surge Current, One Second (See Note 2)	0.5 A
*$I_{FM(surge)}$	Peak Surge Current, 0.3 Second (See Note 2)	1 A
*$I_{FM(pulse)}$	Peak Pulse Current (See Note 3)	2 A
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	250 mW
*$T_{A(opr)}$	Operating Free-Air Temperature Range	−65°C to 150°C
*T_{stg}	Storage Temperature Range	−65°C to 150°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	200		V
* I_R	Static Reverse Current	$V_R = 10$ V		0.025	μA
		$V_R = 100$ V		1	μA
		$V_R = 10$ V, $T_A = 100°C$		5	μA
		$V_R = 100$ V, $T_A = 100°C$		15	μA
* V_F	Static Forward Voltage	$I_F = 10$ mA		1	V

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_{rr}	Reverse Recovery Time	256-JAN, $I_F = 5$ mA, $V_R = 40$ V, $R_L = 2.3\ k\Omega$, $C_L = 40$ pF, Recovery to 200 kΩ, See Note 5		0.3	μs

NOTES: 1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Derate linearly to 0 at 150°C free-air temperature.
2. These values apply for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. This value applies for $t_p \leq 1\ \mu s$, duty cycle $\leq 1\%$.
4. Derate linearly to 150°C free-air temperature at the rate of 2 mW/°C.
5. Reverse recovery time is measured using a forward current pulse of 1-μs duration, PRR ≤ 100 kHz. The waveform is monitored on an oscilloscope with a bandwidth of 30 MHz minimum.

*Indicates JEDEC registered data

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BULLETIN NO. DL-S 739125, OCTOBER 1966—REVISED MARCH 1973

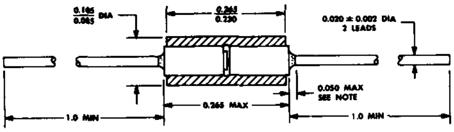
225 V to 600 V • 400 mA AVERAGE

- **Rugged Double-Plug Construction**

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

FALLS WITHIN JEDEC DO-7 DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

REGISTERED BODY DIMENSIONS*
LENGTH .... 0.300 MAX.
DIAMETER .... 0.125 MAX.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		1N645	1N645A	1N646	1N647	1N648	1N649	UNIT
$V_{RM(wkg)}$	Working Peak Reverse Voltage over Operating Free-Air Temperature Range	225	225	300	400	500	600	V
I_O	Average Rectified Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	400						mA
I_O	Average Rectified Forward Current at 150°C Free-Air Temperature	150						mA
$I_{FM(surge)}$	Peak Surge Current, One Second, at 25°C to 150°C Free-Air Temperature (See Note 2)	3						A
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	600						mW
$T_{A(opr)}$	Operating Free-Air Temperature Range	−65 to 150						°C
	Altitude at Rated Working Peak Reverse Voltage	100 000						ft

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	1N645		1N645A		1N646		1N647		1N648		1N649		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$, $T_A = 100°C$	275		275		360		480		600		720		V
I_R	Static Reverse Current	V_R = Rated $V_{RM(wkg)}$		0.2		0.2		0.2		0.2		0.2		0.2	μA
		V_R = Rated $V_{RM(wkg)}$, $T_A = 100°C$		15		15		15		20		20		25	μA
		$V_R = 60$ V				0.05									μA
		$V_R = 60$ V, $T_A = 125°C$				10									μA
V_F	Static Forward Voltage	$I_F = 400$ mA		1		1		1		1		1		1	V
C_T	Total Capacitance	$V_R = 12$ V, f = 1 MHz	6 typ		6 typ		6 typ		6 typ		6 typ		6 typ		pF

NOTES: 1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Derate linearly to 150 mA at 150°C free-air temperature at the rate of 2 mA/°C.
2. These values apply for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. Derate linearly to 200 mW at 150°C free-air temperature at the rate of 3.2 mW/°C.

*JEDEC registered data.

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BULLETIN NO. DL-S 739782, MARCH 1967—REVISED MARCH 1973

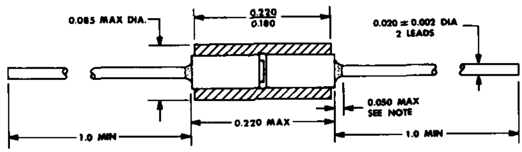
MEDIUM-SPEED SWITCHING DIODES

- Rugged Double-Plug Construction

mechanical data

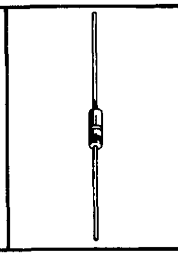
Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



REGISTERED BODY DIMENSIONS*
LENGTH 0.300 MAX
DIAMETER 0.125 MAX

DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		1N659	1N660	1N661	UNIT
*$V_{RM(wkg)}$	Working Peak Reverse Voltage over Operating Free-Air Temperature Range	50	100	200	V
*I_O	Average Rectified Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)		100		mA
*I_O	Average Rectified Forward Current at 100°C Free-Air Temperature (See Note 1)		40		mA
$I_{FM(surge)}$	Peak Surge Current at 25°C Free-Air Temperature (See Note 2)		500		mA
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)		250		mW
*$T_{A(opr)}$	Operating Free-Air Temperature Range		−65 to 150		°C
T_{stg}	Storage Temperature Range		−65 to 150		°C
*	Altitude at Rated Working Peak Reverse Voltage		100 000		ft

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	1N659 MIN	1N659 MAX	1N660 MIN	1N660 MAX	1N661 MIN	1N661 MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$, $T_A = 100°C$	60		120		240		V
I_R	Static Reverse Current	V_R = Rated $V_{RM(wkg)}$		5		5		10	μA
		V_R = Rated $V_{RM(wkg)}$, $T_A = 100°C$		25		50		100	μA
V_F	Static Forward Voltage	$I_F = 6$ mA		1		1		1	V

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	1N659 MIN	1N659 MAX	1N660 MIN	1N660 MAX	1N661 MIN	1N661 MAX	UNIT
t_{rr}	Reverse Recovery Time	256-JAN, $I_F = 30$ mA, $V_R = 35$ V, $R_L = 2\ k\Omega$, $C_L = 20$ pF, Recovery to 400 kΩ		0.3		0.3		0.3	μs

NOTES: 1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Derate linearly to 0 at 150°C free-air temperature.
2. This value applies for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. Derate linearly to 150°C free-air temperature at the rate of 2 mW/°C.

*JEDEC registered data.

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BULLETIN NO. DL-S 739122, SEPTEMBER 1966–REVISED MARCH 1973

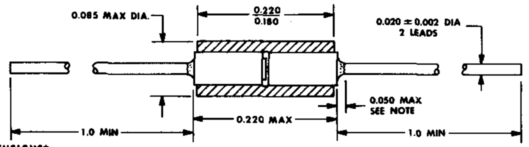
MEDIUM-SPEED SWITCHING DIODE

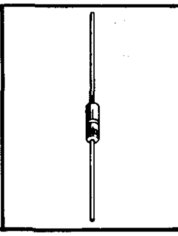
- Rugged Double-Plug Construction

*mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND





REGISTERED BODY DIMENSIONS*
LENGTH 0.265 MAX
DIAMETER 0.140 MAX

DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		1N662	1N663	UNIT
*$V_{RM(wkg)}$	Working Peak Reverse Voltage	80	80	V
*I_O	Average Rectified Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	40	60	mA
*$I_{FM(surge)}$	Peak Surge Current, One Second (See Note 2)	0.5		A
*$I_{FM(surge)}$	Peak Surge Current, 0.3 Second (See Note 2)	1		A
*$I_{FM(pulse)}$	Peak Pulse Current (See Note 3)	2		A
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)	250		mW
*$T_{A(opr)}$	Operating Free-Air Temperature Range	−65 to 150		°C
*T_{stg}	Storage Temperature Range	−65 to 150		°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	1N662		1N663		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	I_R = 100 μA	100		100		V
I_R	Static Reverse Current	V_R = 10 V		1			μA
		V_R = 50 V		20			μA
		V_R = 75 V				5	μA
		V_R = 10 V, T_A = 100°C		20			μA
		V_R = 50 V, T_A = 100°C		100			μA
		V_R = 75 V, T_A = 100°C				50	μA
V_F	Static Forward Voltage	I_F = 10 mA		1			V
		I_F = 100 mA				1	V

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	1N662		1N663		UNIT
			MIN	MAX	MIN	MAX	
t_{rr}	Reverse Recovery Time	256-JAN, I_F = 5 mA, V_R = 40 V, R_L = 2.3 kΩ, C_L = 40 pF, Recovery to 100 kΩ		0.5			μs
		256-JAN, I_F = 5 mA, V_R = 40 V, R_L = 2.3 kΩ, C_L = 40 pF, Recovery to 200 kΩ				0.5	μs

NOTES: 1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Derate linearly to 0 at 150°C free-air temperature.
2. These values apply for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. This value applies for $t_p \leq 1$ μs, duty cycle ≤ 1%.
4. Derate linearly to 150°C free-air temperature at the rate of 2 mW/C°.

* *JEDEC registered data*

TEXAS INSTRUMENTS
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TYPES 1N702 THRU 1N707, 1N702A THRU 1N707A
SILICON VOLTAGE-REGULATOR DIODES

BULLETIN NO. DL-S 739352, DECEMBER 1966—REVISED MARCH 1973

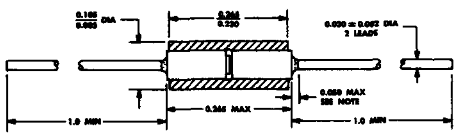
V_Z . . . 2.6 V to 7.1 V
P_D . . . 400 mW

- Available in 5% and 10% Tolerances
- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

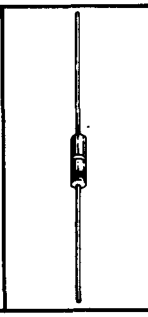
FALLS WITHIN JEDEC DO-7 DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

REGISTERED BODY DIMENSIONS *

	MIN	MAX
LENGTH	0.230	0.300
DIAMETER	0.085	0.125



absolute maximum ratings

TYPE	I_{ZM} Steady-State Regulator Current, $T_A \leq 25°C$ — TI Nominal†	I_{ZM} Steady-State Regulator Current, $T_A \leq 25°C$ — JEDEC Value*	P Dissipation, $T_A \leq 25°C$ (See Note 1)	T_{stg} Storage Temperature Range	T_L Lead Temperature (See Note 2)
1N702	125 mA		400 mW‡ 250 mW*	−65°C to 200°C *	230°C*
1N702A	138 mA	87 mA			
1N703	103 mA				
1N703A	109 mA	66 mA			
1N704	89 mA				
1N704A	93 mA	58 mA			
1N705	74 mA				
1N705A	78 mA	48 mA			
1N706	62 mA				
1N706A	65 mA	41 mA			
1N707	50 mA				
1N707A	53 mA	33 mA			

NOTES: 1. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, figure 1.
2. This value applies $\frac{1}{16}$ inch from the case for 10 seconds.

*Indicates JEDEC registered data

†The nominal I_{ZM} currents shown are applicable to devices having regulator voltages at the upper limit of the range specified for each type. These values do not represent absolute limits. The actual steady-state current-voltage product must not exceed 400 mW.

‡This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

1

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***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER	CHARACTERISTICS							TEST VOLTAGE
	V_Z Zener Breakdown Voltage			z_z Small-Signal Breakdown Impedance	I_R Static Reverse Current		V_F Static Forward Voltage	
TEST CONDITIONS	I_{ZT} = 5 mA			I_{ZT} = 10 mA, I_{zt} = 1 mA, f = 60 Hz	$V_R = V_{R(1)}$, T_A = 25°C	$V_R = V_{R(1)}$, T_A = 100°C	I_F = 200 mA	$V_{R(1)}$
LIMITS	MIN	NOM	MAX	MAX	MAX	MAX	MAX	
UNIT		V		Ω	μA	μA	V	V
1N702	2.00	2.60	3.20	60	75	100		1
1N702A	2.30	2.60	2.90	60	75	100	1	1
1N703	3.00	3.45	3.90	55	50	100		1
1N703A	3.23	3.45	3.67	55	50	100	1	1
1N704	3.70	4.10	4.50	45	5	100		1
1N704A	3.90	4.10	4.30	45	5	100	1	1
1N705	4.30	4.85	5.40	35	5	100		1.5
1N705A	4.58	4.85	5.12	35	5	100	1	1.5
1N706	5.20	5.80	6.40	20	5	100		1.5
1N706A	5.50	5.80	6.10	20	5	100	1	1.5
1N707	6.20	7.10	8.00	10	5	50		3.5
1N707A	6.65	7.10	7.55	10	5	50	1	3.5

*Indicates JEDEC registered data

THERMAL INFORMATION

DISSIPATION DERATING CURVE

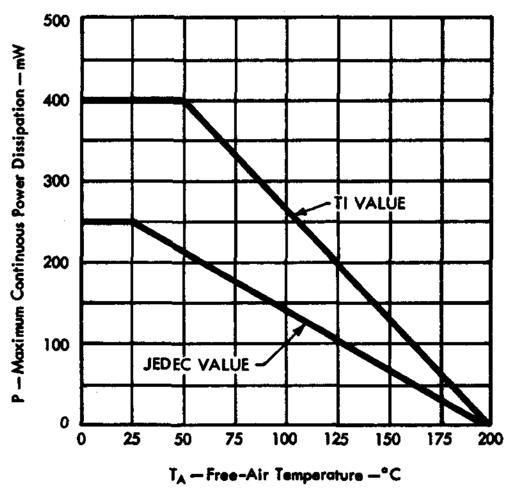

FIGURE 1

TEXAS INSTRUMENTS
INCORPORATED
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BULLETIN NO. DL-S 7311941, MARCH 1973

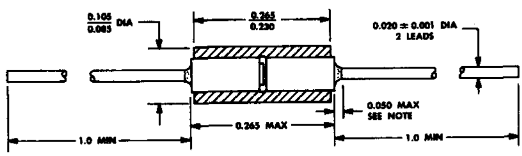
V_Z . . . 5.6 V to 33 V
P_D . . . 400 mW

- Available in 5% and 10% Tolerances
- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contacts by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

FALLS WITHIN JEDEC DO-7 DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

REGISTERED BODY DIMENSIONS*
LENGTH .... 0.265 MAX.
DIAMETER .... 0.105 MAX.

absolute maximum ratings

Continuous Power Dissipation at (or below) 50°C Free-Air Temperature (See Note 1)	400 mW† / 250 mW*
Operating Free-Air Temperature Range	−65°C to 175°C*
Storage Temperature Range	−65°C to 175°C*
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

NOTE 1: For operation above 50°C free-air temperature refer to Dissipation Derating Curve, Figure 1.
†This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.
*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

TEXAS INSTRUMENTS
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TYPES 1N708 THRU 1N726, 1N708A THRU 1N726A SILICON VOLTAGE-REGULATOR DIODES

***electrical characteristics at 25°C free-air temperature**

CHARACTERISTICS							
PARAMETER	V_Z Regulator Voltage					z_z Small-Signal Regulator Impedance	TEST CURRENT
TEST CONDITIONS	$I_R = I_{Z(T)}$					$I_R = I_{Z(T)}$, I_r = 10% $I_{Z(T)}$, f = 60 Hz	$I_{Z(T)}$
LIMIT	NOMINAL‡	1N708-1N726 MIN	1N708-1N726 MAX	1N708A-1N726A MIN	1N708A-1N726A MAX	MAX	
UNIT	V	V	V	V	V	Ω	mA
1N708, A	5.6	5.04	6.16	5.32	5.88	3.6	25
1N709, A	6.2	5.58	6.82	5.89	6.51	4.1	25
1N710, A	6.8	6.12	7.48	6.46	7.14	4.7	25
1N711, A	7.5	6.75	8.25	7.13	7.87	5.3	25
1N712, A	8.2	7.38	9.02	7.79	8.61	6	25
1N713, A	9.1	8.19	10.01	8.65	9.55	7	12
1N714, A	10	9.00	11.00	9.50	10.50	8	12
1N715, A	11	9.90	12.10	10.45	11.55	9	12
1N716, A	12	10.80	13.20	11.40	12.60	10	12
1N717, A	13	11.70	14.30	12.35	13.65	11	12
1N718, A	15	13.50	16.50	14.25	15.75	13	12
1N719, A	16	14.40	17.60	15.20	16.80	15	12
1N720, A	18	16.20	19.80	17.10	18.90	17	12
1N721, A	20	18.00	22.00	19.00	21.00	20	4
1N722, A	22	19.80	24.20	20.90	23.10	24	4
1N723, A	24	21.60	26.40	22.80	25.20	28	4
1N724, A	27	24.30	29.70	25.65	28.35	35	4
1N725, A	30	27.00	33.00	28.50	31.50	42	4
1N726, A	33	29.70	36.30	31.35	34.65	50	4

*JEDEC registered data
‡Tolerance is ±10% for the 1N708 through 1N726 series, ±5% for the 1N708A through 1N726A series.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

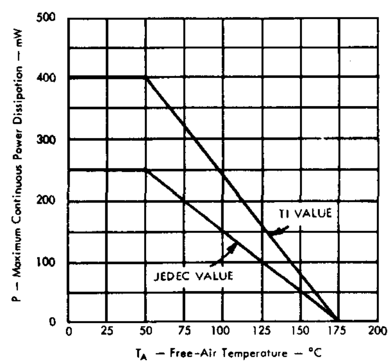

FIGURE 1

TEXAS INSTRUMENTS
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TYPES 1N746 THRU 1N759, 1N746A THRU 1N759A
SILICON VOLTAGE-REGULATOR DIODES

BULLETIN NO. DL-S 7311942, MARCH 1973

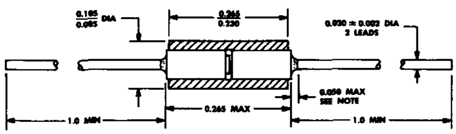
V_Z . . . 3.3 V to 12 V, P_D . . . 400 mW

- **Available in 5% and 10% Tolerances**
- **Rugged Double-Plug Construction**

description and mechanical data

These voltage regulator diodes have been designed using the best of both silicon material processing and packaging technologies. The silicon die is a planar oxide-passivated structure which has additional true-glass passivation over the junction. The double-plug package, proven by years of volume production, ensures the best in mechanical integrity and the lowest possible junction temperature when compared to the thermal characteristics of whisker packages. Because of this rugged double-plug (heat-sink) package, these devices offer very conservatively rated power dissipation capabilities.

FALLS WITHIN JEDEC DO-7 DIMENSIONS
CATHODE END IS DENOTED BY A CONSTRASTING COLOR BAND



REGISTERED BODY DIMENSIONS*
LENGTH .... 0.300 MAX
DIAMETER .... 0.125 MAX

DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

*absolute maximum ratings

Average Rectified Forward Current at (or below) 25°C Free-Air Temperature	230 mA
Average Rectified Forward Current at 150°C Free-Air Temperature	85 mA
Peak Reverse Surge Current	See Table 1
Peak Forward Surge Current	See Figure 1
Continuous Power Dissipation at (or below) 75°C Free-Air Temperature (See Figure 2)	400 mW
Continuous Power Dissipation at 150°C Free-Air Temperature	100 mW
Operating Free-Air Temperature Range	−65°C to 175°C
Storage Temperature Range	−65°C to 175°C

TABLE 1—PEAK REVERSE SURGE CURRENT

TYPE	I_{RSM} Nonrepetitive Reverse Surge Current				I_{RRM} Repetitive Peak Reverse Current (Max Rep Rate = 1 kHz)	
	t = 1 s, T_A = 25°C	t = 0.001 s, T_A = 25°C	t = 1 s, T_A = 150°C	t = 0.001 s, T_A = 150°C	T_A = 25°C	T_A = 150°C
	mA	A	mA	mA	mA	mA
1N746, A	400	4.0	24	70	1000	250
1N747, A	390	4.0	23	69	1000	250
1N748, A	370	4.0	22	67	1000	250
1N749, A	350	4.0	21	63	1000	250
1N750, A	330	3.9	20	58	980	250
1N751, A	310	3.7	19	53	960	250
1N752, A	280	3.5	18	48	940	240
1N753, A	250	3.2	17	45	910	230
1N754, A	220	2.8	16	42	860	220
1N755, A	190	2.5	15	39	800	200
1N756, A	170	2.1	14	36	730	180
1N757, A	150	1.8	13	33	650	150
1N758, A	130	1.5	13	30	530	130
1N759, A	120	1.3	12	28	400	100

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	V_Z Regulator Voltage					α_{VZ} Temperature Coefficient of Regulator Voltage	z_z Small-Signal Regulator Impedance	I_R Static Reverse Current	
TEST CONDITIONS	I_{ZT} = 20 mA					I_{ZT} = 20 mA	I_{ZT} = 20 mA, I_{zt} = 1 mA	V_R = 1 V	V_R = 1 V, T_A = 150°C
LIMIT	NOM	1N746-1N759 MIN	MAX	1N746A-1N759A MIN	MAX	TYP	MAX	MAX	MAX
UNIT	V	V	V	V	V	%/°C	Ω	μA	μA
1N746, A	3.3	2.97	3.63	3.135	3.465	−0.062	28	10	30
1N747, A	3.6	3.24	3.96	3.420	3.780	−0.055	24	10	30
1N748, A	3.9	3.51	4.29	3.705	4.095	−0.049	23	10	30
1N749, A	4.3	3.87	4.73	4.085	4.515	−0.036	22	2	30
1N750, A	4.7	4.23	5.17	4.465	4.935	−0.018	19	2	30
1N751, A	5.1	4.59	5.61	4.845	5.355	−0.008	17	1	20
1N752, A	5.6	5.04	6.16	5.320	5.880	+0.006	11	1	20
1N753, A	6.2	5.58	6.82	5.890	6.510	+0.022	7	0.1	20
1N754, A	6.8	6.12	7.48	6.460	7.140	+0.035	5	0.1	20
1N755, A	7.5	6.75	8.25	7.125	7.875	+0.045	6	0.1	20
1N756, A	8.2	7.38	9.02	7.790	8.610	+0.052	8	0.1	20
1N757, A	9.1	8.19	10.01	8.645	9.555	+0.056	10	0.1	20
1N758, A	10.0	9.00	11.00	9.500	10.500	+0.060	17	0.1	20
1N759, A	12.0	10.80	13.20	11.400	12.600	+0.060	30	0.1	20

*JEDEC registered data

THERMAL INFORMATION

MAXIMUM PEAK FORWARD
NONREPETITIVE SURGE CURRENT
vs
PULSE WIDTH

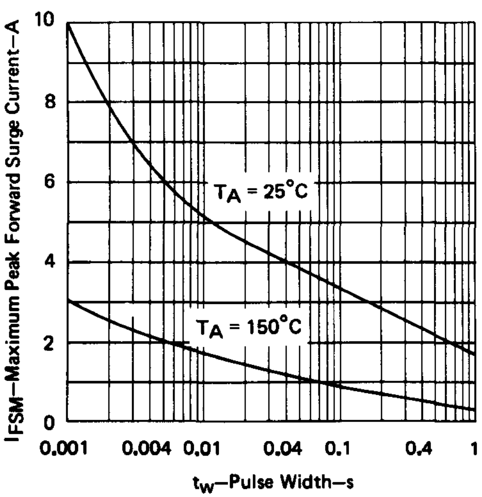


FIGURE 1

DISSIPATION DERATING CURVE

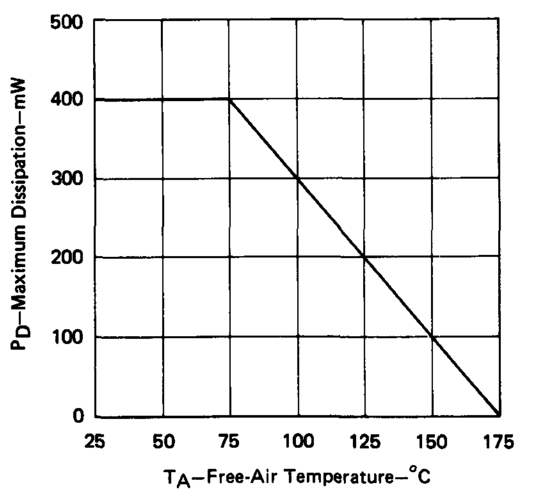


FIGURE 2

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BULLETIN NO. DL-S 7311940, MARCH 1973

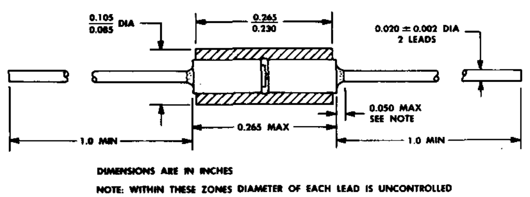
V_Z . . . 4.85 V to 23.5 V
P_D . . . 400 mW

- Tolerances Range from 9% to 15%
- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contacts by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

FALLS WITHIN JEDEC DO-7* DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



absolute maximum ratings

TYPE	I_{ZM} Steady-State Regulator Current $T_A \le 25°C$		I_{ZM} Steady-State Regulator Current $T_A = 125°C$		P Dissipation $T_A \le 25°C$ (See Note 1)	T_{stg} Storage Temperature Range		T_L Lead Temperature* (See Note 2)
	TI Nominal†	JEDEC Value*	TI Nominal†	JEDEC Value*		TI Value‡	JEDEC Value*	
1N761	74 mA	50 mA	24 mA	10 mA				
1N762	62 mA	40 mA	20 mA	8 mA				
1N763	50 mA	30 mA	16 mA	6 mA				
1N764	40 mA	25 mA	13 mA	5 mA				
1N765	33 mA	20 mA	11 mA	4 mA	400 mW‡ 250 mW*	−65°C to 175°C	−65°C to 150°C	230°C
1N766	27 mA	17 mA	9 mA	3.5 mA				
1N767	22 mA	14 mA	7 mA	3 mA				
1N768	19 mA	12 mA	6 mA	2.5 mA				
1N769	15 mA	10 mA	5 mA	2 mA				

NOTES: 1. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, Figure 1.
2. This value applies 1/8 inch from the case for 8 seconds.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†The nominal I_{ZM} currents shown are applicable to devices having regulator voltages at the upper limit of the range specified for each type. These values do not represent absolute limits. The actual steady-state current-voltage product must not exceed the power rating shown in Figure 1.

‡This value is guaranteed by Texas Instruments in addition to the JEDEC registered value which is also shown.

***electrical characteristics at 25°C free-air temperature**

CHARACTERISTICS					
PARAMETER	V_Z Regulator Voltage			Z_Z Small-Signal Regulator Impedance	TEST CURRENT
TEST CONDITIONS	$I_R = I_{Z(T)}$			$I_R = I_{Z(T)}$, $I_r = 10\% \ I_{Z(T)}$, f = 60 Hz	$I_{Z(T)}$
LIMIT	MIN	NOM	MAX	MAX	
UNIT	V	V	V	Ω	mA
1N761	4.3	4.85	5.4	40	10
1N762	5.2	5.80	6.4	18	10
1N763	6.2	7.10	8.0	7	10
1N764	7.5	8.75	10.0	12	10
1N765	9.0	10.50	12.0	45	5
1N766	11.0	12.75	14.5	55	5
1N767	13.5	15.75	18.0	70	5
1N768	17.0	19.00	21.0	100	5
1N769	20.0	23.50	27.0	150	5

*JEDEC registered data (nominal values excluded).

THERMAL CHARACTERISTICS

DISSIPATION DERATING CURVE

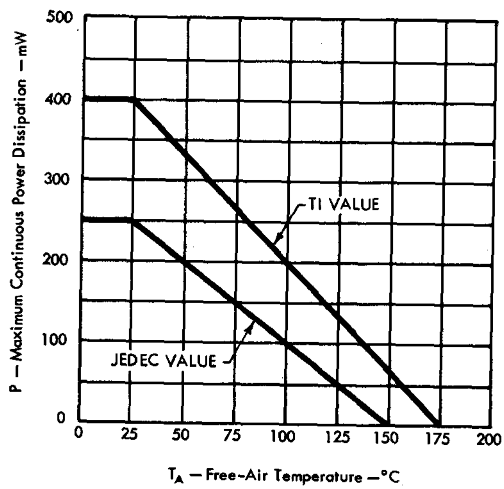


FIGURE 1

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TYPES 1N914, 1N914A, 1N914B, 1N915, 1N916, 1N916A, 1N916B, 1N917
SILICON SWITCHING DIODES

BULLETIN NO. DL-S 7311954, MARCH 1973

FAST SWITCHING DIODES

- **Rugged Double-Plug Construction**

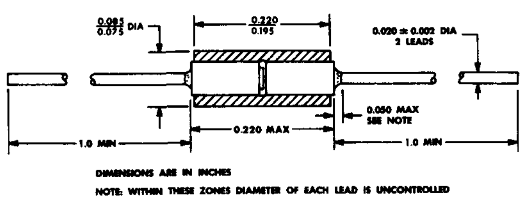
Electrical Equivalents

1N914 . . . 1N4148 . . . 1N4531
1N914A . . . 1N4446
1N914B . . . 1N4448
1N916 . . . 1N4149
1N916A . . . 1N4447
1N916B . . . 1N4449

mechanical data

Double-plug construction affords integral positive contacts by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY COLOR BAND



absolute maximum ratings at specified free-air temperature

		1N914 1N914A 1N914B	1N915	1N916 1N916A 1N916B	1N917	UNIT
Working Peak Reverse Voltage from −65°C to 150°C		75*	50*	75*	30*	V
Average Rectified Forward Current (See Note 1)	at (or below) 25°C	75*	75*	75*	50*	mA
	at 150°C	10*	10*	10*	10*	
Peak Surge Current, 1 Second at 25°C (See Note 2)		500*	500	500*	300	mA
Continuous Power Dissipation at (or below) 25°C (See Note 3)		250*	250	250*	250	mW
Operating Free-Air Temperature Range		−65 to 175				°C
Storage Temperature Range		−65 to 200*				°C
Lead Temperature 1/16 Inch from Case for 10 Seconds		300				°C

NOTES: 1. These values may be applied continuously under a single-phase 60-Hz half-sine-wave operation with resistive load.
2. These values apply for a one-second square-wave pulse with the devices at nonoperating thermal equilibrium immediately prior to the surge.
3. Derate linearly to 175°C free-air temperature at the rate of 1.67 mW/°C.

*JEDEC registered data

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1N914 SERIES AND 1N915

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	1N914		1N914A		1N914B		1N915		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	100		100		100		65		V
I_R	Static Reverse Current	$V_R = 10\ V$								25	nA
		$V_R = 20\ V$		25		25		25			nA
		$V_R = 20\ V$, $T_A = 100°C$						3		5	µA
		$V_R = 20\ V$, $T_A = 150°C$		50		50		50			µA
		$V_R = 50\ V$								5	µA
		$V_R = 75\ V$		5		5		5			µA
V_F	Static Forward Voltage	$I_F = 5\ mA$					0.62	0.72	0.6	0.73	V
		$I_F = 10\ mA$, See Note 4		1							V
		$I_F = 20\ mA$, See Note 4				1					V
		$I_F = 50\ mA$, See Note 4								1	V
		$I_F = 100\ mA$, See Note 4						1			V
C_T	Total Capacitance	$V_R = 0$, $f = 1\ MHz$		4		4		4		4	pF

1N916 SERIES AND 1N917

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	1N916		1N916A		1N916B		1N917		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	100		100		100		40		V
I_R	Static Reverse Current	$V_R = 10\ V$								50	nA
		$V_R = 20\ V$		25		25		25			nA
		$V_R = 20\ V$, $T_A = 100°C$						3		25	µA
		$V_R = 20\ V$, $T_A = 150°C$		50		50		50			µA
		$V_R = 75\ V$		5		5		5			µA
V_F	Static Forward Voltage	$I_F = 0.25\ mA$								0.64	V
		$I_F = 1.5\ mA$								0.74	V
		$I_F = 3.5\ mA$								0.83	V
		$I_F = 5\ mA$					0.63	0.73			V
		$I_F = 10\ mA$, See Note 4		1						1	V
		$I_F = 20\ mA$, See Note 4				1					V
		$I_F = 30\ mA$, See Note 4						1			V
C_T	Total Capacitance	$V_R = 0$, $f = 1\ MHz$		2		2		2		2.5	pF

NOTE 4: These parameters must be measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$.

*JEDEC registered data

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operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS			1N914 1N914A 1N914B 1N916 1N916A 1N916B MIN	MAX	1N915 MIN	MAX	1N917 MIN	MAX	UNIT
t_{rr}	Reverse Recovery Time	I_F = 10 mA, R_L = 100 Ω,	I_{RM} = 10 mA, i_{rr} = 1 mA, See Figure 1 (Condition 1)			8		10*		3*	ns
		I_F = 10 mA, R_L = 100 Ω,	V_R = 6 V, i_{rr} = 1 mA, See Figure 1 (Condition 2)			4*					ns
$V_{FM(rec)}$	Forward Recovery Voltage	I_F = 50 mA,	R_L = 50 Ω,	See Figure 2		2.5*					V
η_r	Rectification Efficiency	V_r = 2 V, Z_{source} = 50 Ω,	R_L = 5 kΩ, f = 100 MHz	C_L = 20 pF,	45*						%

PARAMETER MEASUREMENT INFORMATION

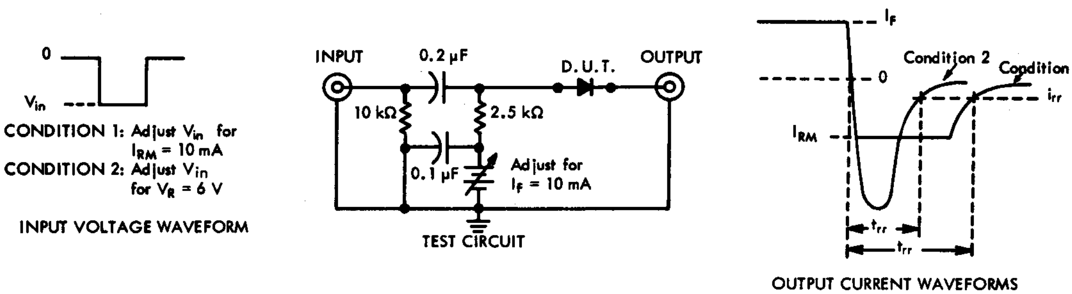

FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq$ 0.5 ns, t_w = 100 ns.
b. Output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq$ 0.6 ns, Z_{in} = 50 Ω.

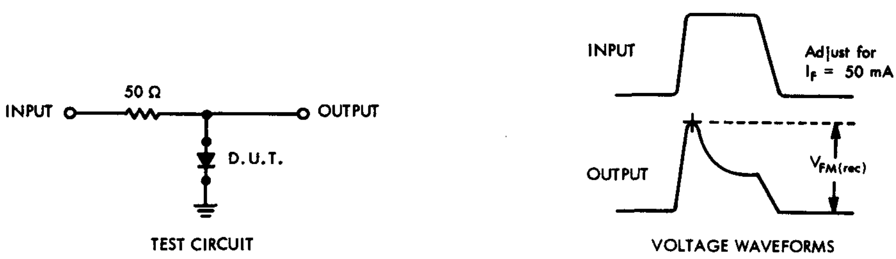

FIGURE 2 — FORWARD RECOVERY VOLTAGE

NOTES: c. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq$ 30 ns, t_w = 100 ns, PRR = 5 to 100 kHz.
d. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq$ 15 ns, $R_{in} \geq$ 1 MΩ, $C_{in} \leq$ 5 pF.

* JEDEC registered data

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TYPES 1N957 THRU 1N973, 1N957A THRU 1N973A, 1N957B THRU 1N973B SILICON VOLTAGE-REGULATOR DIODES

BULLETIN NO. DL-S 7311943, MARCH 1973

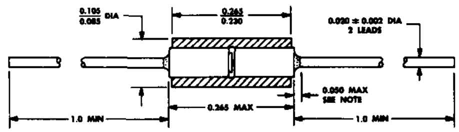
V_Z . . . 6.8 V to 33 V
P_D . . . 400 mW

- **Available in 5%, 10% and 20% Tolerances**
- **Rugged Double-Plug Construction**

description and mechanical data

These voltage regulator diodes have been designed using the best of both silicon material processing and packaging technologies. The silicon die is a planar oxide-passivated structure which has additional true-glass passivation over the junction. The double-plug package, proven by years of volume production, ensures the best in mechanical integrity and the lowest possible junction temperature when compared to the thermal characteristics of whisker packages. Because of this rugged double-plug (heat-sink) package, these devices offer very conservatively rated power dissipation capabilities.

FALLS WITHIN JEDEC DO-7* DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

TYPE	*I_{ZM} Steady-State Regulator Current (See Note 1)	*I_{RSM} Nonrepetitive Reverse Surge Current (See Note 2)	*P_D Continuous Power Dissipation ($T_A \leq 25°C$, See Note 3)	T_{stg} Storage Temperature Range
	mA	mA	mW	°C
1N957, A, B	55	300		
1N958, A, B	50	275		
1N959, A, B	45	250		
1N960, A, B	41	225		
1N961, A, B	38	200		
1N962, A, B	32	175		
1N963, A, B	31	160		
1N964, A, B	28	150		
1N965, A, B	25	130	400	−65 to 175
1N966, A, B	24	120		
1N967, A, B	20	110		
1N968, A, B	18	100		
1N969, A, B	16	90		
1N970, A, B	15	80		
1N971, A, B	13	70		
1N972, A, B	12	65		
1N973, A, B	11	60		

NOTES: 1. The nominal I_{ZM} currents shown are applicable for devices having regulator voltages approximately 10% above the nominal V_Z values shown under electrical characteristics. These values do not represent absolute limits. The actual steady-state current-voltage product must not exceed the power rating in Figure 1.
2. These values apply for an 8.3-ms square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. Derate linearly to 175°C free-air temperature at the rate of 2.67 mW/°C. See Dissipation Derating Curve, Figure 1.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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electrical characteristics at 25°C free-air temperature

PARAMETER	CHARACTERISTICS *V_Z Regulator Voltage	*$\Delta V_{Z(\Delta I_R)}$ Voltage Regulation	*z_z Small-Signal Regulator Impedance	*z_{zk} Small-Signal Regulator Knee Impedance	I_R‡ Static Reverse Current	*V_F Static Forward Voltage	TEST CURRENT AND VOLTAGE $I_{Z(T)}$	I_{ZK}	$V_{R(1)}$‡ 1N957A thru 1N973A	$V_{R(1)}$‡ 1N957B thru 1N973B
TEST CONDITIONS	$I_R = I_{Z(T)}$	$I_{R(1)}$ = 10% rated I_R, $I_{R(2)}$ = 50% rated I_R, t = 90 s	$I_R = I_{Z(T)}$, I_r = 10% $I_{Z(T)}$, f = 60 Hz	$I_R = I_{ZK}$, I_r = 10% I_{ZK}, f = 60 Hz	$V_R = V_{R(1)}$	I_F = 200 mA				
LIMIT	NOM†	MAX	MAX	MAX	MAX	MAX				
UNIT	V	V	Ω	Ω	µA	V	mA	mA	V	V
1N957, A, B	6.8	0.25	4.5	700	150	1.5	18.5	1.0	4.9	5.2
1N958, A, B	7.5	0.30	5.5	700	75	1.5	16.5	0.5	5.4	5.7
1N959, A, B	8.2	0.35	6.5	700	50	1.5	15.0	0.5	5.9	6.2
1N960, A, B	9.1	0.40	7.5	700	25	1.5	14.0	0.5	6.6	6.9
1N961, A, B	10	0.45	8.5	700	10	1.5	12.5	0.25	7.2	7.6
1N962, A, B	11	0.50	9.5	700	5	1.5	11.5	0.25	8.0	8.4
1N963, A, B	12	0.55	11.5	700	5	1.5	10.5	0.25	8.6	9.1
1N964, A, B	13	0.60	13	700	5	1.5	9.5	0.25	9.4	9.9
1N965, A, B	15	0.70	16	700	5	1.5	8.5	0.25	10.8	11.4
1N966, A, B	16	0.75	17	700	5	1.5	7.8	0.25	11.5	12.2
1N967, A, B	18	0.85	21	750	5	1.5	7.0	0.25	13.0	13.7
1N968, A, B	20	0.95	25	750	5	1.5	6.2	0.25	14.4	15.2
1N969, A, B	22	1.05	29	750	5	1.5	5.6	0.25	15.8	16.7
1N970, A, B	24	1.15	33	750	5	1.5	5.2	0.25	17.3	18.2
1N971, A, B	27	1.30	41	750	5	1.5	4.6	0.25	19.4	20.6
1N972, A, B	30	1.45	49	1000	5	1.5	4.2	0.25	21.6	22.8
1N973, A, B	33	1.60	58	1000	5	1.5	3.8	0.25	23.8	25.1

†V_Z tolerance is ± 20% for 1N957 thru 1N973, ± 10% for 1N957A thru 1N973A, and ± 5% for 1N957B thru 1N973B.
‡These limits apply for A and B suffix types only. There is no reverse current specification for 1N957 through 1N973.
*JEDEC registered data

THERMAL INFORMATION

DISSIPATION DERATING CURVE

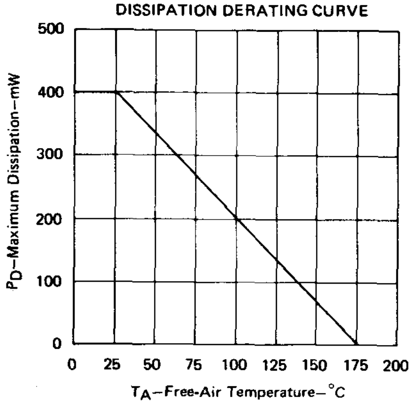

FIGURE 1

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TYPES 1N2069, 1N2070, 1N2071, 1N2069A, 1N2070A, 1N2071A SILICON RECTIFIERS

BULLETIN NO. DL-S 7211697, NOVEMBER 1972

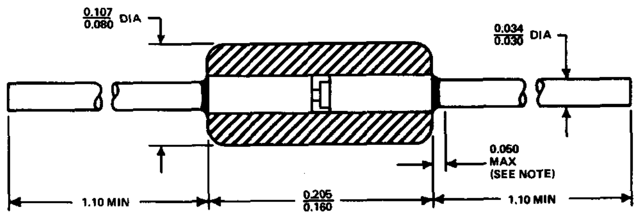
200-600 VOLTS • 750 mA AVERAGE

- **Rugged Double-Plug Construction**
- **Hermetic Case**
- **Small Size**

description and mechanical data

These rectifier diodes are the product of combining the best of both silicon material processing and packaging technologies. The silicon die is a mesa oxide-passivated structure which has additional nitride passivation and glass passivation over the junction. Years of volume production have shown the double-plug package to have the highest inherent mechanical integrity of all hermetic-case diodes.

FALLS WITHIN JEDEC DO-41 DIMENSIONS



ALL DIMENSIONS ARE IN INCHES

REGISTERED BODY DIMENSIONS*
LENGTH .... 0.375 MAX
DIAMETER .... 0.220 MAX

NOTE: Within this zone lead diameter is uncontrolled.

CATHODE END IS DENOTED BY A COLOR BAND

*absolute maximum ratings at specified ambient† temperature (unless otherwise noted)

		1N2069	1N2070	1N2071	1N2069A	1N2070A	1N2071A	UNIT
V_{RM}	Peak Reverse Voltage at (or below) 100°C (See Note 1)	200	400	600	200	400	600	V
V_R	Steady State Reverse Voltage at (or below) 100°C	200	400	600	200	400	600	V
I_O	Average Rectified Forward Current at (or below) 25°C (See Notes 1 and 2)	750						mA
I_O	Average Rectified Forward Current at 100°C (See Notes 1 and 2)	500						mA
I_{FRM}	Repetitive Peak Forward Current, 10 Cycles, at (or below) 25°C (See Notes 3 and 4)	6						A
I_{FSM}	Peak Surge Current, One Cycle, at (or below) 100°C (See Note 3)	22						A
$T_{A(opr)}$	Operating Ambient Temperature Range	−30 to 100			−35 to 100			°C
T_{stg}	Storage Temperature Range	−30 to 100			−35 to 100			°C
	Lead Temperature 1/2 Inch from Case for 5 Seconds	240						°C

NOTES:
1. These values may be applied continuously under single-phase, 60-Hz, half-sine-wave operation with resistive load. Above 25°C derate I_O according to Figure 1.
2. This rectifier is a lead-conduction-cooled device. At (or above) ambient temperatures of 25°C, the lead temperature 3/8 inch from case must be no higher than 5°C above the ambient temperature for these ratings to apply.
3. These values apply for 60-Hz half sine waves when the device is operating at (or below) rated values of peak reverse voltage and average rectified forward current. Surge may be repeated after the device has returned to original thermal equilibrium.
4. Derate linearly to 4 A at 100°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†The ambient temperature is measured at a point 2 inches below the device. Natural air cooling is used.

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*electrical characteristics at specified ambient† temperature

PARAMETER		TEST CONDITIONS	1N2069 1N2070 1N2071 MAX	1N2069A 1N2070A 1N2071A MAX	UNIT
I_R	Static Reverse Current	V_R = Rated V_R, $T_A = 25°C$	10	5	μA
$I_{R(av)}$	Average Reverse Current	V_{RM} = Rated V_{RM}, I_O = 500 mA, f = 60 Hz, $T_A = 100°C$	200	50	μA
V_F	Static Forward Voltage	I_F = 500 mA, $T_A = 25°C$	1.2	1	V
$V_{F(av)}$	Average Forward Voltage	V_{RM} = Rated V_{RM}, I_O = 500 mA, f = 60 Hz, $T_A = 100°C$	0.6	0.5	V

*JEDEC registered data

THERMAL INFORMATION

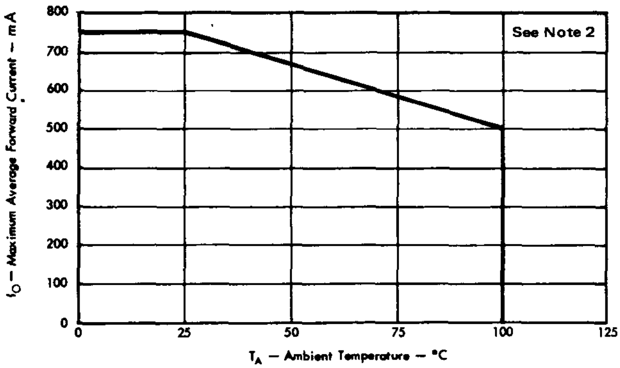

FIGURE 1

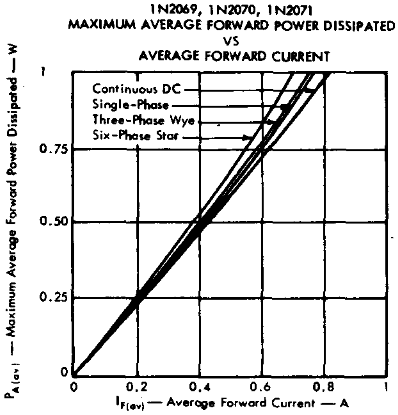

FIGURE 2

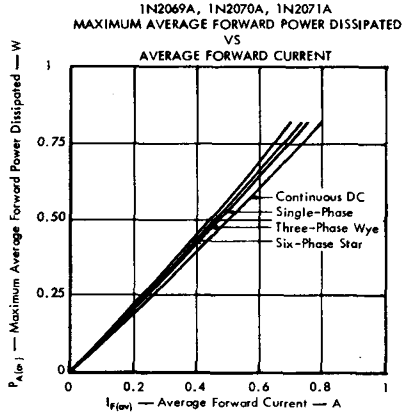

FIGURE 3

NOTE 2: This rectifier is a lead-conduction-cooled device. At (or above) ambient temperatures of 25°C, the lead temperature 3/8 inch from case must be no higher than 5°C above the ambient temperature for these ratings to apply.

†*The ambient temperature is measured at a point 2 inches below the device. Natural air cooling is used.*

TEXAS INSTRUMENTS
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TYPE 1N3064
SILICON SWITCHING DIODE

BULLETIN NO. DL-S 739114, SEPTEMBER 1966—REVISED MARCH 1973

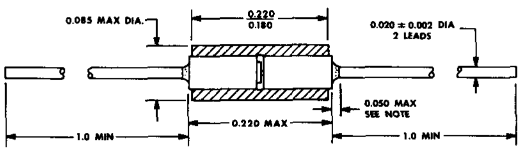
FAST SWITCHING DIODE

- Rugged Double-Plug Construction
- Electrically Equivalent to 1N4454 (DO-35) and 1N4532 (DO-34)

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES

NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

*V_{RM}	Peak Reverse Voltage	75 V
I_F	Steady-State Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	115 mA
$I_{FM(surge)}$	Peak Surge Current, One Second (See Note 2)	500 mA
$I_{FM(surge)}$	Peak Surge Current, One Microsecond (See Note 2)	2 A
*P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	250 mW
*T_{stg}	Storage Temperature Range	−65°C to 200°C
*T_L	Lead Temperature 1/16 Inch from Case for 2 Seconds	250°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 5\ \mu A$	75		V
I_R	Static Reverse Current	$V_R = 50$ V		0.1	μA
		$V_R = 50$ V, $T_A = 150°C$		100	μA
V_F	Static Forward Voltage	$I_F = 10$ mA		1	V
α_{VF}	Temperature Coefficient of Static Forward Voltage	$I_F = 10$ mA, See Note 4		3	mV/°C
C_T	Total Capacitance	$V_R = 0$, f = 1 MHz		2	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_{rr}	Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 10$ mA, $R_L = 100\ \Omega$, $C_L = 10$ pF, $i_{rr} = 1$ mA, See Figure 1		4	ns
$V_{FM(rec)}$	Forward Recovery Voltage	$I_F = 100$ mA, $R_L = 50\ \Omega$, See Figure 2		3	V
η_r	Rectification Efficiency	$V_r = 2$ V, $R_L = 5\ k\Omega$, $C_L = 20$ pF, $Z_{source} = 50\ \Omega$, f = 100 MHz	45%		

NOTES:
1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Derate linearly to 0 at 150°C free-air temperature.
2. These values apply for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. Derate linearly at the rate of 1.5 mW/°C.
4. Temperature coefficient, α_{VF}, is determined by the following formula:

$$\alpha_{VF} = \frac{V_F @ 150°C - V_F @ -55°C}{150°C - (-55°C)}$$

* JEDEC registered data

TEXAS INSTRUMENTS
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PARAMETER MEASUREMENT INFORMATION

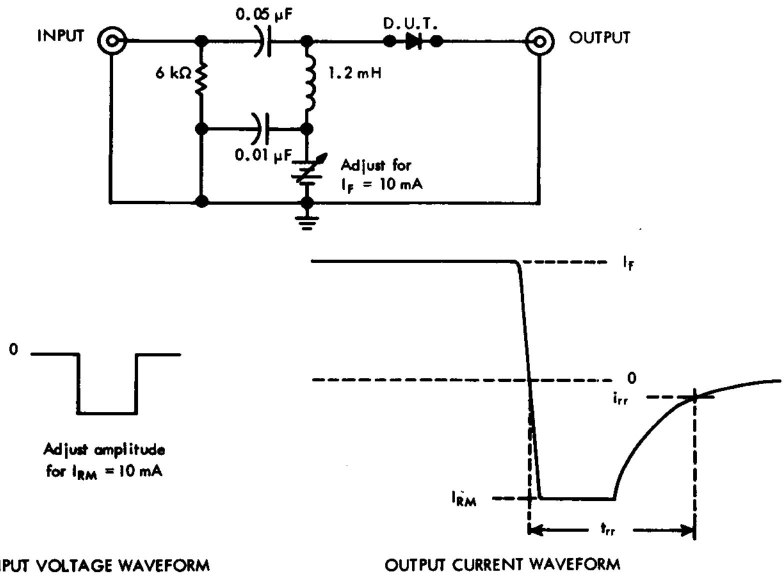

FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 0.25$ ns, $t_p = 100$ ns.
b. Output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.35$ ns, $Z_{in} = 50\ \Omega$.

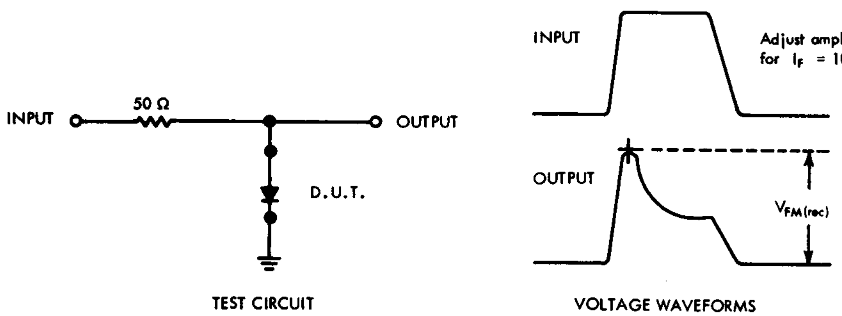

FIGURE 2 — FORWARD RECOVERY VOLTAGE

NOTES: c. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 20$ ns, $t_p = 100$ ns, PRR ≤ 100 kHz.
d. Output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.4$ ns, $R_{in} \geq 1\ M\Omega$, $C_{in} \leq 5$ pF.

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TYPE 1N3070
SILICON SWITCHING DIODE

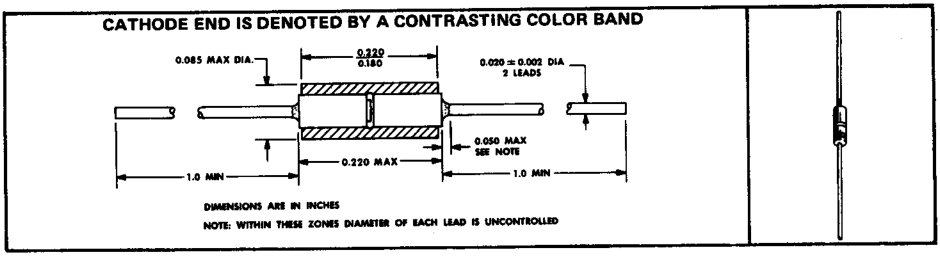
BULLETIN NO. DL-S 739370, NOVEMBER 1966—REVISED MARCH 1973

HIGH-VOLTAGE SWITCHING DIODE

- Rugged Double-Plug Construction
- Electrically Equivalent to 1N4938 (DO-35)

*mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

*V_{RM}	Peak Reverse Voltage	200 V
I_F	Steady-State Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	150 mA
$I_{FM(surge)}$	Peak Surge Current, One Second (See Note 2)	500 mA
$I_{FM(surge)}$	Peak Surge Current, One Microsecond (See Note 2)	2 A
*P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	250 mW
*T_{stg}	Storage Temperature Range	−65°C to 200°C
*T_L	Lead Temperature 1/16 Inch from Case for 2 Seconds	250°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 0.1$ mA	200		V
I_R	Static Reverse Current	$V_R = 175$ V		0.1	μA
		$V_R = 175$ V, $T_A = 150°C$		100	μA
V_F	Static Forward Voltage	$I_F = 100$ mA		1	V
α_{VF}	Temperature Coefficient of Static Forward Voltage	$I_F = 100$ mA, See Note 4		3	mV/°C
C_T	Total Capacitance	$V_R = 0$, $f = 1$ MHz		5	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_{rr}	Reverse Recovery Time	$I_F = 30$ mA, $I_{RM} = 30$ mA, $R_L = 100\ \Omega$, $C_L = 10$ pF, $i_{rr} = 1$ mA, See Figure 2		50	ns
η_r	Rectification Efficiency	$V_r = 2$ V, $R_L = 5$ kΩ, $C_L = 20$ pF, $Z_{source} = 50\ \Omega$, $f = 100$ MHz	35 %		

NOTES: 1. These values may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Derate linearly to 0 at 200°C free-air temperature.
2. These values apply for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, figure 1.
4. Temperature coefficient, α_{VF}, is determined by the following formula:

$$\alpha_{VF} = \frac{V_F @ 150°C - V_F @ -55°C}{150°C - (-55°C)}$$

* JEDEC registered data

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THERMAL CHARACTERISTICS

DISSIPATION DERATING CURVE

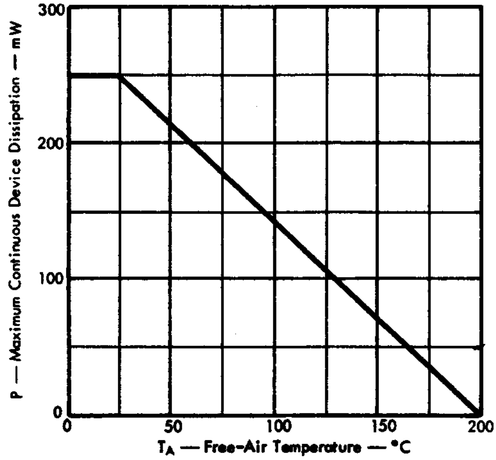
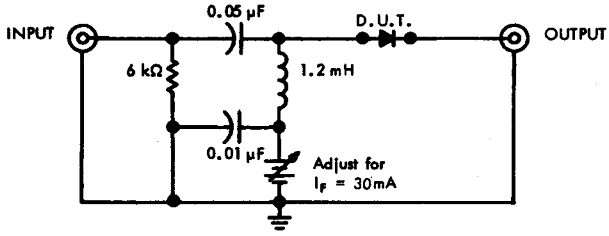
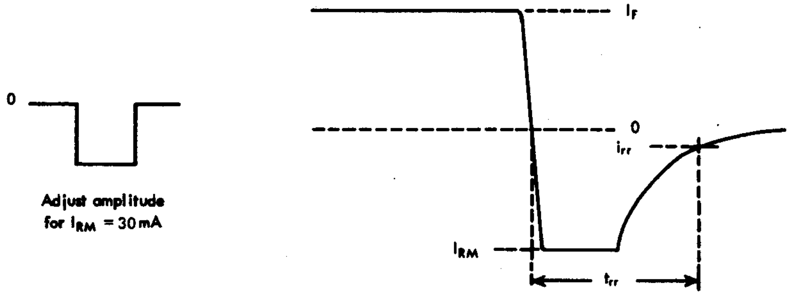


FIGURE 1

PARAMETER MEASUREMENT INFORMATION





INPUT VOLTAGE WAVEFORM   OUTPUT CURRENT WAVEFORM

FIGURE 2 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 0.25$ ns, $t_p = 100$ ns.
b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.35$ ns, $Z_{in} = 50\ \Omega$.

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BULLETIN NO. DL-S 7311945, MARCH 1973

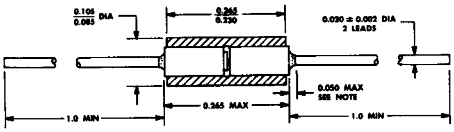
V_Z . . . 3.3 V to 33 V, P_D . . . 400 mW

- **5% Tolerance**
- **Rugged Double-Plug Construction**

mechanical data

These voltage regulator diodes have been designed using the best of both silicon material processing and packaging technologies. The silicon die is a planar oxide-passivated structure which has additional true-glass passivation over the junction. The double-plug package, proven by years of volume production, ensures the best in mechanical integrity and the lowest possible junction temperature when compared to the thermal characteristics of whisker packages. Because of this rugged double-plug (heat-sink) package, these devices offer very conservatively rated power dissipation capabilities.

FALLS WITHIN JEDEC DO-7* DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES

NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

*absolute maximum ratings

TYPE	I_{ZM} Steady-State Regulator Current ($T_A \leq 50°C$, See Note 1)	I_{RSM} Nonrepetitive Reverse Surge Current ($T_A \leq 25°C$, See Note 2)	P_D Continuous Power Dissipation ($T_A \leq 50°C$, See Note 3)	T_{stg} Storage Temperature Range
	mA	mA	mW	°C
1N3506	120	1000	400	−65 to 200
1N3507	110	1000		
1N3508	100	1000		
1N3509	90	990		
1N3510	85	980		
1N3511	75	960		
1N3512	70	950		
1N3513	65	910		
1N3514	60	870		
1N3515	50	810		
1N3516	45	740		
1N3517	40	650		
1N3518	38	540		
1N3519	35	450		
1N3520	32	400		
1N3521	30	350		
1N3522	26	250		
1N3523	24	200		
1N3524	21	175		
1N3525	19	150		
1N3526	17	130		
1N3527	16	115		
1N3528	14	110		
1N3529	13	100		
1N3530	12	95		

NOTES:
1. The I_{ZM} currents shown are nominal and do not represent absolute limits. The actual steady-state current-voltage product must not exceed the power rating in Figure 1.
2. These values apply for 10 square-wave surges of 8.3 ms duration at one-minute intervals.
3. Derate linearly to 200°C free-air temperature at the rate of 2.67 mW/°C. See Dissipation Derating Curve, Figure 1.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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*electrical characteristics at 25°C free-air temperature

CHARACTERISTICS						TEST CURRENT AND VOLTAGE	
PARAMETER	V_Z Regulator Voltage			z_z Small-Signal Regulator Impedance	I_R Static Reverse Current		
TEST CONDITIONS	$I_R = I_{Z(T)}$			$I_R = I_{Z(T)}$, I_r = 10% $I_{Z(T)}$ f = 60 Hz	$V_R = V_{R(T)}$	$I_{Z(T)}$	$V_{R(T)}$
LIMIT	NOM†	MIN	MAX	MAX	MAX		
UNIT	V	V	V	Ω	μA	mA	V
1N3506	3.3	3.14	3.46	24	4	20	1
1N3507	3.6	3.42	3.78	22	2	20	1
1N3508	3.9	3.71	4.09	20	0.4	20	1
1N3509	4.3	4.09	4.51	18	0.1	20	1
1N3510	4.7	4.47	4.93	16	5	20	2
1N3511	5.1	4.85	5.35	14	2	20	2
1N3512	5.6	5.32	5.88	8	5	20	3
1N3513	6.2	5.89	6.51	3	5	20	4
1N3514	6.8	6.46	7.14	3	1	20	5
1N3515	7.5	7.13	7.87	4	0.5	10	6
1N3516	8.2	7.79	8.61	5	0.25	10	7
1N3517	9.1	8.65	9.55	6	0.025	10	7
1N3518	10	9.50	10.50	7	0.01	10	8
1N3519	11	10.45	11.55	8	0.01	10	9
1N3520	12	11.40	12.60	10	0.01	10	10
1N3521	13	12.35	13.65	12	0.01	5	11
1N3522	15	14.25	15.75	14	0.01	5	13
1N3523	16	15.20	16.80	16	0.01	5	14
1N3524	18	17.10	18.90	18	0.01	5	16
1N3525	20	19.00	21.00	20	0.01	5	18
1N3526	22	20.90	23.10	35	0.01	5	19
1N3527	24	22.80	25.20	38	0.01	5	20
1N3528	27	25.65	28.35	40	0.01	4	22
1N3529	30	28.50	31.50	48	0.01	4	24
1N3530	33	31.35	34.65	50	0.01	3	26

†V_Z tolerance is ±5%.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

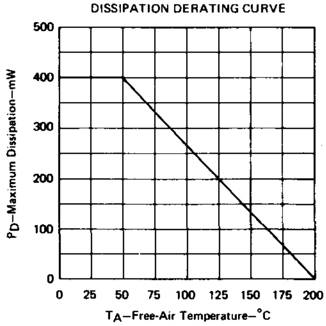


FIGURE 1

*JEDEC registered data

TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

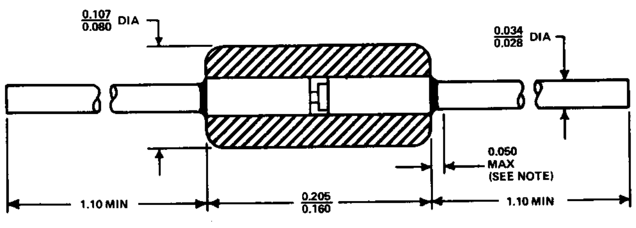
BULLETIN NO. DL-S 7211698, NOVEMBER 1972

50-1000 VOLTS • 1 AMP AVERAGE

- **Rugged Double-plug Construction**
- **Hermetic Case**
- **30-Amp Surge Rating**

description and mechanical data

These one-amp rectifier diodes are the product of combining the best of both silicon material processing and packaging technologies. The silicon die is a mesa oxide-passivated structure which has additional nitride passivation and glass passivation over the junction. Years of volume production have shown the double-plug package to have the highest inherent mechanical integrity of all hermetic-case diodes.



*absolute maximum ratings at specified ambient† temperature (unless otherwise noted)

		1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	UNIT
V_{RM}	Peak Reverse Voltage from −65°C to 175°C (See Note 1)	50	100	200	400	600	800	1000	V
V_R	Steady State Reverse Voltage from 25°C to 75°C	50	100	200	400	600	800	1000	V
I_O	Average Rectified Forward Current from 25°C to 75°C (See Notes 1 and 2)	1							A
I_{FRM}	Repetitive Peak Forward Current, 10 Cycles, at (or below) 75°C (See Note 3)	10							A
I_{FSM}	Peak Surge Current, One Cycle, at (or below) 75°C (See Note 3)	30							A
$T_{A(opr)}$	Operating Ambient Temperature Range	−65 to 175							°C
T_{stg}	Storage Temperature Range	−65 to 200							°C
	Lead Temperature 3/8 Inch from Case for 10 Seconds	350							°C

NOTES: 1. These values may be applied continuously under single-phase, 60-Hz, half-sine-wave operation with resistive load. Above 75°C derate I_O according to Figure 1.
2. This rectifier is a lead-conduction-cooled device. At (or above) ambient temperatures of 75°C, the lead temperature 3/8 inch from case must be no higher than 5°C above the ambient temperature for these ratings to apply.
3. These values apply for 60-Hz half sine waves when the device is operating at (or below) rated values of peak reverse voltage and average rectified forward current. Surge may be repeated after the device has returned to original thermal equilibrium.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

†The ambient temperature is measured at a point 2 inches below the device. Natural air cooling is used.

*electrical characteristics at specified ambient† temperature

PARAMETER		TEST CONDITIONS		MAX	UNIT
I_R	Static Reverse Current	V_R = Rated V_R,	T_A = 25°C	10	μA
		V_R = Rated V_R,	T_A = 100°C	50	
$I_{R(av)}$	Average Reverse Current	V_{RM} = Rated V_{RM}, f = 60 Hz,	I_O = 1 A, T_A = 75°C	30	μA
V_F	Static Forward Voltage	I_F = 1 A,	T_A = 25°C to 75°C	1.1	V
$V_{F(av)}$	Average Forward Voltage	V_{RM} = Rated V_{RM}, f = 60 Hz,	I_O = 1 A, T_A = 25°C to 75°C	0.8	V
V_{FM}	Peak Forward Voltage	V_{RM} = Rated V_{RM}, f = 60 Hz,	I_O = 1 A, T_A = 25°C to 75°C	1.6	V

*JEDEC registered data

THERMAL INFORMATION

FORWARD CURRENT DERATING CURVE

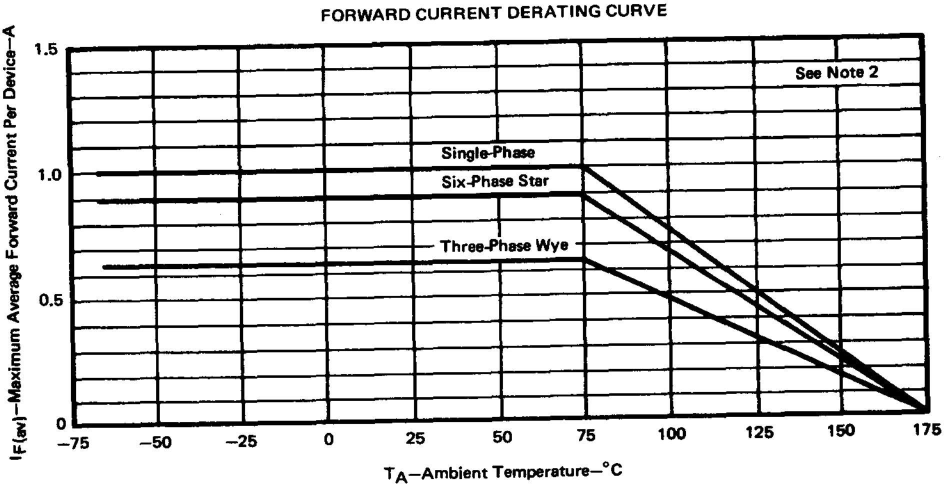


FIGURE 1

NOTE 2: This rectifier is a lead-conduction-cooled device. At (or above) ambient temperatures of 75°C, the lead temperature 3/8 inch from case must be no higher than 5°C above the ambient temperature for these ratings to apply.

†The ambient temperature is measured at a point 2 inches below the device. Natural air cooling is used.

TYPES 1N4148, 1N4149, 1N4446 THRU 1N4449
SILICON SWITCHING DIODES

BULLETIN NO. DL-S 739269, OCTOBER 1966—REVISED MARCH 1973

FAST SWITCHING DIODES

- Rugged Double-Plug Construction

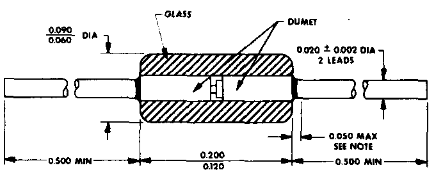
Electrical Equivalents:

1N4148 . . . 1N914 . . . 1N4531   1N4447 . . . 1N916A
1N4149 . . . 1N916   1N4448 . . . 1N914B
1N4446 . . . 1N914A   1N4449 . . . 1N916B

mechanical data

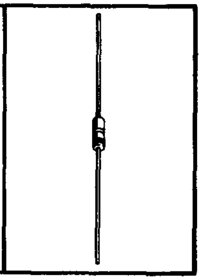
Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

*ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND



*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

$V_{RM(wkg)}$	Working Peak Reverse Voltage . . .	75 V
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1) . . .	500 mW
T_{stg}	Storage Temperature Range . . .	−65°C to 200°C
T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds . . .	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	1N4148		1N4149		1N4446		1N4447		1N4448		1N4449		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$ Reverse Breakdown Voltage	$I_R = 5\ \mu A$	75		75		75		75		75		75		V
	$I_R = 100\ \mu A$	100		100		100		100		100		100		V
I_R Static Reverse Current	$V_R = 20\ V$		25		25		25		25		25		25	nA
	$V_R = 20\ V, T_A = 100°C$										3		3	µA
	$V_R = 20\ V, T_A = 150°C$		50		50		50		50		50		50	µA
V_F Static Forward Voltage	$I_F = 5\ mA$									0.62	0.72	0.63	0.73	V
	$I_F = 10\ mA$		1		1									V
	$I_F = 20\ mA$						1		1					V
	$I_F = 30\ mA$												1	V
	$I_F = 100\ mA$										1			V
C_T Total Capacitance	$V_R = 0,\ f = 1\ MHz$		4		2		4		2		4		2	pF

NOTE 1: Derate linearly to 200°C at the rate of 2.85 mW/°C.

* JEDEC registered data

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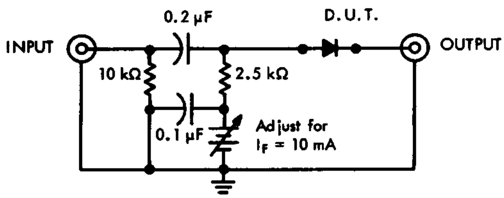
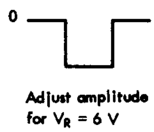
***switching characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	1N4148 MIN	1N4148 MAX	1N4149 MIN	1N4149 MAX	1N4446 MIN	1N4446 MAX	1N4447 MIN	1N4447 MAX	1N4448 MIN	1N4448 MAX	1N4449 MIN	1N4449 MAX	UNIT
t_{rr}	Reverse Recovery Time	$I_F = 10$ mA, $V_R = 6$ V, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1		4		4		4		4		4		4	ns
$V_{FM(rec)}$	Forward Recovery Voltage	$I_F = 50$ mA, $R_L = 50\ \Omega$, See Figure 2										2.5		2.5	V

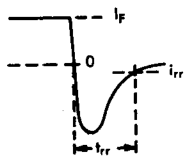
*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



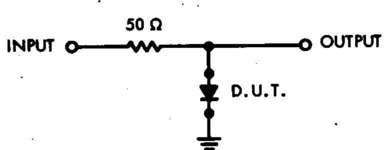
INPUT VOLTAGE WAVEFORM



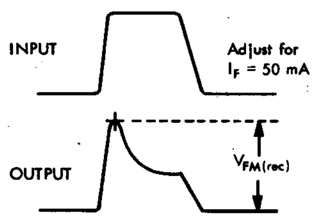
OUTPUT CURRENT WAVEFORM

FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 0.5$ ns, $t_p = 100$ ns.
b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.6$ ns, $Z_{in} = 50\ \Omega$.



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 2 — FORWARD RECOVERY VOLTAGE

NOTES: c. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 30$ ns, $t_p = 100$ ns, PRR = 5 to 100 kHz.
d. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 1\ M\Omega$, $C_{in} \leq 5$ pF.

*JEDEC registered data

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TYPE 1N4150
SILICON SWITCHING DIODE

BULLETIN NO. DL-S 7011352, JULY 1970

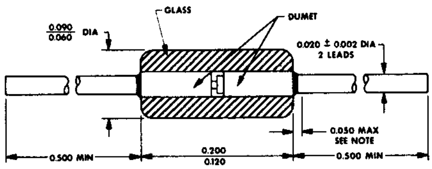
HIGH-CURRENT, CORE-DRIVER SWITCHING DIODE

- **Rugged Double-Plug Construction**
- **Electrically Equivalent to 1N3600 (DO-7)**

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

•ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

V_{RM}	Peak Reverse Voltage	50 V
$I_{FM(surge)}$	Peak Surge Current, One Second (See Note 1)	500 mA
$I_{FM(surge)}$	Peak Surge Current, One Microsecond (See Note 1)	4 A
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	500 mW
T_{stg}	Storage Temperature Range	−65°C to 200°C
T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds	250°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
I_R	Static Reverse Current	V_R = 50 V		0.1	μA
		V_R = 50 V, T_A = 150°C		100	μA
V_F	Static Forward Voltage	I_F = 1 mA	0.54	0.62	V
		I_F = 10 mA	0.66	0.74	V
		I_F = 50 mA	0.76	0.86	V
		I_F = 100 mA	0.82	0.92	V
		I_F = 200 mA	0.87	1	V
C_T	Total Capacitance	V_R = 0, f = 1 MHz		2.5	pF

*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_{fr}	Forward Recovery Time	I_F = 200 mA, v_{fr} = 1 V, See Figure 1		10	ns
t_{rr}	Reverse Recovery Time	I_F = I_{RM} = 10 mA to 200 mA, i_{rr} = 0.1 I_F, R_L = 100 Ω, See Figure 2		4	ns
		I_F = I_{RM} = 200 mA to 400 mA, i_{rr} = 0.1 I_F, R_L = 100 Ω, See Figure 2		6	ns

NOTES: 1. These values apply for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
2. Derate linearly to 200°C free-air temperature at the rate of 2.85 mW/°C.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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PARAMETER MEASUREMENT INFORMATION

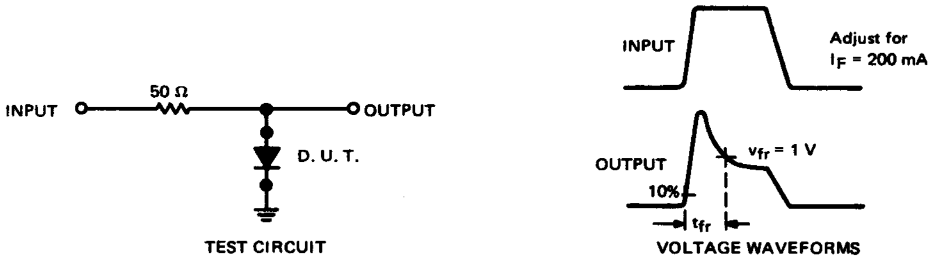

FIGURE 1—FORWARD RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, t_r ≤ 0.4 ns, t_w = 100 ns, duty cycle ≤ 1%.

b. The output waveform is monitored on an oscilloscope with the following characteristics: t_r ≤ 0.5 ns, R_{in} ≥ 1 MΩ, C_{in} ≤ 5 pF.

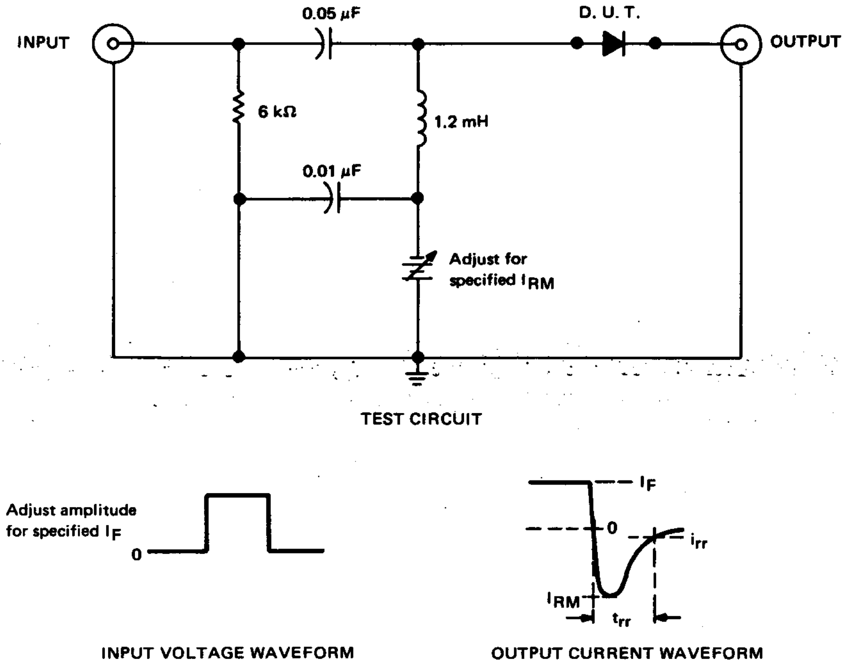

FIGURE 2—REVERSE RECOVERY TIME

NOTES: c. The input pulse is supplied by a generator with the following characteristics: t_f ≤ 1 ns, Z_{out} = 50 Ω, t_w = 100 ns, duty cycle ≤ 1%.

d. The output waveform is monitored on an oscilloscope with the following characteristics: t_r ≤ 0.4 ns, R_{in} = 50 Ω.

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BULLETIN NO. DL-S 699270, OCTOBER 1966—REVISED AUGUST 1969

FAST SWITCHING DIODES

- Rugged Double-Plug Construction

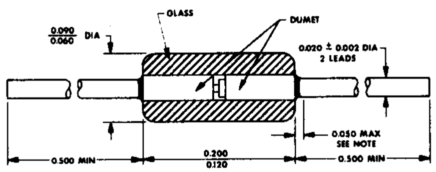
Electrical Equivalents

1N4151 . . . 1N3604
1N4152 . . . 1N3605 . . . 1N4533
1N4153 . . . 1N3606 . . . 1N4534
1N4154 . . . 1N4009 . . . 1N4536

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

*ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		1N4151	1N4152	1N4153	1N4154	UNIT
V_{RM}	Peak Reverse Voltage	75	40	75		V
$V_{RM(wkg)}$	Working Peak Reverse Voltage	50	30	50	25	V
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	500				mW
T_{stg}	Storage Temperature Range	−65 to 200				°C
T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds	300				°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	1N4151		1N4152		1N4153		1N4154		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 5\ \mu A$	75		40		75		35		V
I_R	Static Reverse Current	V_R = rated $V_{RM(wkg)}$		0.05		0.05		0.05		0.1	μA
		V_R = rated $V_{RM(wkg)}$, $T_A = 150°C$		50		50		50		100	μA
V_F	Static Forward Voltage	$I_F = 0.1$ mA			0.49	0.55	0.49	0.55			V
		$I_F = 0.25$ mA			0.53	0.59	0.53	0.59			V
		$I_F = 1$ mA			0.59	0.67	0.59	0.67			V
		$I_F = 2$ mA			0.62	0.70	0.62	0.70			V
		$I_F = 10$ mA			0.70	0.81	0.70	0.81			V
		$I_F = 20$ mA			0.74	0.88	0.74	0.88			V
		$I_F = 30$ mA								1	V
		$I_F = 50$ mA		1							V
C_T	Total Capacitance	$V_R = 0$, f = 1 MHz		2		2		2		4	pF

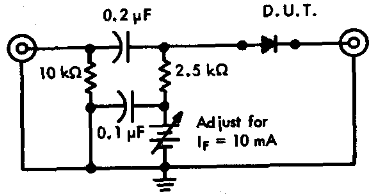
NOTE 1: Derate linearly to 200°C at the rate of 2.85 mW/°C.

* JEDEC registered data

***switching characteristics at 25°C free-air temperature**

PARAMETER	TEST CONDITIONS	1N4151 MIN	1N4151 MAX	1N4152 MIN	1N4152 MAX	1N4153 MIN	1N4153 MAX	1N4154 MIN	1N4154 MAX	UNIT
t_{rr} Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 10$ mA, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1 (Condition 1)		4		4		4		4	ns
	$I_F = 10$ mA, $V_R = 6$ V, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1 (Condition 2)		2		2		2		2	ns

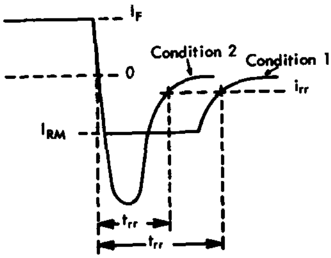
*PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

CONDITION 1: Adjust V_{in} for $I_{RM} = 10$ mA
CONDITION 2: Adjust V_{in} for $V_R = 6$ V

INPUT VOLTAGE WAVEFORM



OUTPUT CURRENT WAVEFORMS

FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 0.5$ ns, $t_p = 100$ ns.
b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.6$ ns, $Z_{in} = 50\ \Omega$.

*JEDEC registered data.

TEXAS INSTRUMENTS
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TYPES 1N4305, 1N4444, 1N4454
SILICON SWITCHING DIODES

BULLETIN NO. DL-S 699266, OCTOBER 1966—REVISED AUGUST 1969

FAST SWITCHING DIODES

- Rugged Double-Plug Construction

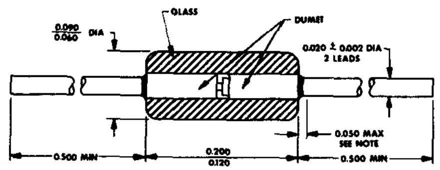
Electrical Equivalents

1N4305 . . . 1N3063 . . . 1N4532
1N4454 . . . 1N3064

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

*ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		1N4305	1N4444	1N4454	UNIT
V_{RM}	Peak Reverse Voltage	75		75	V
$V_{RM(wkg)}$	Working Peak Reverse Voltage		50		V
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	500			mW
T_{stg}	Storage Temperature Range	−65 to 200			°C
T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds	300			°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	1N4305 MIN	1N4305 MAX	1N4444 MIN	1N4444 MAX	1N4454 MIN	1N4454 MAX	UNIT
$V_{(BR)}$ Reverse Breakdown Voltage	$I_R = 5\ \mu A$	75		70		75		V
I_R Static Reverse Current	$V_R = 50$ V		0.1		0.05		0.1	μA
	$V_R = 50$ V, $T_A = 150°C$		100		50		100	μA
V_F Static Forward Voltage	$I_F = 0.1$ mA			0.44	0.55			V
	$I_F = 0.25$ mA	0.505	0.575					V
	$I_F = 1$ mA	0.55	0.65	0.56	0.68			V
	$I_F = 2$ mA	0.61	0.71					V
	$I_F = 10$ mA	0.70	0.85	0.69	0.82		1	V
	$I_F = 100$ mA			0.85	1			V
α_{VF} Forward Voltage Temperature Coefficient	$I_F = 10\ \mu A$ to 10 mA, See Note 2		3					mV/°C
C_T Total Capacitance	$V_R = 0$, f = 1 MHz		2		2		2	pF

NOTES: 1. Derate linearly to 200°C at the rate of 2.85 mW/°C.
2. Temperature coefficient, α_{VF}, is determined by the following formula:

$$\alpha_{VF} = \frac{V_F @ 150°C - V_F @ -55°C}{150°C - (-55°C)}$$

* JEDEC registered data

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TEXAS INSTRUMENTS
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***operating characteristics at 25°C free-air temperature**

PARAMETER	TEST CONDITIONS	1N4305 MIN	1N4305 MAX	1N4444 MIN	1N4444 MAX	1N4454 MIN	1N4454 MAX	UNIT
t_{rr} Reverse Recovery Time	I_F = 10 mA, I_{RM} = 10 mA, i_{rr} = 1 mA, R_L = 100 Ω, See Figure 1, Condition 1		4		7		4	ns
	I_F = 10 mA, V_R = 6 V, i_{rr} = 1 mA, R_L = 100 Ω, See Figure 1, Condition 2		2				2	ns
$V_{FM(rec)}$ Forward Recovery Voltage	I_F = 100 mA, R_L = 50 Ω, See Figure 2						3	V
η_r Rectification Efficiency	V_r = 2 V, R_L = 5 kΩ, C_L = 20 pF, Z_{source} = 50 Ω, f = 100 MHz	45 %						

*PARAMETER MEASUREMENT INFORMATION

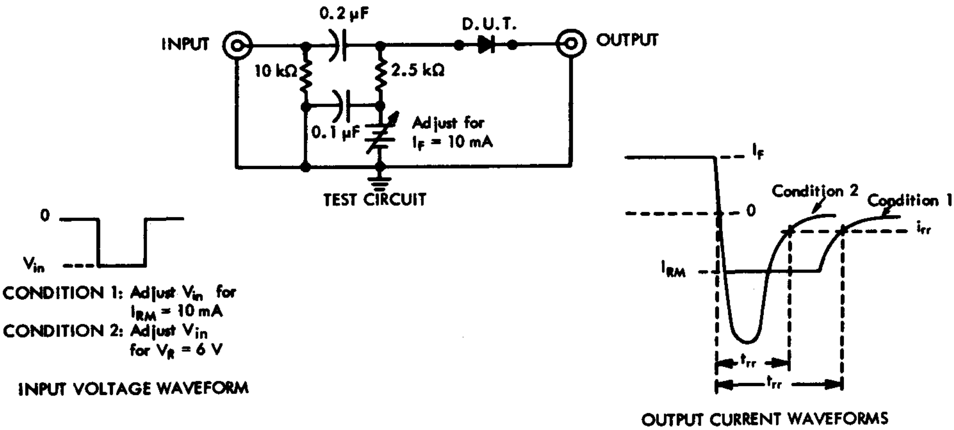


FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq$ 0.5 ns, t_p = 100 ns.
b. Output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq$ 0.6 ns, Z_{in} = 50 Ω.

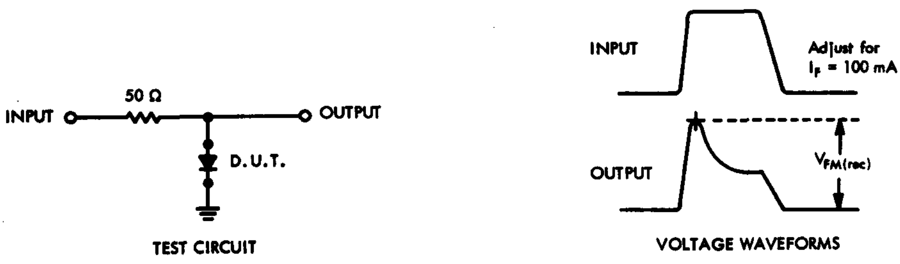


FIGURE 2 — FORWARD RECOVERY VOLTAGE

NOTES: c. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq$ 30 ns, t_p = 100 ns, PRR = 5 to 100 kHz.
d. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq$ 15 ns, $R_{in} \geq$ 1 MΩ, $C_{in} \leq$ 5 pF.

*JEDEC registered data

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 1N4148, 1N4149, 1N4446 THRU 1N4449
SILICON SWITCHING DIODES

BULLETIN NO. DL-S 739269, OCTOBER 1966—REVISED MARCH 1973

FAST SWITCHING DIODES

- **Rugged Double-Plug Construction**

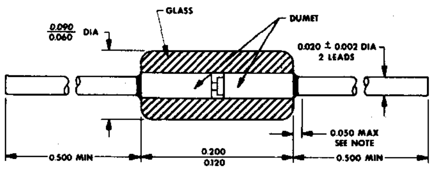
Electrical Equivalents:

1N4148 . . . 1N914 . . . 1N4531	1N4447 . . . 1N916A
1N4149 . . . 1N916	1N4448 . . . 1N914B
1N4446 . . . 1N914A	1N4449 . . . 1N916B

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

***ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE**



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

$V_{RM(wkg)}$	Working Peak Reverse Voltage	75 V
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	500 mW
T_{stg}	Storage Temperature Range	−65°C to 200°C
T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	1N4148		1N4149		1N4446		1N4447		1N4448		1N4449		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$ Reverse Breakdown Voltage	$I_R = 5\ \mu A$	75		75		75		75		75		75		V
	$I_R = 100\ \mu A$	100		100		100		100		100		100		V
I_R Static Reverse Current	$V_R = 20$ V		25		25		25		25		25		25	nA
	$V_R = 20$ V, $T_A = 100°C$										3		3	µA
	$V_R = 20$ V, $T_A = 150°C$		50		50		50		50		50		50	µA
V_F Static Forward Voltage	$I_F = 5$ mA									0.62	0.72	0.63	0.73	V
	$I_F = 10$ mA		1		1									V
	$I_F = 20$ mA						1		1					V
	$I_F = 30$ mA												1	V
	$I_F = 100$ mA										1			V
C_T Total Capacitance	$V_R = 0$, f = 1 MHz		4		2		4		2		4		2	pF

NOTE 1: Derate linearly to 200°C at the rate of 2.85 mW/°C.

* JEDEC registered data

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*switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	1N4148		1N4149		1N4446		1N4447		1N4448		1N4449		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{rr}	Reverse Recovery Time	I_F = 10 mA, V_R = 6 V, i_{rr} = 1 mA, R_L = 100 Ω, See Figure 1		4		4		4		4		4		4	ns
$V_{FM(rec)}$	Forward Recovery Voltage	I_F = 50 mA, R_L = 50 Ω, See Figure 2										2.5		2.5	V

*PARAMETER MEASUREMENT INFORMATION

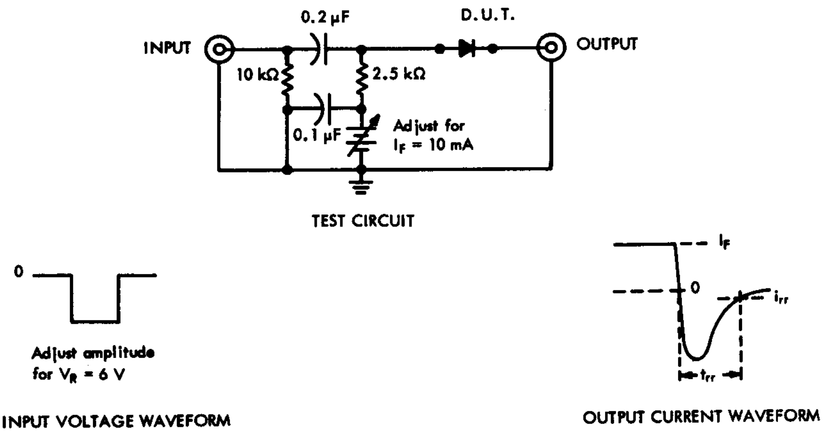

FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq$ 0.5 ns, t_p = 100 ns.
b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq$ 0.6 ns, Z_{in} = 50 Ω.

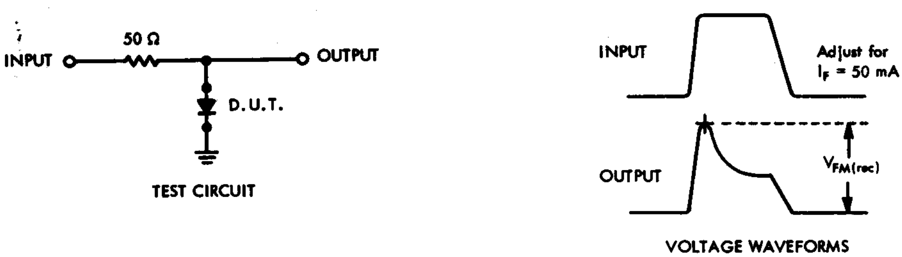

FIGURE 2 — FORWARD RECOVERY VOLTAGE

NOTES: c. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq$ 30 ns, t_p = 100 ns, PRR = 5 to 100 kHz.
d. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq$ 15 ns, $R_{in} \geq$ 1 MΩ, $C_{in} \leq$ 5 pF.

*JEDEC registered data

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BULLETIN NO. DL-S 699266, OCTOBER 1966–REVISED AUGUST 1969

FAST SWITCHING DIODES

- Rugged Double-Plug Construction

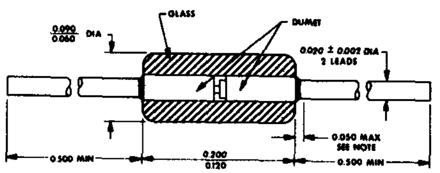
Electrical Equivalents

1N4305 . . . 1N3063 . . . 1N4532
1N4454 . . . 1N3064

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

*ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		1N4305	1N4444	1N4454	UNIT
V_{RM}	Peak Reverse Voltage	75		75	V
$V_{RM(wkg)}$	Working Peak Reverse Voltage		50		V
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	500			mW
T_{stg}	Storage Temperature Range	−65 to 200			°C
T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds	300			°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	1N4305		1N4444		1N4454		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 5\ \mu A$	75		70		75		V
I_R	Static Reverse Current	$V_R = 50$ V		0.1		0.05		0.1	µA
		$V_R = 50$ V, $T_A = 150°C$		100		50		100	µA
V_F	Static Forward Voltage	$I_F = 0.1$ mA			0.44	0.55			V
		$I_F = 0.25$ mA	0.505	0.575					V
		$I_F = 1$ mA	0.55	0.65	0.56	0.68			V
		$I_F = 2$ mA	0.61	0.71					V
		$I_F = 10$ mA	0.70	0.85	0.69	0.82		1	V
		$I_F = 100$ mA			0.85	1			V
α_{VF}	Forward Voltage Temperature Coefficient	$I_F = 10\ \mu A$ to 10 mA, See Note 2		3					mV/°C
C_T	Total Capacitance	$V_R = 0$, f = 1 MHz		2		2		2	pF

NOTES: 1. Derate linearly to 200°C at the rate of 2.85 mW/°C.
2. Temperature coefficient, α_{VF}, is determined by the following formula:

$$\alpha_{VF} = \frac{V_F @ 150°C - V_F @ -55°C}{150°C - (-55°C)}$$

*JEDEC registered data

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***operating characteristics at 25°C free-air temperature**

PARAMETER	TEST CONDITIONS	1N4305		1N4444		1N4454		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{rr} Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 10$ mA, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1, Condition 1		4		7		4	ns
t_{rr} Reverse Recovery Time	$I_F = 10$ mA, $V_R = 6$ V, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1, Condition 2		2				2	ns
$V_{FM(rec)}$ Forward Recovery Voltage	$I_F = 100$ mA, $R_L = 50\ \Omega$, See Figure 2						3	V
η_r Rectification Efficiency	$V_r = 2$ V, $R_L = 5$ kΩ, $C_L = 20$ pF, $Z_{source} = 50\ \Omega$, f = 100 MHz	45 %						

*PARAMETER MEASUREMENT INFORMATION

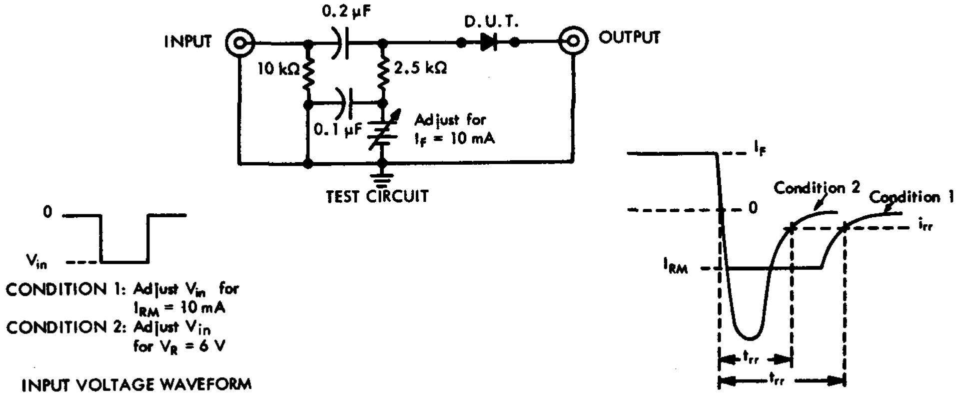

FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 0.5$ ns, $t_p = 100$ ns.
b. Output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 0.6$ ns, $Z_{in} = 50\ \Omega$.

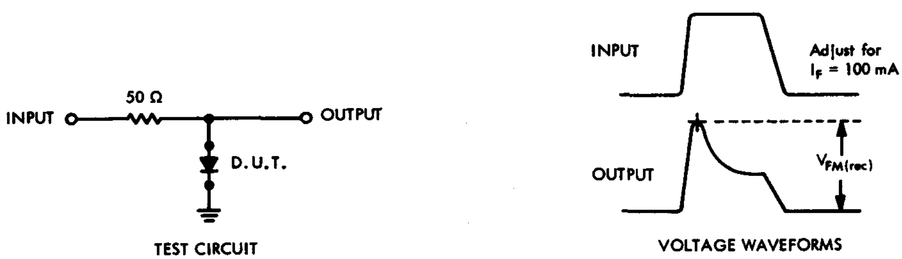

FIGURE 2 — FORWARD RECOVERY VOLTAGE

NOTES: c. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 30$ ns, $t_p = 100$ ns, PRR = 5 to 100 kHz.
d. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 1$ MΩ, $C_{in} \leq 5$ pF.

*JEDEC registered data

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TYPES 1N4531 THRU 1N4534, 1N4536
SILICON SWITCHING DIODES

BULLETIN NO. DL-S 739774, MARCH 1967—REVISED MARCH 1973

FAST SWITCHING DIODES

- **Rugged Double-Plug Construction**

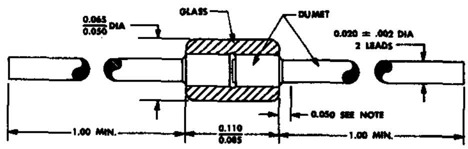
Electrical Equivalents

1N4531 . . . 1N4148 . . . 1N914   1N4533 . . . 1N4152 . . . 1N3605
1N4532 . . . 1N4454 . . . 1N3064   1N4534 . . . 1N4153 . . . 1N3606
1N4536 . . . 1N4154 . . . 1N4009

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CASE OUTLINE FALLS WITHIN JEDEC DO-34



REGISTERED BODY DIMENSIONS*

	MIN	MAX
LENGTH	0.080	0.110
DIAMETER	0.045	0.065

DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		1N4531	1N4532	1N4533	1N4534	1N4536	UNIT
V_{RM}	Peak Reverse Voltage	100				35	V
*$V_{RM(wkg)}$	Working Peak Reverse Voltage	75	75	40	50	25	V
*P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	500					mW
*T_{stg}	Storage Temperature Range	−65 to 200					°C
*T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds	300					°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	1N4531 MIN	1N4531 MAX	1N4532 MIN	1N4532 MAX	1N4533 MIN	1N4533 MAX	1N4534 MIN	1N4534 MAX	1N4536 MIN	1N4536 MAX	UNIT
$V_{(BR)}$ Reverse Breakdown Voltage	$I_R = 5\ \mu A$	75		75		40		75		35		V
	$I_R = 100\ \mu A$	100										V
I_R Static Reverse Current	$V_R = 20$ V		0.025									μA
	$V_R = 20$ V, $T_A = 150°C$		50									μA
	$V_R = 25$ V										0.1	μA
	$V_R = 25$ V, $T_A = 150°C$										100	μA
	$V_R = 30$ V						0.05					μA
	$V_R = 30$ V, $T_A = 150°C$						50					μA
	$V_R = 50$ V				0.1				0.05			μA
	$V_R = 50$ V, $T_A = 150°C$				100				50			μA
V_F Static Forward Voltage	$I_F = 0.1$ mA					0.49	0.55	0.49	0.55			V
	$I_F = 0.25$ mA					0.53	0.59	0.53	0.59			V
	$I_F = 1$ mA					0.59	0.67	0.59	0.67			V
	$I_F = 2$ mA					0.62	0.70	0.62	0.70			V
	$I_F = 10$ mA		1		1	0.70	0.81	0.70	0.81			V
	$I_F = 20$ mA					0.74	0.88	0.74	0.88			V
	$I_F = 30$ mA										1	V
C_T Total Capacitance	$V_R = 0$, f = 1 MHz		4		2		2		2		4	pF

NOTE 1: Derate linearly to 200°C free-air temperature at the rate of 2.85 mW/°C.

*JEDEC registered data

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*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	1N4531		1N4532		1N4533		1N4534		1N4536		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{rr}	Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 10$ mA, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1, Condition 1				4		4		4		4	ns
		$I_F = 10$ mA, $V_R = 6$ V, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1, Condition 2		4		2		2		2		2	ns
$V_{FM(rec)}$	Forward Recovery Voltage	$I_F = 100$ mA, $R_L = 50\ \Omega$, See Figure 2				3							V

*PARAMETER MEASUREMENT INFORMATION

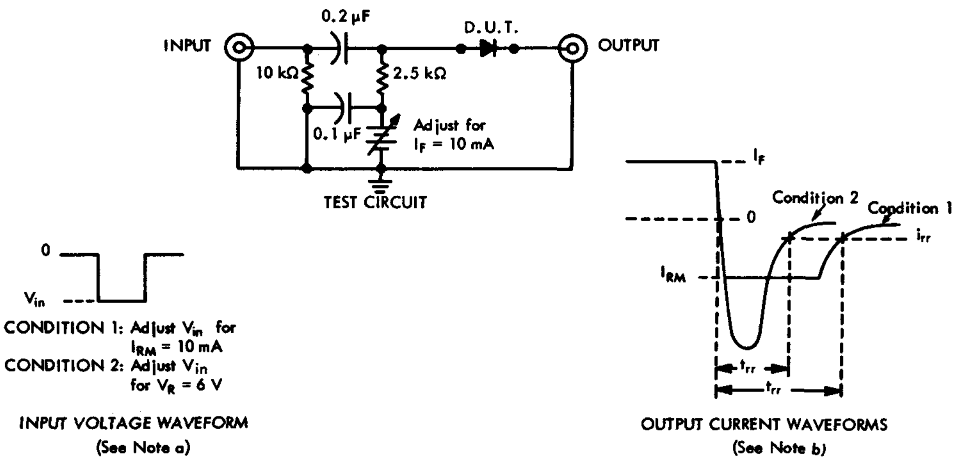

FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 0.5$ ns, $t_p = 100$ ns.

b. Output waveforms are monitored on an oscilloscope with the following characteristics: $t_r \leq 0.6$ ns, $Z_{in} = 50\ \Omega$.

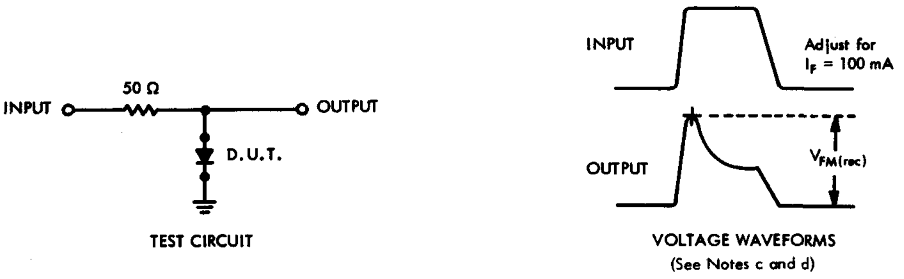

FIGURE 2 — FORWARD RECOVERY VOLTAGE

NOTES: c. The input pulse is supplied by a generator with the following characteristics: $Z_{out} = 50\ \Omega$, $t_r \leq 30$ ns, $t_p = 100$ ns, PRR = 5 to 100 kHz.

d. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 15$ ns, $R_{in} \geq 1$ MΩ, $C_{in} \leq 5$ pF.

* JEDEC registered data

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BULLETIN NO. DL-S 739271, OCTOBER 1966—REVISED MARCH 1973

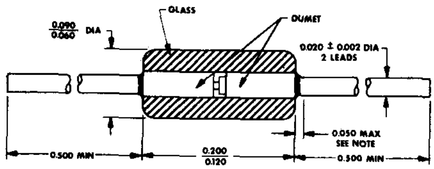
FAST HIGH-CURRENT CORE-DRIVER SWITCHING DIODES

- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

*ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

$V_{RM(wkg)}$	Working Peak Reverse Voltage	70 V
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	500 mW
T_{stg}	Storage Temperature Range	−65°C to 200°C
T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	1N4606		1N4607		1N4608		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	85		85		85		V
I_R	Static Reverse Current	$V_R = 50$ V		0.1		0.1		0.1	μA
		$V_R = 70$ V		0.25		0.25		0.25	μA
		$V_R = 50$ V, $T_A = 100°C$		25		25		25	μA
V_F	Static Forward Voltage	$I_F = 0.1$ mA	0.43	0.55	0.39	0.50	0.39	0.49	V
		$I_F = 1$ mA	0.54	0.66	0.50	0.61	0.50	0.60	V
		$I_F = 10$ mA	0.65	0.77	0.61	0.72	0.61	0.71	V
		$I_F = 50$ mA, See Note 2	0.74	0.86					V
		$I_F = 100$ mA, See Note 2	0.79	0.92	0.74	0.87	0.74	0.85	V
		$I_F = 200$ mA, See Note 2	0.86	1.0					V
		$I_F = 250$ mA, See Note 2		1.1	0.81	0.95	0.81	0.93	V
		$I_F = 350$ mA, See Note 2				1.0	0.84	0.96	V
		$I_F = 400$ mA, See Note 2				1.1			V
		$I_F = 450$ mA, See Note 2						1.0	V
		$I_F = 500$ mA, See Note 2						1.1	V
C_T	Total Capacitance	$V_R = 0$, $f = 1$ MHz		2.5		4		4	pF

NOTES: 1. Derate linearly to 200°C at the rate of 2.85 mW/°C.
2. These parameters must be measured using pulse techniques. $t_w \leq 300\ \mu s$, duty cycle $\leq 2\%$.

*JEDEC registered data

***switching characteristics at 25°C free-air temperature**

PARAMETER	TEST CONDITIONS	1N4606		1N4607		1N4608		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{rr} Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 1$ mA, $i_{rr} = 0.1$ mA, $R_L = 100\ \Omega$, See Figure 1		6					ns
	$I_F = I_{RM} = 10$ mA to 200 mA, $i_{rr} = 0.1\ I_F$, $R_L = 100\ \Omega$, See Figure 2		4					ns
	$I_F = I_{RM} = 200$ mA to 400 mA, $i_{rr} = 0.1\ I_F$, $R_L = 100\ \Omega$, See Figure 2		6					ns
	$I_F = 10$ mA, $I_{RM} = 10$ mA, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1				10		10	ns
	$I_F = 500$ mA, $I_{RM} = 500$ mA, $i_{rr} = 50$ mA, $R_L = 100\ \Omega$, See Figure 2				15		15	ns

PARAMETER MEASUREMENT INFORMATION

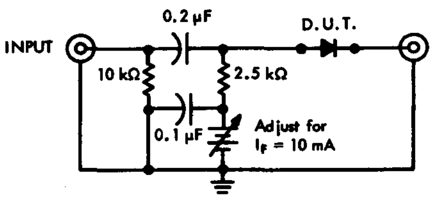


FIGURE 1 — LOW-CURRENT t_{rr} TEST CIRCUIT

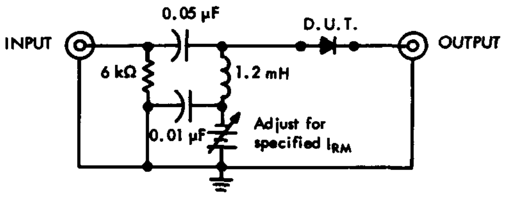
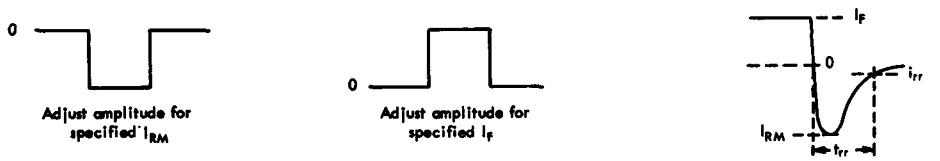


FIGURE 2 — HIGH-CURRENT t_{rr} TEST CIRCUIT



INPUT VOLTAGE WAVEFORM FOR LOW-CURRENT TEST CIRCUIT

INPUT VOLTAGE WAVEFORM FOR HIGH-CURRENT TEST CIRCUIT

OUTPUT CURRENT WAVEFORM

FIGURE 3 — WAVEFORMS

NOTES: 1. Input pulses are supplied by generators with the following characteristics.
FIGURE 1: $Z_{out} = 50\ \Omega$, $t_r \leq 0.5$ ns, $t_p = 100$ ns
FIGURE 2: $Z_{out} = 50\ \Omega$, $t_r \leq 0.5$ ns, $t_p = 90$ ns

2. *Output waveforms are viewed on an oscilloscope with the following characteristics: $t_r \leq 0.6$ ns, $Z_{in} = 50\ \Omega$.*

* JEDEC registered data

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INCORPORATED
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TYPE 1N4727
SILICON SWITCHING DIODE

BULLETIN NO. DL-S 739330, NOVEMBER 1966—REVISED MARCH 1973

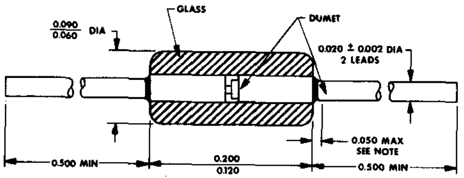
FAST SWITCHING DIODE

- Rugged Double-Plug Construction
- Electrically Equivalent to 1N4726

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

*ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

***absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)**

$V_{RM(wkg)}$	Working Peak Reverse Voltage	20 V
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	500 mW
T_{stg}	Storage Temperature Range	−65°C to 200°C
T_L	Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

***electrical characteristics at 25°C free-air temperature (unless otherwise noted)**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 5\ \mu A$	30		V
I_R	Static Reverse Current	$V_R = 20$ V		0.1	μA
		$V_R = 20$ V, $T_A = 100°C$		10	μA
V_F	Static Forward Voltage	$I_F = 10$ mA		0.85	V
C_T	Total Capacitance	$V_R = 0$, f = 1 MHz		4	pF

***operating characteristics at 25°C free-air temperature**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
Q_S	Stored Charge	$I_F = 10$ mA, See Note 2		40	pC

NOTES: 1. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve figure 1.

2. Stored charge is measured in accordance with JEDEC Suggested Standard No. 1 (June, 1966), using the test circuit of figure 2.

* JEDEC registered data

*THERMAL CHARACTERISTICS

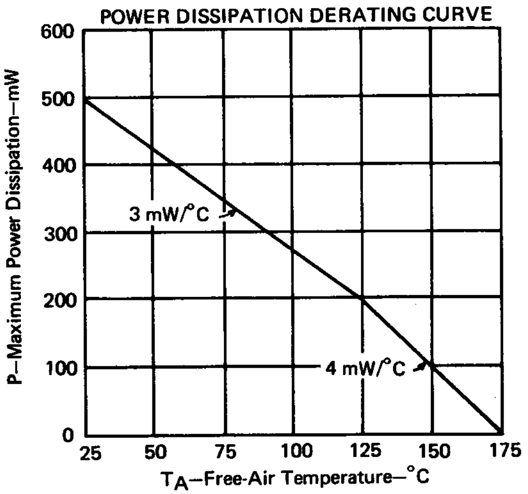


FIGURE 1

*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION

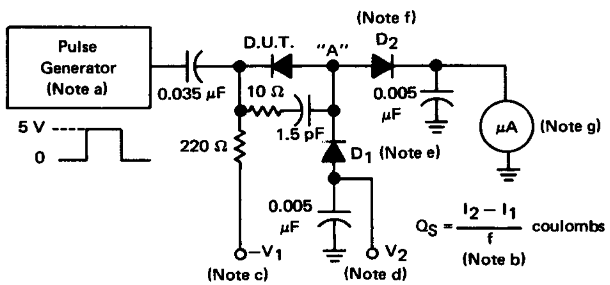


FIGURE 2—STORED CHARGE TEST CIRCUIT

NOTES:
a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 10 Ω, t_r (1% to 50%) ≤ 5 ns, t_w = 50 ns.
b. I_1 is the reading of the meter with zero voltage across the diode under test (hence zero current through the diode under test); I_2 is the reading of the meter when the specified forward current (10 mA) flows; f is the pulse-generator frequency.
c. V_1 is adjusted for I_F = 10 mA.
d. V_2 is adjusted so that the voltage between point A and ground is −0.6 V when the diode under test is conducting forward current.
e. The stored charge of diode D_1 is small compared to the stored charge of the diode under test.
f. The reverse recovery time of diode D_2 is short relative to the 50-ns input pulse.
g. The resistance of the current meter is sufficiently low that doubling it does not affect the reading by more than the required accuracy.

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POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

TYPES 1N4728 THRU 1N4752, 1N4728A THRU 1N4752A
SILICON VOLTAGE-REGULATOR DIODES

BULLETIN NO. DL-S 7311949, MARCH 1973

V_Z . . . 3.3 V to 33 V
P_D . . . 1 W

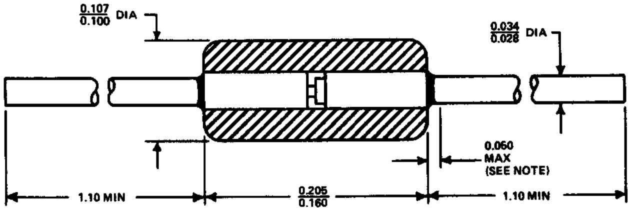
- **Available in 5% and 10% Tolerances**
- **Rugged Double-Plug Construction**

mechanical data

These voltage regulator diodes have been designed using the best of both silicon material processing and packaging technologies. The silicon die is a planar oxide-passivated structure which has additional true-glass passivation over the junction. The double-plug package, proven by years of volume production, ensures the best in mechanical integrity and the lowest possible junction temperature when compared to the thermal characteristics of whisker packages.

*OUTLINE DRAWING

FALLS WITHIN JEDEC DO-41 OUTLINE



DIMENSIONS ARE IN INCHES

NOTE: Within this zone lead diameter is uncontrolled.

CATHODE END IS DENOTED BY A COLOR BAND

absolute maximum ratings at specified free-air temperature (unless otherwise noted)

*Steady-State Regulator Current, I_{ZM}, at (or below) 50°C (See Note 1)	See Table 1
*Nonrepetitive Reverse Surge Current, I_{RSM}, at (or below) 25°C (See Note 2)	See Table 1
*Continuous Power Dissipation at (or below) 50°C (See Note 3)	1 W
*Operating Free-Air Temperature Range	−65°C to 200°C
Storage Temperature Range	−65°C to 200°C
*Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

TABLE 1—CURRENT RATINGS

TYPE	I_{ZM} (mA)	I_{RSM} (mA)	TYPE	I_{ZM} (mA)	I_{RSM} (mA)	TYPE	I_{ZM} (mA)	I_{RSM} (mA)
1N4728, A	276	1380	1N4738, A	110	550	1N4748, A	41	205
1N4729, A	252	1260	1N4739, A	100	500	1N4749, A	38	190
1N4730, A	234	1190	1N4740, A	91	454	1N4750, A	34	170
1N4731, A	217	1070	1N4741, A	83	414	1N4751, A	30	150
1N4732, A	193	970	1N4742, A	76	380	1N4752, A	27	135
1N4733, A	178	890	1N4743, A	69	344			
1N4734, A	162	810	1N4744, A	61	304			
1N4735, A	146	730	1N4745, A	57	285			
1N4736, A	133	660	1N4746, A	50	250			
1N4737, A	121	605	1N4747, A	45	225			

NOTES:
1. The nominal I_{ZM} currents shown are applicable for devices having regulator voltages approximately 10% above the nominal V_Z values shown under electrical characteristics. These values do not represent absolute limits. The actual steady-state current-voltage product must not exceed the power rating.
2. These values apply for an 8.3-ms square-wave pulse superposed on a steady-state reverse current equal to $I_{Z(T)}$ as shown under electrical characteristics.
3. Derate linearly to 200°C at the rate of 6.67 mW/°C. See Figure 1.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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***electrical characteristics at 25°C free-air temperature**

CHARACTERISTICS						TEST CURRENT AND VOLTAGE		
PARAMETER	V_Z Regulator Voltage	z_z Small-Signal Regulator Impedance	z_{zk} Small-Signal Regulator Knee Impedance	I_R Static Reverse Current	V_F Static Forward Voltage			
TEST CONDITIONS	$I_R = I_{Z(T)}$	$I_R = I_{Z(T)}$, $I_r = 10\%\ I_{Z(T)}$, f = 60 Hz	$I_R = I_{ZK}$, $I_r = 10\%\ I_{ZK}$, f = 60 Hz	$V_R = V_{R(T)}$	I_F = 200 mA	$I_{Z(T)}$	I_{ZK}	$V_{R(T)}$
LIMIT	NOM†	MAX	MAX	MAX	MAX			
UNIT	V	Ω	Ω	μA	V	mA	mA	V
1N4728, A	3.3	10	400	100	1.2	76	1	1
1N4729, A	3.6	10	400	100	1.2	69	1	1
1N4730, A	3.9	9	400	50	1.2	64	1	1
1N4731, A	4.3	9	400	10	1.2	58	1	1
1N4732, A	4.7	8	500	10	1.2	53	1	1
1N4733, A	5.1	7	550	10	1.2	49	1	1
1N4734, A	5.6	5	600	10	1.2	45	1	2
1N4735, A	6.2	2	700	10	1.2	41	1	3
1N4736, A	6.8	3.5	700	10	1.2	37	1	4
1N4737, A	7.5	4.0	700	10	1.2	34	0.5	5
1N4738, A	8.2	4.5	700	10	1.2	31	0.5	6
1N4739, A	9.1	5	700	10	1.2	28	0.5	7
1N4740, A	10	7	700	10	1.2	25	0.25	7.6
1N4741, A	11	8	700	5	1.2	23	0.25	8.4
1N4742, A	12	9	700	5	1.2	21	0.25	9.1
1N4743, A	13	10	700	5	1.2	19	0.25	9.9
1N4744, A	15	14	700	5	1.2	17	0.25	11.4
1N4745, A	16	16	700	5	1.2	15.5	0.25	12.2
1N4746, A	18	20	750	5	1.2	14.0	0.25	13.7
1N4747, A	20	22	750	5	1.2	12.5	0.25	15.2
1N4748, A	22	23	750	5	1.2	11.5	0.25	16.7
1N4749, A	24	25	750	5	1.2	10.5	0.25	18.2
1N4750, A	27	35	750	5	1.2	9.5	0.25	20.6
1N4751, A	30	40	1000	5	1.2	8.5	0.25	22.8
1N4752, A	33	45	1000	5	1.2	7.5	0.25	25.1

†V_Z tolerance is ±10% for 1N4728 through 1N4752; ±5% for 1N4728A through 1N4752A.

THERMAL INFORMATION

DISSIPATION DERATING CURVE

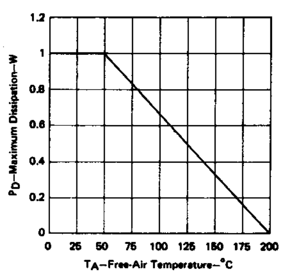

FIGURE 1

*JEDEC registered data

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TEXAS INSTRUMENTS INCORPORATED
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TYPE 1N4938
SILICON SWITCHING DIODE

BULLETIN NO. DL-S 7311938, JUNE 1973

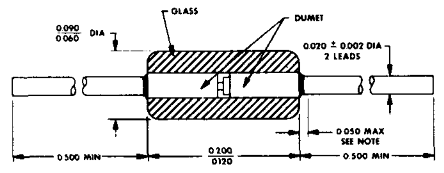
HIGH-VOLTAGE SWITCHING DIODE

- Rugged Double-Plug Construction
- Electrically Equivalent to 1N3070

mechanical data

Double-plug construction affords integral positive contacts by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

***ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE**



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

*Peak Reverse Voltage	200 V
Steady-State Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	150 mA
Peak Surge Current, One Second (See Note 2)	500 mA
Peak Surge Current, One Microsecond (See Note 2)	2 A
*Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	250 mW
*Storage Temperature Range	−65°C to 200°C
*Lead Temperature 1/16 Inch from Case for 2 Seconds	250°C

*electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 0.1$ mA	200		V
I_R	Static Reverse Current	$V_R = 175$ V		0.1	μA
		$V_R = 175$ V, $T_A = 150°C$		100	
V_F	Static Forward Voltage	$I_F = 100$ mA		1	V
C_T	Total Capacitance	$V_R = 0$, f = 1 MHz		5	pF

*operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_{rr}	Reverse Recovery Time	$I_F = 30$ mA, $I_{RM} = 30$ mA, $R_L = 100\ \Omega$, $C_L = \leqslant 3$ pF, $i_{rr} = 1$ mA, See Figure 2		50	ns

NOTES:
1. This value may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load. Derate linearly to 0 at 200°C free-air temperature.
2. These values apply for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, Figure 1.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

THERMAL CHARACTERISTICS

DISSIPATION DERATING CURVE

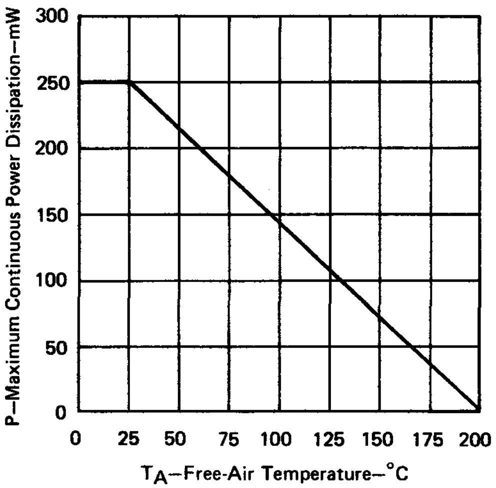
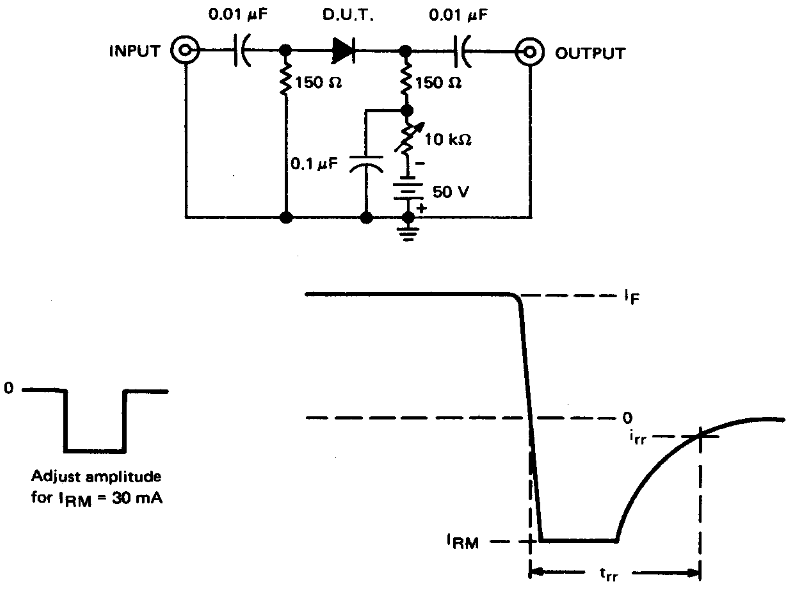


FIGURE 1

PARAMETER MEASUREMENT INFORMATION



INPUT VOLTAGE WAVEFORM

OUTPUT CURRENT WAVEFORM

NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, t_r < 0.5 ns, t_w = 100 ns.
b. The output waveform is monitored on an oscilloscope with the following characteristics: t_r < 0.5 ns, Z_{in} = 50 Ω.

FIGURE 2—REVERSE RECOVERY TIME

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TYPES 1N5226 THRU 1N5257, 1N5226A THRU 1N5257A, 1N5226B THRU 1N5257B SILICON VOLTAGE-REGULATOR DIODES

BULLETIN NO. DL-S 7311944, MARCH 1973

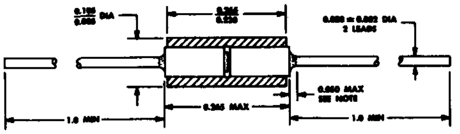
V_Z . . . 3.3 V to 33 V
P_D . . . 500 mW

- **Available with 5%, 10% and 20% Tolerances**
- **Rugged Double-Plug Construction**

description and mechanical data

These voltage regulator diodes have been designed using the best of both silicon material processing and packaging technologies. The silicon die is a planar oxide-passivated structure which has additional true-glass passivation over the junction. The double-plug package, proven by years of volume production, ensures the best in mechanical integrity and the lowest possible junction temperature when compared to the thermal characteristics of whisker packages. Because of this rugged double-plug (heat-sink) package, these devices offer very conservatively rated power dissipation capabilities.

FALLS WITHIN JEDEC DO-7* DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

*absolute maximum ratings at specified lead temperature

Steady-State Regulator Current, I_{ZM}, at (or below) 75°C	See Table 2
Continuous Power Dissipation at (or below) 75°C (See Note 1)	500 mW
Peak Nonrepetitive Reverse Surge Power at 55°C (See Note 2)	10 W
Operating Lead Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	230°C

TABLE 1—STEADY-STATE REGULATOR CURRENT

TYPE	I_{ZM}† (mA)	TYPE	I_{ZM}† (mA)	TYPE	I_{ZM}† (mA)	TYPE	I_{ZM}† (mA)
1N5226, A, B	138	1N5234, A, B	73	1N5242, A, B	38	1N5250, A, B	23
1N5227, A, B	126	1N5235, A, B	67	1N5243, A, B	35	1N5251, A, B	21
1N5228, A, B	115	1N5236, A, B	61	1N5244, A, B	32	1N5252, A, B	19.1
1N5229, A, B	106	1N5237, A, B	55	1N5245, A, B	30	1N5253, A, B	18.2
1N5230, A, B	97	1N5238, A, B	52	1N5246, A, B	28	1N5254, A, B,	16.8
1N5231, A, B	89	1N5239, A, B	50	1N5247, A, B	27	1N5255, A, B	16.2
1N5232, A, B	81	1N5240, A, B	45	1N5248, A, B	25	1N5256, A, B	15.1
1N5233, A, B	76	1N5241, A, B	41	1N5249, A, B	24	1N5257, A, B	13.8

†The nominal I_{ZM} currents shown are applicable for devices having regulator voltages approximately 10% above the nominal V_Z values shown under electrical characteristics. These values do not represent absolute limits. The actual steady-state current-voltage product must not exceed the power rating.

NOTES: 1. Derate linearly to 200°C lead temperature at the rate of 4 mW/°C.
2. This value applies for an 8.3-ms square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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1N5226 THRU 1N5257

***electrical characteristics at 25°C lead temperature**

PARAMETER	V_Z Regulator Voltage	I_R Static Reverse Current	V_F Static Forward Voltage	TEST CURRENT AND VOLTAGE	
TEST CONDITIONS	$I_R = I_{Z(T)}$, See Note 3	$V_R = V_{R(T)}$	$I_F = 200$ mA	$I_{Z(T)}$	$V_{R(T)}$
LIMIT	NOM‡	MAX	MAX		
UNIT	V	μA	V	mA	V
1N5226	3.3	100	1.1	20	0.95
1N5227	3.6	100	1.1	20	0.95
1N5228	3.9	75	1.1	20	0.95
1N5229	4.3	50	1.1	20	0.95
1N5230	4.7	50	1.1	20	1.9
1N5231	5.1	50	1.1	20	1.9
1N5232	5.6	50	1.1	20	2.9
1N5233	6.0	50	1.1	20	3.3
1N5234	6.2	50	1.1	20	3.8
1N5235	6.8	30	1.1	20	4.8
1N5236	7.5	30	1.1	20	5.7
1N5237	8.2	30	1.1	20	6.2
1N5238	8.7	30	1.1	20	6.2
1N5239	9.1	30	1.1	20	6.7
1N5240	10	30	1.1	20	7.6
1N5241	11	30	1.1	20	8.0
1N5242	12	10	1.1	20	8.7
1N5243	13	10	1.1	9.5	9.4
1N5244	14	10	1.1	9.0	9.5
1N5245	15	10	1.1	8.5	10.5
1N5246	16	10	1.1	7.8	11.4
1N5247	17	10	1.1	7.4	12.4
1N5248	18	10	1.1	7.0	13.3
1N5249	19	10	1.1	6.6	13.3
1N5250	20	10	1.1	6.2	14.3
1N5251	22	10	1.1	5.6	16.2
1N5252	24	10	1.1	5.2	17.1
1N5253	25	10	1.1	5.0	18.1
1N5254	27	10	1.1	4.6	20
1N5255	28	10	1.1	4.5	20
1N5256	30	10	1.1	4.2	22
1N5257	33	10	1.1	3.8	24

‡V_Z tolerance is ±20% for 1N5226 thru 1N5257. See next page for 5%-tolerance and 10%-tolerance devices.

NOTE 3: V_Z is measured with the device at thermal equilibrium while held in clips at least 3/8 inch from the case in still air at 25°C.

*JEDEC registered data

1N5226A THRU 1N5257A AND 1N5226B THRU 1N5257B

***electrical characteristics at 25°C lead temperature (unless otherwise noted)**

PARAMETER	CHARACTERISTICS V_Z Regulator Voltage	α_{VZ} Temperature Coefficient of Regulator Voltage	z_z Small-Signal Regulator Impedance	z_{zk} Small-Signal Regulator Knee Impedance	I_R Static Reverse Current	V_F Static Forward Voltage	TEST CURRENT AND VOLTAGE		
								$V_{R(T)}$	
TEST CONDITIONS	$I_R = I_{Z(T)}$, See Note 3	See Note 4	$I_R = I_{Z(T)}$, $I_r = 10\%\ I_{Z(T)}$, f = 60 Hz	$I_{ZK} = 250\ \mu A$, $I_{zk} = 25\ \mu A$, f = 60 Hz	$V_R = V_{R(T)}$	$I_F = 200$ mA	$I_{Z(T)}$	1N5226A thru 1N5257A	1N5226B thru 1N5257B
LIMIT	NOM§	MAX	MAX	MAX	MAX	MAX			
UNIT	V	%/°C	Ω	Ω	μA	V	mA	V	V
1N5226A, B	3.3	−0.070	28	1600	25	1.1	20	0.95	1.0
1N5227A, B	3.6	−0.065	24	1700	15	1.1	20	0.95	1.0
1N5228A, B	3.9	−0.060	23	1900	10	1.1	20	0.95	1.0
1N5229A, B	4.3	±0.055	22	2000	5	1.1	20	0.95	1.0
1N5230A, B	4.7	±0.030	19	1900	5	1.1	20	1.9	2.0
1N5231A, B	5.1	±0.030	17	1600	5	1.1	20	1.9	2.0
1N5232A, B	5.6	+0.038	11	1600	5	1.1	20	2.9	3.0
1N5233A, B	6.0	+0.038	7	1600	5	1.1	20	3.3	3.5
1N5234A, B	6.2	+0.045	7	1000	5	1.1	20	3.8	4.0
1N5235A, B	6.8	+0.050	5	750	3	1.1	20	4.8	5.0
1N5236A, B	7.5	+0.058	6	500	3	1.1	20	5.7	6.0
1N5237A, B	8.2	+0.062	8	500	3	1.1	20	6.2	6.5
1N5238A, B	8.7	+0.065	8	600	3	1.1	20	6.2	6.5
1N5239A, B	9.1	+0.068	10	600	3	1.1	20	6.7	7.0
1N5240A, B	10	+0.075	17	600	3	1.1	20	7.6	8.0
1N5241A, B	11	+0.076	22	600	2	1.1	20	8.0	8.4
1N5242A, B	12	+0.077	30	600	1	1.1	20	8.7	9.1
1N5243A, B	13	+0.079	13	600	0.5	1.1	9.5	9.4	9.9
1N5244A, B	14	+0.082	15	600	0.1	1.1	9.0	9.5	10
1N5245A, B	15	+0.082	16	600	0.1	1.1	8.5	10.5	11
1N5246A, B	16	+0.083	17	600	0.1	1.1	7.8	11.4	12
1N5247A, B	17	+0.084	19	600	0.1	1.1	7.4	12.4	13
1N5248A, B	18	+0.085	21	600	0.1	1.1	7.0	13.3	14
1N5249A, B	19	+0.086	23	600	0.1	1.1	6.6	13.3	14
1N5250A, B	20	+0.086	25	600	0.1	1.1	6.2	14.3	15
1N5251A, B	22	+0.087	29	600	0.1	1.1	5.6	16.2	17
1N5252A, B	24	+0.088	33	600	0.1	1.1	5.2	17.1	18
1N5253A, B	25	+0.089	35	600	0.1	1.1	5.0	18.1	19
1N5254A, B	27	+0.090	41	600	0.1	1.1	4.6	20	21
1N5225A, B	28	+0.091	44	600	0.1	1.1	4.5	20	21
1N5226A, B	30	+0.091	49	600	0.1	1.1	4.2	22	23
1N5257A, B	33	+0.092	58	700	0.1	1.1	3.8	24	25

§V_Z tolerance is ±10% for 1N5226A thru 1N5257A series; ±5% for 1N5226B thru 1N5257B series. See preceding page for 20%-tolerance devices.

NOTES: 3. V_Z is measured with the device at thermal equilibruim while held in clips at least 3/8 inch from the case in still air at 25°C.

4. Temperature Coefficient $\alpha_{VZ} = \left[\dfrac{(V_Z @ 125°C)-(V_Z @ 25°C)}{V_Z @ 25°C}\right] \times \dfrac{100\%.}{125°C - 25°C}$

For determining α_{VZ}, V_Z is measured at 7.5 mA for 1N5226A/1N5226B thru 1N5242A/1N5242B and at I_{ZT} for 1N5243A/1N5243B thru 1N5257A/1N5257B.

*JEDEC registered data

TEXAS INSTRUMENTS INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

BULLETIN NO. DL-S 7311987, MARCH 1973

CORE-DRIVER DIODE ARRAYS

For Application With

- Magnetic Cores
- Thin-Film Memories
- Plated-Wire Memories
- Decoding or Encoding Applications

For Use In

- Airborne Computers
- Industrial Computers
- Military Computers
- Peripheral Equipment

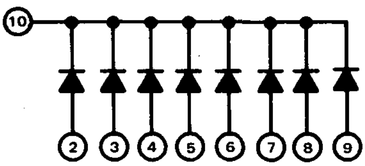
Electrically Equivalent to TID21A thru TID26A, TID131, TID132

description

These diode arrays are multiple diode junctions fabricated by a planar process and mounted in integrated circuit packages for use in high-current, fast-switching core-driver applications. These arrays offer many of the advantages of integrated circuits such as high-density packaging and improved reliability. These advantages result from such factors as fewer connections, more uniform device parameters, smaller size, less weight, fewer glass-to-metal seals, and the elimination of pressure contacts and whiskers.

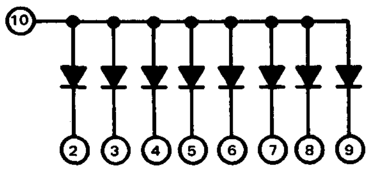
*terminal assignments and schematics

1N5768, 1N5769
8-DIODE ARRAY (COMMON CATHODE)
10-PIN PACKAGE



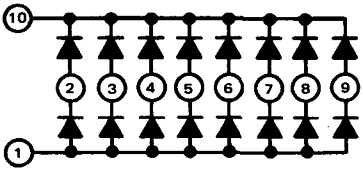
1 No internal connection

1N5770, 1N5771
8-DIODE ARRAY (COMMON ANODE)
10-PIN PACKAGE

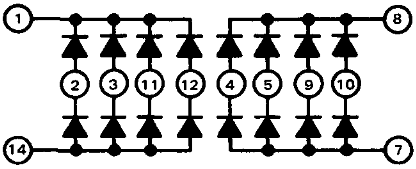


1 No internal connection

1N5772, 1N5773
16-DIODE ARRAY
10-PIN PACKAGE



1N5774, 1N5775
DUAL 8-DIODE ARRAY
14-PIN PACKAGE



6 13 No internal connection

*JEDEC registered data. This data sheet contains all applicable registered data in effect at the time of publication.

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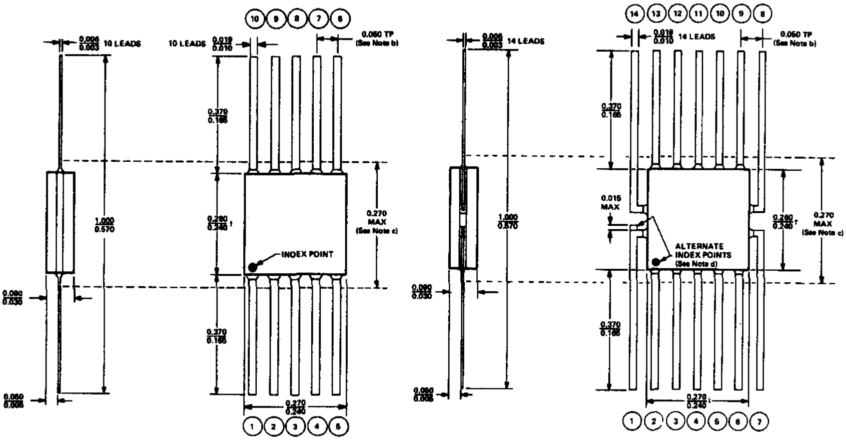
TYPES 1N5768 THRU 1N5775
SILICON DIODE ARRAYS

mechanical data

These hermetically-sealed packages consist of a ceramic base♦, metal cap♦, and a 10- or 14-lead frame. Gold-plated leads require no additional cleaning or processing when used in welded or soldered assembly.

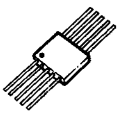
***OUTLINE DRAWINGS**

1N5768 THRU 1N5773 | 1N5774, 1N5775

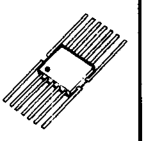


†Registered dimension is 0.120 min, 0.260 max
‡Registered dimension is 0.240 min, 0.375 max

1N5768 THRU 1N5773



1N5774
1N5775



NOTES: a. All dimensions are in inches.
b. Leads are within 0.005 radius of true position (TP) at maximum material condition.
c. This dimension determines a zone within which all body and lead irregularities lie.
d. Terminal identification is provided by either an index tab on pin 1 or an index dot.

♦The JEDEC registration allows these devices to be built with top and bottom surfaces either metallic or nonmetallic at the option of the manufacturer.

*absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH DIODE		TOTAL DEVICE	UNIT
8-DIODE ARRAYS (COMMON CATHODE)	1N5768	1N5769	ALL TYPES	
8-DIODE ARRAYS (COMMON ANODE)	1N5770	1N5771		
16-DIODE ARRAYS	1N5772	1N5773		
DUAL 8-DIODE ARRAYS	1N5774	1N5775		
Peak Reverse Voltage (See Note 1)	60	40		V
Steady-State Reverse Voltage, V_R	40	25		V
Peak Forward Current at (or below) 25°C Free-Air Temperature (See Notes 1 and 2)	500			mA
Continuous Forward Current at (or below) 25°C Free-Air Temperature (See Note 3)	300			mA
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 4)			500	mW
Operating Free-Air Temperature Range	−65 to 150			°C
Storage Temperature Range	−65 to 200			°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300			°C

NOTES: 1. These values apply for $t_w \leq 100\ \mu s$, duty cycle ≤ 20%.
2. Derate linearly to 150°C free-air temperature at the rate of 4 mA/°C.
3. Derate linearly to 150°C free-air temperature at the rate of 2.4 mA/°C.
4. Derate linearly to 150°C free-air temperature at the rate of 4 mW/°C.

*JEDEC registered data

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*electrical characteristics at 25°C free-air temperature

single-diode operation (see note 6)

PARAMETER		TEST CONDITIONS		1N5768		1N5769		1N5770 1N5772 1N5774		1N5771 1N5773 1N5775		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 10\ \mu A$,	See Note 5	60		40		60		40		V
I_R	Static Reverse Current	$V_R = 40$ V,	See Note 7		0.1				0.1			μA
		$V_R = 25$ V,	See Note 7				0.1				0.1	μA
V_F	Static Forward Voltage	$I_F = 100$ mA			1		1.1		1		1.1	V
v_F	Instantaneous Forward Voltage	$I_F = 500$ mA,	See Note 8		1.3		1.5		1.3		1.5	V
V_{FM}	Peak Forward Voltage	$I_F = 500$ mA,	See Note 9		5		5		5		5	V
C_T	Total Capacitance†	$V_R = 0$,	f = 1 MHz		4		4		8		8	pF

multiple-diode operation

PARAMETER		TEST CONDITIONS		ALL TYPES		UNIT
				MIN	MAX	
I_R	Static Reverse Current	V_R = rated V_R,	See Note 10		10	μA
V_F	Static Forward Voltage	$I_F = 25$ mA,	See Note 10		1	V

*switching characteristics at 25°C free-air temperature

single-diode operation (see note 6)

PARAMETER		TEST CONDITIONS		ALL TYPES		UNIT
				MIN	MAX	
t_{fr}	Forward Recovery Time	$I_F = 500$ mA,	See Figure 3		40	ns
t_{rr}	Reverse Recovery Time	$I_F = 200$ mA, $R_L = 100\ \Omega$, See Figure 4	$I_{RM} = 200$ mA, $i_{rr} = 20$ mA,		20	ns

NOTES:
5. This parameter must be measured using pulse techniques. $t_w = 100\ \mu s$, duty cycle ≤ 20%.
6. Test conditions and limits apply separately to each of the diodes. The diodes not under test are open-circuited during the measurement of these characteristics except for the measurement of I_R on arrays having both common-cathode and common-anode diodes (see Figures 1 and 2).
7. For arrays having both common-anode and common-cathode diodes see Figures 1 and 2, Parameter Measurement Information section.
8. This parameter is measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle ≤ 2%. Read time is 90 μs from the leading edge of the pulse.
9. The initial instantaneous value is measured using pulse techniques. $t_w = 150$ ns, duty cycle ≤ 2%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.
10. These parameters are measured with each of the other diodes in the section conducting 25 mA forward current. Each diode is individually tested after the device reaches operating thermal equilibrium. Test conditions apply separately to common-anode and common-cathode sections.

†C_T is the total pin-to-pin capacitance measured across any of the diodes. For arrays having both common-anode and common-cathode sections, the interaction of the other diodes cannot easily be separated out unless three-terminal guarded measurement techniques are used. The actual capacitance of a single isolated diode will typically be 30% of the measured pin-to-pin value for the common-cathode diodes, and 75% of the measured value for the common-anode diodes.

*JEDEC registered data

PARAMETER MEASUREMENT INFORMATION

When measuring the reverse current of an individual diode of a device having both common-anode and common-cathode sections, the current meter must be placed so that the shunt current through the other diodes is bypassed around the meter. To obtain accurate readings, the voltage drop across the current meter must be less than 10 mV.

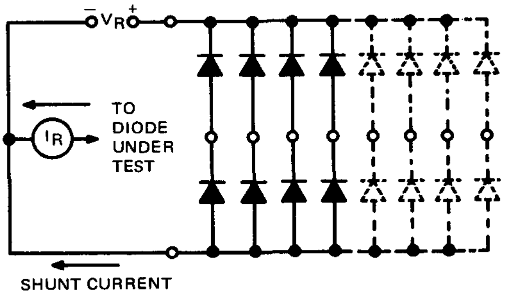


FIGURE 1—TEST CIRCUIT FOR COMMON-CATHODE DIODES

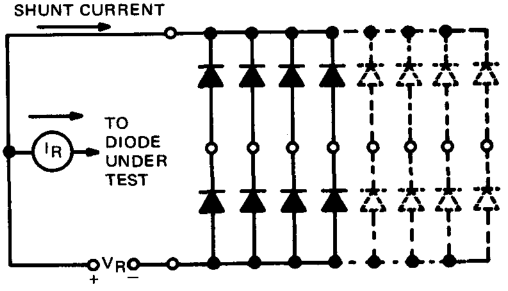
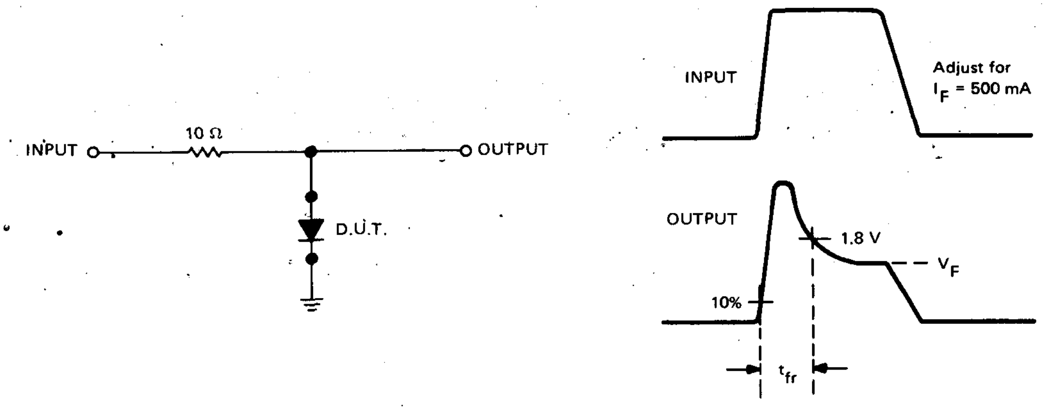


FIGURE 2—TEST CIRCUIT FOR COMMON-ANODE DIODES



TEST CIRCUIT VOLTAGE WAVEFORMS

FIGURE 3—FORWARD RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 150$ ns, duty cycle $\leq$ 2%.

b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 4.5$ ns, $R_{in} \geq 1\ M\Omega$, $C_{in} \leq 5$ pF.

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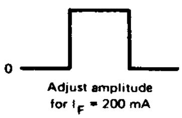
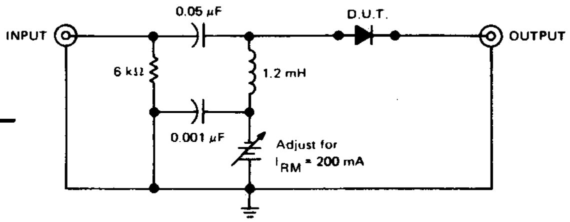
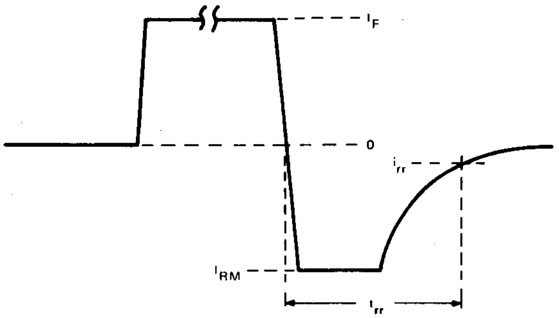
PARAMETER MEASUREMENT INFORMATION



INPUT VOLTAGE WAVEFORM



TEST CIRCUIT



OUTPUT CURRENT WAVEFORM

FIGURE 4—REVERSE RECOVERY TIME

NOTES: c. The input pulse is supplied by a generator with the following characteristics: $t_f \leq 1$ ns, Z_{out} = 50 Ω, t_w = 200 ns, duty cycle ≤ 1%.

d. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.4$ ns, R_{in} = 50 Ω.

TYPICAL CHARACTERISTICS

FORWARD CONDUCTION CHARACTERISTICS

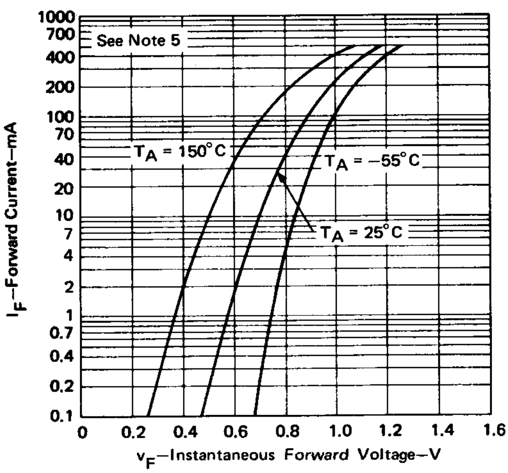


FIGURE 5

NOTE 8: This parameter is measured using pulse techniques. t_w = 300 µs, duty cycle = 2%. Read time is 90 µs from the leading edge of the pulse.

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TYPE G129
SILICON STABISTOR DIODE

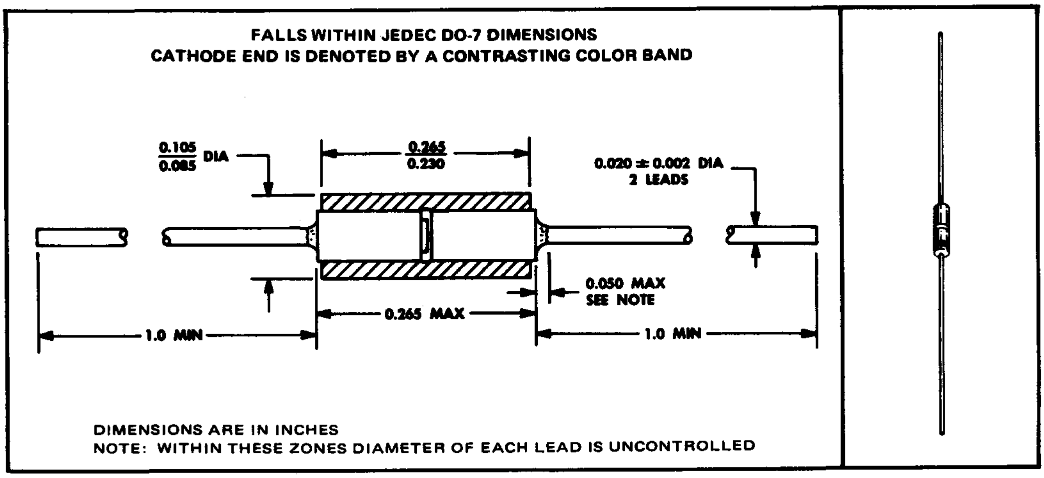
BULLETIN NO. DL-S 7311936, MARCH 1973

FOR STABISTOR APPLICATIONS

- Meter Protectors
- Temperature Sensors
- Transistor Biasing
- Signal Limiters
- Voltage Stabilizers
- Logarithmic Attenuators

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Peak Reverse Voltage	10 V
Continuous Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	250 mA
Repetitive Peak Forward Current at (or below) 25°C Free-Air Temperature (See Note 2)	1 A
Peak Surge Current, One Second (See Note 3)	1.5 A
Storage Temperature Range	−65°C to 150°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
I_R	Static Reverse Current	$V_R = 2$ V		0.1	μA
V_F	Static Forward Voltage	$I_F = 1$ mA	500	610	mV
		$I_F = 100$ mA		1	V
r_f	Small-Signal Forward Resistance	$I_F = 1$ mA, f = 1 kHz		60	Ω

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2 mA/°C.
2. This value applies for a 60-Hz sine wave.
3. This value applies for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.

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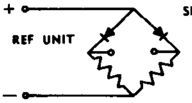
TYPICAL APPLICATIONS

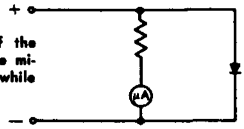
TEMPERATURE-SENSING BRIDGE

The temperature coefficient of the stabistor makes it well-suited to bridge circuit sensing applications.



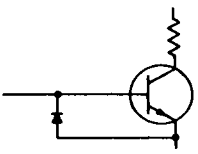
METER PROTECTION

The low threshold voltage of the stabistor will protect a sensitive microammeter from over voltage while allowing normal operation.



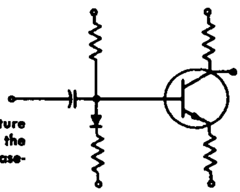
BASE-CLAMPING DIODE

The stabistor in this circuit provides protection for transistors having low $V_{(BR)EBO}$, by clamping the reverse base voltage. This type of protection allows high collector currents and does not require additional base bias.



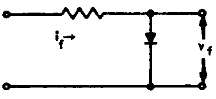
STABILIZED TRANSISTOR BIAS

The stabistor provides temperature compensation proportional to the temperature coefficient of the base-emitter diode of the transistor.



LOGARITHMIC ATTENUATORS

The characteristic of the stabistor approximates a log function according to the equation:



$$v_f \cong \frac{\eta KT}{q} \ln \left(\frac{i_f + I_{sat}}{I_{sat}} \right)$$

where:

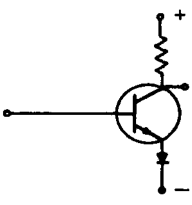
K = Boltzmann's Constant
T = Free-Air Temperature in ° Kelvin
q = Charge on an Electron
i_f = Forward Diode Current
I_{sat} = Diode Saturation Current ($\approx 10^{-9}$ amp)

η may be considered an efficiency factor, which, for an efficient stabistor, is a number close to one.

for $v_f > \frac{KT}{q}$ and $\frac{KT}{q} \approx 25.5$ mV at $T_A = 25°C$

TRANSISTOR EMITTER VARISTOR

The stabistor, acting as a variable emitter resistor for switching applications, presents a high small-signal impedance for a low d-c emitter current and a low small-signal impedance for a high d-c emitter current. The temperature dependence of the d-c voltage across the stabistor must be allowed for in setting the quiescent biasing of the transistor.



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TEXAS INSTRUMENTS
INCORPORATED
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SILICON STABISTOR DIODE

BULLETIN NO. DL-S 7311937, MARCH 1973

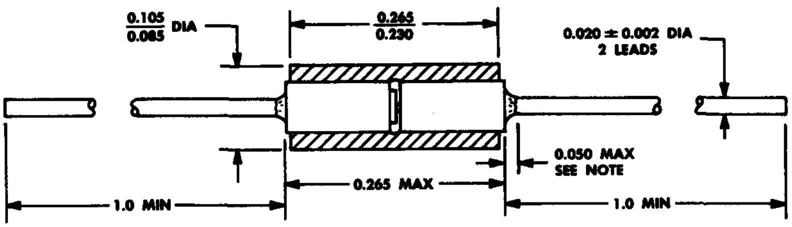
FOR STABISTOR APPLICATIONS

- Meter Protectors
- Temperature Sensors
- Transistor Biasing
- Signal Limiters
- Voltage Stabilizers
- Logarithmic Attenuators

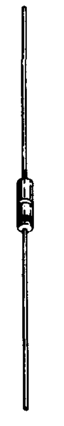
mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

FALLS WITHIN JEDEC DO-7 DIMENSIONS
CATHODE END IS DENOTED BY A CONTRASTING COLOR BAND



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Peak Reverse Voltage	6 V
Continuous Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	150 mA
Repetitive Peak Forward Current at (or below) 25°C Free-Air Temperature (See Note 2)	0.5 A
Peak Surge Current, One Second (See Note 3)	0.5 A
Storage Temperature Range	−65°C to 150°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
I_R	Static Reverse Current	$V_R = 2$ V		0.1	μA
V_F	Static Forward Voltage	$I_F = 1$ mA	570	700	mV
		$I_F = 100$ mA		1	V
r_f	Small-Signal Forward Resistance	$I_F = 1$ mA, f = 1 kHz		60	Ω

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2 mA/°C.
2. This value applies for a 60-Hz sine wave.
3. This value applies for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.

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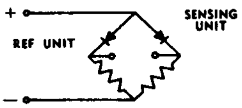
TYPICAL APPLICATIONS

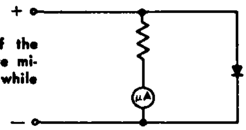
TEMPERATURE-SENSING BRIDGE

The temperature coefficient of the stabistor makes it well-suited to bridge circuit sensing applications.



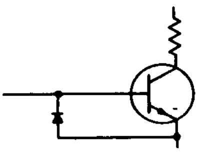
METER PROTECTION

The low threshold voltage of the stabistor will protect a sensitive microammeter from over voltage while allowing normal operation.



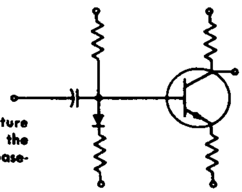
BASE-CLAMPING DIODE

The stabistor in this circuit provides protection for transistors having low $V_{(BR)EBO}$, by clamping the reverse base voltage. This type of protection allows high collector currents and does not require additional base bias.



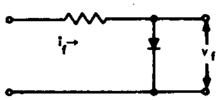
STABILIZED TRANSISTOR BIAS

The stabistor provides temperature compensation proportional to the temperature coefficient of the base-emitter diode of the transistor.



LOGARITHMIC ATTENUATORS

The characteristic of the stabistor approximates a log function according to the equation:



$$v_f \cong \frac{\eta KT}{q} \ln\left(\frac{I_f + I_{sat}}{I_{sat}}\right)$$

where:

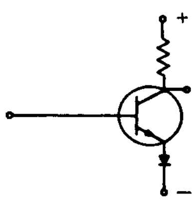
K = Boltzmann's Constant
T = Free-Air Temperature in ° Kelvin
q = Charge on an Electron
I_f = Forward Diode Current
I_{sat} = Diode Saturation Current ($\approx 10^{-12}$ amp)

η may be considered an efficiency factor, which, for an efficient stabistor, is a number close to one.

for $v_f > \frac{KT}{q}$ and $\frac{KT}{q} \approx 25.5$ mV at $T_A = 25°C$

TRANSISTOR EMITTER VARISTOR

The stabistor, acting as a variable emitter resistor for switching applications, presents a high small-signal impedance for a low d-c emitter current and a low small-signal impedance for a high d-c emitter current. The temperature dependence of the d-c voltage across the stabistor must be allowed for in setting the quiescent biasing of the transistor.



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TEXAS INSTRUMENTS
INCORPORATED
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

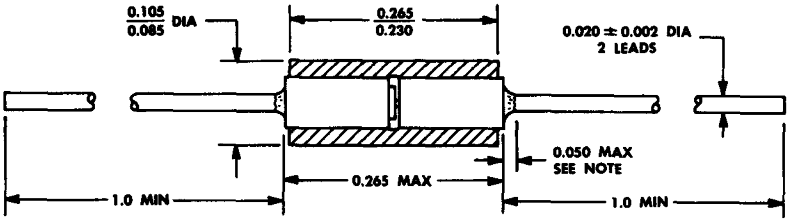
TYPES TI51 THRU TI60
SILICON GENERAL PURPOSE DIODES

BULLETIN NO. DL-S 739040, AUGUST 1966—REVISED MARCH 1973

- $V_{RM(wkg)}$ . . . 10 to 300 Volts
- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.



absolute maximum ratings

		TI51	TI52	TI53	TI54	TI55	TI56	TI57	TI58	TI59	TI60	UNIT
$V_{RM(wkg)}$	Working Peak Reverse Voltage at 25°C Free-Air Temperature	10	20	30	40	60	100	150	175	200	300	V
P	Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note)	400										mW
$T_{A(opr)}$	Operating Free-Air Temperature Range	−65 to 100										°C
T_{stg}	Storage Temperature Range	−65 to 125										°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TI51	TI52	TI53	TI54	TI55	TI56	TI57	TI58	TI59	TI60	UNIT	LIMIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	20	30	40	50	80	120	200	270	320	400	V	MIN
I_R	Static Reverse Current	V_R = Rated $V_{RM(wkg)}$	1	1	1	1	1	1	1	1	1	1	µA	MAX
V_F	Static Forward Voltage	$I_F = 200$ mA	1	1	1	1	1						V	MAX
		$I_F = 400$ mA						1	1	1	1	1	V	MAX

NOTE: Derate linearly to 100°C free-air temperature at the rate of 5.33 mW/°C.

10

TEXAS INSTRUMENTS
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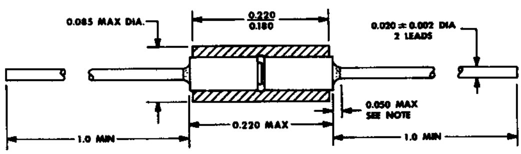
MEDIUM-SPEED SWITCHING DIODES

- For Industrial Switching Applications
- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contacts by means of a thermal compression bond. Moisture-free stability is ensured through hermeti sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY COLOR BAND



DIMENSIONS ARE IN INCHES

NOTE: WITHIN THESE ZONES DIAMETER OF EACH LEAD IS UNCONTROLLED

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Peak Reverse Voltage	40 V
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	250 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TI71		TI72		TI73		TI74		TI75		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	40		40		40		40		40		V
I_R	Static Reverse Current	$V_R = 15\ V$								1			µA
		$V_R = 20\ V$		1		1		1					
		$V_R = 35\ V$										5	
V_F	Static Forward Voltage	$I_F = 6\ mA$		1									V
		$I_F = 10\ mA$				1							
		$I_F = 20\ mA$						1					
		$I_F = 30\ mA$								1			
		$I_F = 75\ mA$										1	

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TI71		TI72		TI73		TI74		TI75		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{rr}	Reverse Recovery Time	$I_F = 10\ mA$, $I_{RM} = 10\ mA$, $R_L = 100\ \Omega$, $C_L = 10\ pF$, $i_{rr} = 1\ mA$, See Figure 1		10		20		20		30		50	ns

NOTE 1: Derate linearly to 200°C free-air temperature at the rate of 1.43 mW/°C. See Figure 2.

PARAMETER MEASUREMENT INFORMATION

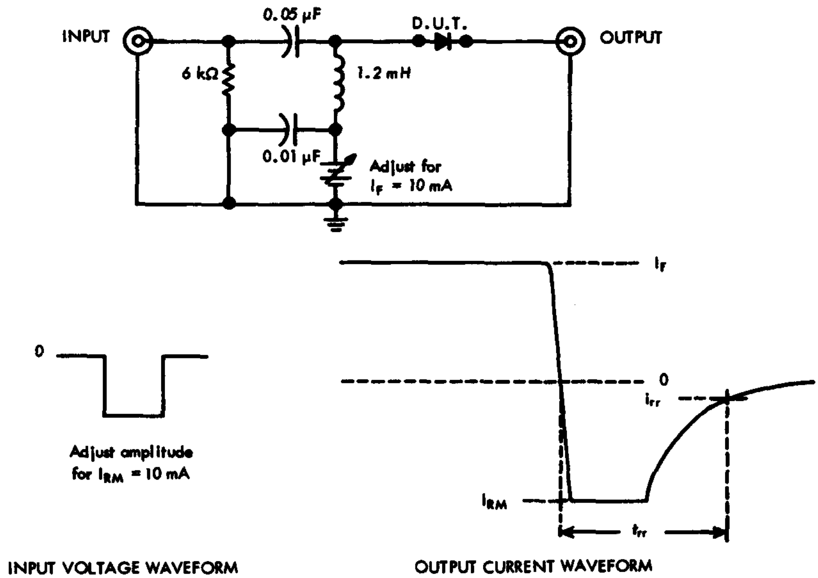


FIGURE 1 — REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, t_r ≤ 0.25 ns, t_w = 100 ns.
b. Output waveform is monitored on an oscilloscope with the following characteristics: t_r ≤ 0.35 ns, Z_{in} = 50 Ω.

THERMAL CHARACTERISTICS

DISSIPATION DERATING CURVE

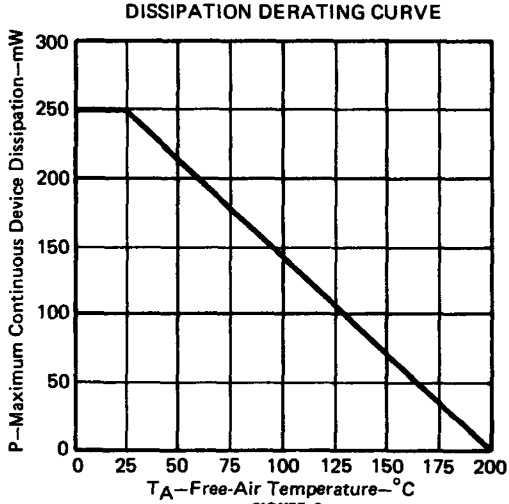


FIGURE 2

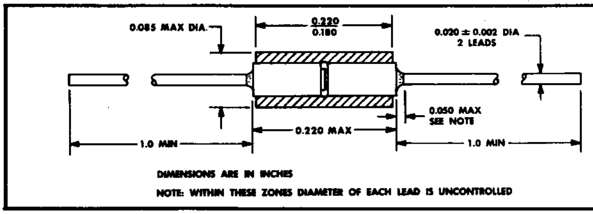
BULLETIN NO. DL-S 735081, MARCH 1964—REVISED MARCH 1973

HIGH-VOLTAGE RADIATION-TOLERANT DIODES

- Extremely Resistant to Radiation Environments
- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.



CATHODE END IS DENOTED BY COLOR BAND

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		TI550	TI551	UNIT
V_R	Steady State Reverse Voltage	175	225	v
I_O	Average Rectified Forward Current from −55°C to +75° Free-Air Temperature (See Note 1)	150	150	ma
I_{FM}	Peak Forward Current from −55°C to +75°C Free-Air Temperature (See Note 1)	500	500	ma
$I_{FM(surge)}$	Surge Current, One Cycle (See Note 2)	4	4	a
$T_{A(opr)}$	Operating Free-Air Temperature Range	−55 to +125		°C
T_{stg}	Storage Temperature Range	−55 to +200		°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TI550		TI551		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	I_R = 100 ua	200	300	290	400	v
$\Delta V_{(BR)}$	Breakdown Voltage Change With Reverse Current	I_R = 1 μa to I_R = 100 μa		20		20	v
I_R	Static Reverse Current	V_R = Rated V_R		0.1		0.1	μa
I_R	Static Reverse Current	V_R = Rated V_R, T_A = 125°C		10		10	μa
V_F	Static Forward Voltage	I_F = 100 ma		1		1	v
C_T	Total Capacitance	V_R = 0, f = 1 Mc		20		20	pf

switching characteristics at 25°C free-air temperature

t_{rr}	Reverse Recovery Time	See Note 3	0.7	0.7	μsec

radiation-resistance characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	RADIATION DOSE†		TI550		TI551		UNIT
			TI550	TI551	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	I_R = 100 μa	5×10^{16} e/cm²	1×10^{16} e/cm²	200		290		v
I_R	Static Reverse Current	V_R = Rated V_R	5×10^{16} e/cm²	1×10^{16} e/cm²		0.1		0.1	μa
V_F	Static Forward Voltage	I_F = 100 ma	5×10^{16} e/cm²	1×10^{16} e/cm²		1		1	v
$V_{(BR)}$	Reverse Breakdown Voltage	I_R = 100 μa	2×10^{15} N/cm²	1×10^{15} N/cm²	200		290		v
I_R	Static Reverse Current	V_R = Rated V_R	2×10^{15} N/cm²	1×10^{15} N/cm²		0.1		0.1	μa
V_F	Static Forward Voltage	I_F = 100 ma	2×10^{15} N/cm²	1×10^{15} N/cm²		1.1		1.2	v

†Radiation levels are electrons (e) at E = 2 Mev or neutrons (N) at E ≥ 10 kev.

NOTES: 1. These values may be applied continuously under single-phase, 60-cps, half-sine-wave operation with resistive load. Above 75°C, derate I_O and I_{FM} linearly to 125°C free-air temperature.

2. This value applies for one 60-cps half-sine-wave when the device is operating at or below rated values of peak reverse voltage and average rectified forward current. Surge may be repeated after the device has returned to original thermal equilibrium conditions.

3. Reverse recovery time is measured in the test circuit of Drawing 256-JAN with I_F = 5 ma, V_R = 40 v, I_{rr} = 500 μa, R_L = 2 kΩ, and C_L = 10 pf.

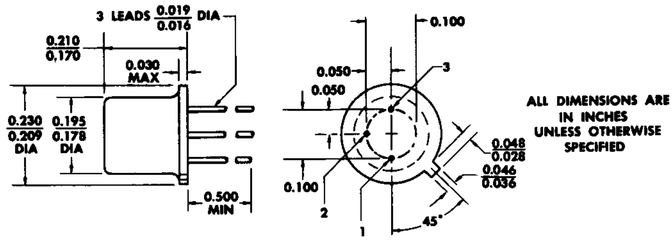
10

BULLETIN NO. DL-S 7211699, MARCH 1972

DUAL-DIODE CORE DRIVERS
For Application with
Magnetic Cores • Memory Drums • Memory Tapes
Magnetic Discs • Diode-Capacitor Storage

mechanical data

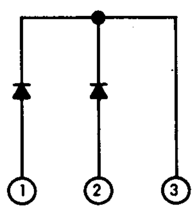
TERMINAL 3 IS IN ELECTRICAL CONTACT WITH THE CASE



ALL JEDEC TO-18 DIMENSIONS AND NOTES ARE APPLICABLE

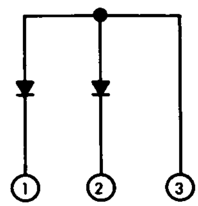
schematic diagrams

TID17, TID18



COMMON CATHODE

TID19, TID20



COMMON ANODE

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	EACH DIODE		TOTAL DEVICE	UNIT
	TID17 TID19	TID18 TID20	ALL TYPES	
Peak Reverse Voltage (See Note 1)	60	40		V
Steady State Reverse Voltage, V_R	30	15		V
Peak Forward Current at (or below) 25°C Free-Air Temperature (See Notes 1 and 2)	500		500	mA
Continuous Forward Current at (or below) 25°C Free-Air Temperature (See Note 3)	100		200	mA
Storage Temperature Range	−65 to 200			°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300			°C

NOTES: 1. These values apply for $t_w \leq 100\ \mu s$, duty cycle $\leq 20\%$.
2. Derate linearly to 150°C free-air temperature at the rate of 4 mA/°C.
3. Derate linearly to 150°C free-air temperature at the rate of 0.8 mA/°C for each diode and 1.6 mA/°C for the total device.

TEXAS INSTRUMENTS
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electrical characteristics at 25°C free-air temperature

single-diode operation (see note 4)

PARAMETER		TEST CONDITIONS		TID17		TID18		TID19		TID20		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 10\ \mu A$,	See Note 5	60		40		60		40		V
I_R	Static Reverse Current	$V_R = 30\ V$			0.1				0.1			µA
		$V_R = 15\ V$					0.1				0.1	
V_F	Static Forward Voltage	$I_F = 100\ mA$			1		1.1		1		1.1	V
v_F	Instantaneous Forward Voltage	$I_F = 500\ mA$,	See Note 6		1.5		1.7		1.5		1.7	V
V_{FM}	Peak Forward Voltage	$I_{FM} = 500\ mA$,	See Note 7		5		5		5		5	V
C_T	Total Capacitance	$V_R = 0$,	f = 1 MHz		4		4		7		7	pF

dual-diode operation (see note 8)

PARAMETER		TEST CONDITIONS	TID17		TID18		TID19		TID20		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
I_{R1} (or I_{R2})	Static Reverse Current	V_{R1} (or V_{R2}) = rated V_R, I_{F2} (or I_{F1}) = 100 mA		1		1		1		1	µA
V_{F1} (or V_{F2})	Static Forward Voltage	$I_F = I_{F2} = 100\ mA$		1		1.1		1		1.1	V

switching characteristics at 25°C free-air temperature

single-diode operation (see note 4)

PARAMETER		TEST CONDITIONS	ALL TYPES MAX	UNIT
t_{fr}	Forward Recovery Time	$I_F = 500\ mA$, See Figure 2	40	ns
t_{rr}	Reverse Recovery Time	$I_F = 200\ mA$, $I_{RM} = 200\ mA$, $R_L = 100\ \Omega$, $i_{rr} = 20\ mA$, See Figure 3	25	ns

NOTES: 4. Test conditions and limits apply separately to each of the two diodes. The diode not under test is open-circuited during the measurement of these characteristics.
5. This parameter must be measured using pulse techniques. $t_w = 100\ \mu s$, duty cycle ≤ 20%.
6. This parameter is measured using pulse techniques. $t_w = 100\ \mu s$, duty cycle ≤ 2%. Read time is 90 µs from leading edge of the pulse.
7. The initial instantaneous value is measured using pulse techniques. $t_w = 150\ \mu s$, duty cycle ≤ 2%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.
8. Each diode is individually tested after the device reaches operating thermal equilibrium.

TYPICAL CHARACTERISTICS

FORWARD CONDUCTION CHARACTERISTICS

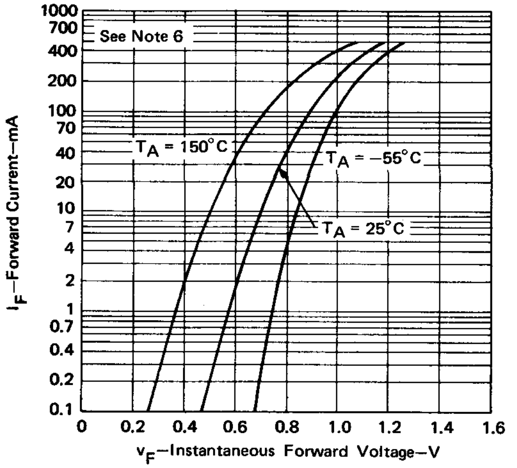
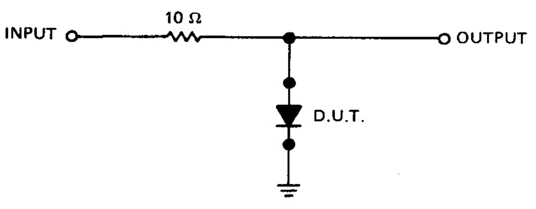


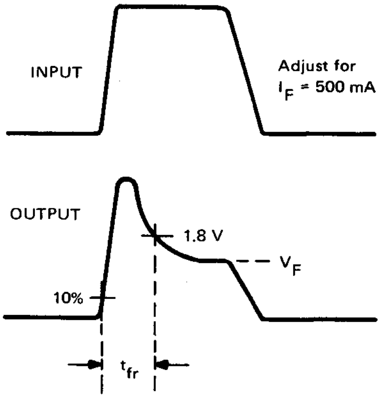
FIGURE 1

NOTE 6: This parameter is measured using pulse techniques. t_w = 100 μs, duty cycle ⩽ 2%. Read time is 90 μs from leading edge of the pulse.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



VOLTAGE WAVEFORMS

FIGURE 2—FORWARD RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: t_r ⩽ 15 ns, Z_{out} = 50 Ω, t_w = 150 ns, duty cycle ⩽ 2%.
b. Output waveform is monitored on an oscilloscope with the following characteristics: t_r ⩽ 4.5 ns, R_{in} ⩾ 1 MΩ, C_{in} ⩽ 5 pF.

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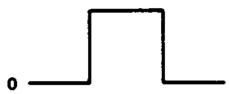
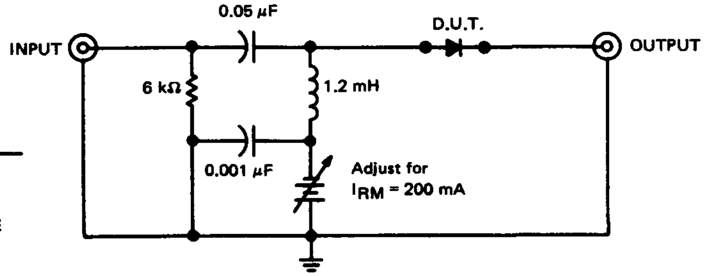
PARAMETER MEASUREMENT INFORMATION

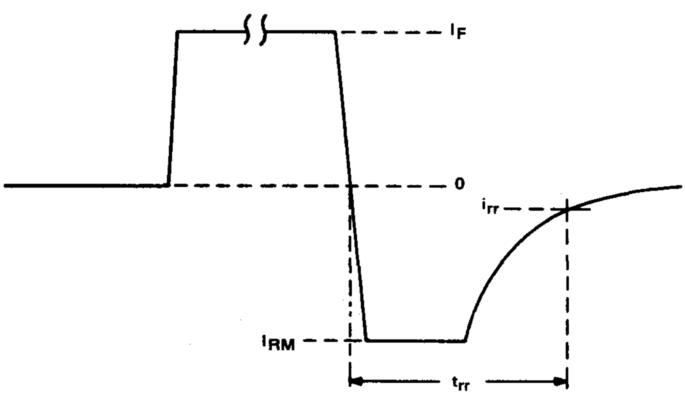


Adjust amplitude
for I_F = 200mA

INPUT VOLTAGE WAVEFORM



TEST CIRCUIT



OUTPUT CURRENT WAVEFORM

NOTES: c. The input pulse is supplied by a generator with the following characteristics: $t_f \leq 1$ ns, $Z_{out} = 50\ \Omega$, $t_w = 200$ ns, duty cycle < 1%.

d. Output waveform is monitored on an oscilloscope with the following characteristics: $t_r < 0.4$ ns, $R_{in} \geq 50\ \Omega$.

TEXAS INSTRUMENTS
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BULLETIN NO. DL-S 7011325, MARCH 1970

CORE-DRIVER DIODE ARRAYS

For Application With

- Magnetic Cores
- Thin-Film Memories
- Plated-Wire Memories
- Decoding or Encoding Applications

For Use In

- Airborne Computers
- Industrial Computers
- Military Computers
- Peripheral Equipment

description

These diode arrays are multiple diode junctions fabricated by a planar process and mounted in integrated circuit packages for use in high-current, fast-switching core-driver applications. These arrays offer many of the advantages of integrated circuits such as high-density packaging and improved reliability. These advantages result from such factors as fewer connections, more uniform device parameters, smaller size, less weight, fewer glass-to-metal seals, and the elimination of pressure contacts and whiskers.

The arrays are available in hermetically sealed, welded flat packages (F) or in dual-in-line plastic packages (N).

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	FLAT PACKAGE			DUAL-IN-LINE PACKAGE			UNIT
	EACH DIODE		TOTAL DEVICE	EACH DIODE		TOTAL DEVICE	
8-DIODE ARRAYS (COMMON CATHODE)	TID21A	TID22A	ALL TYPES	TID121	TID122	ALL TYPES	
8-DIODE ARRAYS (COMMON ANODE)	TID23A	TID24A		TID123	TID124		
16-DIODE ARRAYS	TID25A	TID26A		TID125	TID126		
DUAL 10-DIODE ARRAYS	TID29A	TID30A		TID129	TID130		
DUAL 8-DIODE ARRAYS	TID131	TID132		TID133	TID134		
Peak Reverse Voltage (See Note 1)	60	40		60	40		V
Steady-State Reverse Voltage, V_R	40	25		40	25		V
Peak Forward Current at (or below) 25°C Free-Air Temperature (See Note 1)	500†			500‡			mA
Continuous Forward Current at (or below) 25°C Free-Air Temperature	300§			400¶			mA
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature			500◇			600□	mW
Operating Free-Air Temperature Range	−65 to 150			−65 to 125			°C
Storage Temperature Range	−65 to 200			−65 to 150			°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300			260			°C

NOTE 1: These values apply for $t_w \leq 100\ \mu s$, duty cycle ≤ 20%.

†Derate linearly to 150°C free-air temperature at the rate of 4 mA/°C.
‡Derate linearly to 125°C free-air temperature at the rate of 5 mA/°C.
§Derate linearly to 150°C free-air temperature at the rate of 2.4 mA/°C.
¶Derate linearly to 125°C free-air temperature at the rate of 4 mA/°C.
◇Derate linearly to 150°C free-air temperature at the rate of 4 mW/°C.
□Derate linearly to 125°C free-air temperature at the rate of 6 mW/°C.

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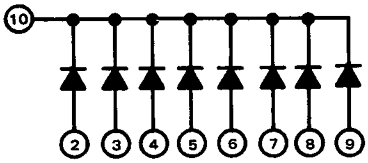
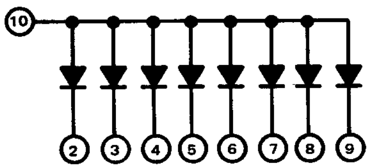
F FLAT PACKAGES

TID21A, TID22A
8-DIODE ARRAY (COMMON CATHODE)
10-PIN PACKAGE



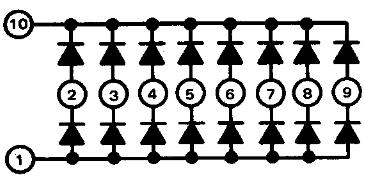
1 No internal connection

TID23A, TID24A
8-DIODE ARRAY (COMMON ANODE)
10-PIN PACKAGE

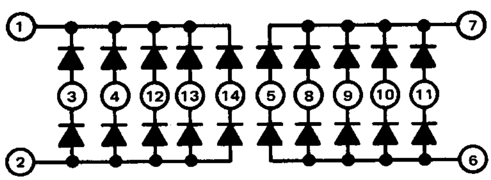


1 No internal connection

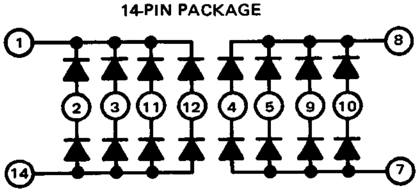
TID25A, TID26A
16-DIODE ARRAY
10-PIN PACKAGE



TID29A, TID30A
DUAL 10-DIODE ARRAY
14-PIN PACKAGE



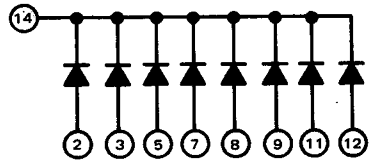
TID131, TID132
DUAL 8-DIODE ARRAY
14-PIN PACKAGE



6 13 No internal connection

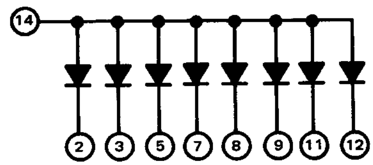
14-PIN N PLASTIC DUAL-IN-LINE PACKAGES

TID121, TID122
8-DIODE ARRAY (COMMON CATHODE)
14-PIN PACKAGE



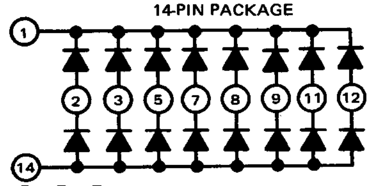
1 4 6 10 13 No internal connection

TID123, TID124
8-DIODE ARRAY (COMMON ANODE)
14-PIN PACKAGE



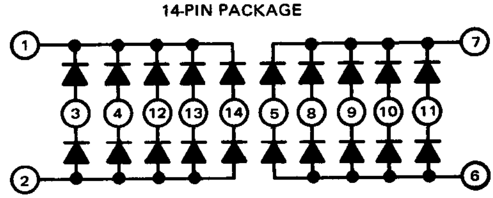
1 4 6 10 13 No internal connection

TID125, TID126
16-DIODE ARRAY
14-PIN PACKAGE

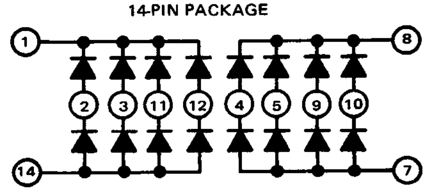


4 6 10 13 No internal connection

TID129, TID130
DUAL 10-DIODE ARRAY
14-PIN PACKAGE



TID133, TID134
DUAL 8-DIODE ARRAY
14-PIN PACKAGE



6 13 No internal connection

10

electrical characteristics at 25°C free-air temperature

single-diode operation (see note 3)

PARAMETER		TEST CONDITIONS		TID21A TID121		TID22A TID122		TID23A TID25A TID29A TID123 TID125 TID129 TID131 TID133		TID24A TID26A TID30A TID124 TID126 TID130 TID132 TID134		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 10\ \mu A$,	See Note 2	60		40		60		40		V
I_R	Static Reverse Current	$V_R = 40$ V,	See Note 4		0.1				0.1			μA
		$V_R = 25$ V,	See Note 4				0.1				0.1	μA
V_F	Static Forward Voltage	$I_F = 100$ mA			1		1.1		1		1.1	V
v_F	Instantaneous Forward Voltage	$I_F = 500$ mA,	See Note 5		1.3		1.5		1.3		1.5	V
V_{FM}	Peak Forward Voltage	$I_F = 500$ mA,	See Note 6		5		5		5		5	V
C_T	Total Capacitance†	$V_R = 0$,	f = 1 MHz		4		4		8		8	pF

multiple-diode operation

PARAMETER		TEST CONDITIONS		ALL TYPES		UNIT
				MIN	MAX	
I_R	Static Reverse Current	V_R = rated V_R,	See Note 7		10	μA
V_F	Static Forward Voltage	$I_F = 25$ mA,	See Note 7		1	V

switching characteristics at 25°C free-air temperature

single-diode operation (see note 3)

PARAMETER		TEST CONDITIONS		ALL TYPES		UNIT
				MIN	MAX	
t_{fr}	Forward Recovery Time	$I_F = 500$ mA,	See Figure 3		40	ns
t_{rr}	Reverse Recovery Time	$I_F = 200$ mA, $R_L = 100\ \Omega$, See Figure 4	$I_{RM} = 200$ mA, $i_{rr} = 20$ mA,		20	ns

NOTES: 2. This parameter must be measured using pulse techniques. $t_w = 100\ \mu s$, duty cycle $\leq 20\%$.
3. Test conditions and limits apply separately to each of the diodes. The diodes not under test are open-circuited during the measurement of these characteristics except for the measurement of I_R on arrays having both common-cathode and common-anode diodes (see Figures 1 and 2).
4. For arrays having both common-anode and common-cathode diodes see Figures 1 and 2, Parameter Measurement Information section.
5. This parameter is measured using pulse techniques. $t_w = 300\ \mu s$, duty cycle $\leq 2\%$. Read time is 90 μs from the leading edge of the pulse.
6. The initial instantaneous value is measured using pulse techniques. $t_w = 150$ ns, duty cycle $\leq 2\%$, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.
7. These parameters are measured with each of the other diodes in the section conducting 25 mA forward current. Each diode is individually tested after the device reaches operating thermal equilibrium. Test conditions apply separately to common-anode and common-cathode sections.

†C_T is the total pin-to-pin capacitance measured across any of the diodes. For arrays having both common-anode and common-cathode sections, the interaction of the other diodes cannot easily be separated out unless three-terminal guarded measurement techniques are used. The actual capacitance of a single isolated diode will typically be 30% of the measured pin-to-pin value for the common-cathode diodes, and 75% of the measured value for the common-anode diodes.

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PARAMETER MEASUREMENT INFORMATION

When measuring the reverse current of an individual diode of a device having both common-anode and common-cathode sections, the current meter must be placed so that the shunt current through the other diodes is bypassed around the meter. To obtain accurate readings, the voltage drop across the current meter must be less than 10 mV.

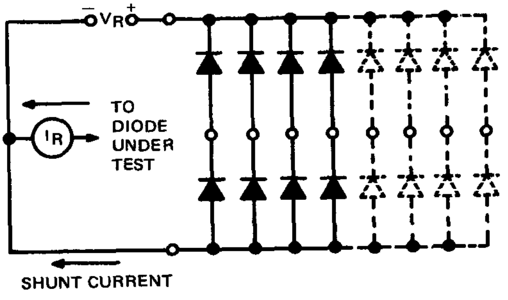


FIGURE 1—TEST CIRCUIT FOR COMMON-CATHODE DIODES

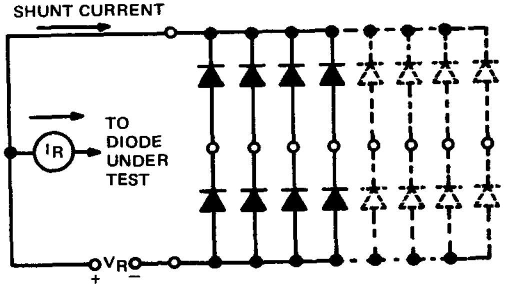
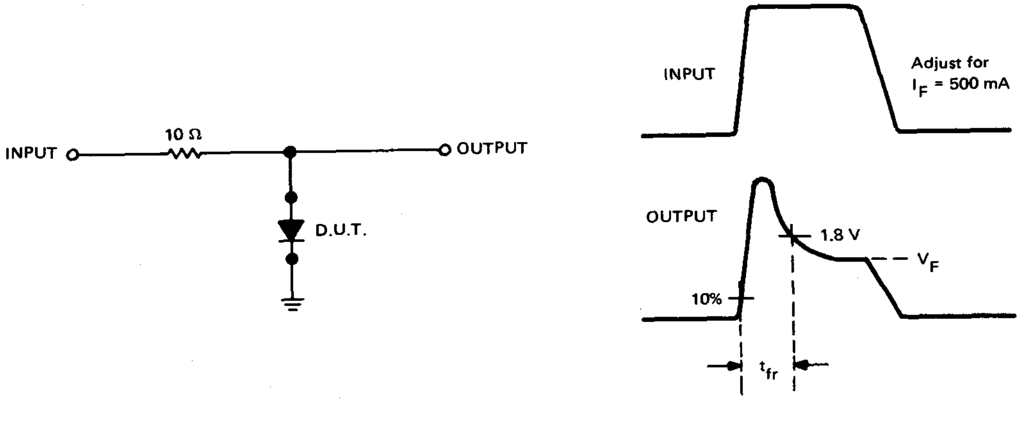


FIGURE 2—TEST CIRCUIT FOR COMMON-ANODE DIODES



TEST CIRCUIT

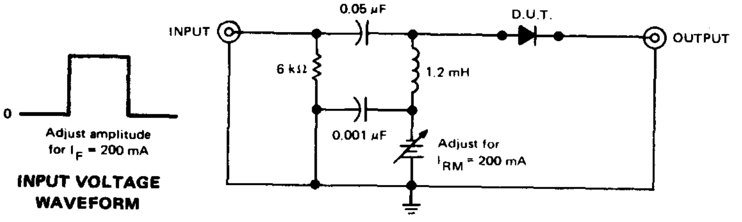
VOLTAGE WAVEFORMS

FIGURE 3—FORWARD RECOVERY TIME

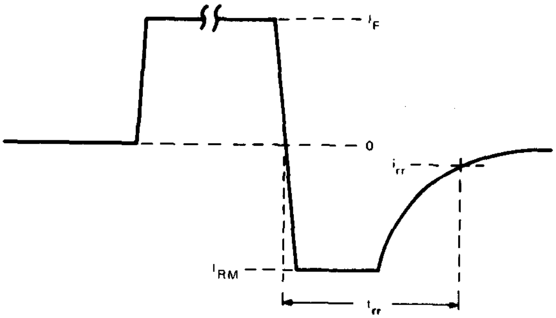
NOTES: a. The input pulse is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 150$ ns, duty cycle $\leq$ 2%.

b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 4.5$ ns, $R_{in} \geq 1\ M\Omega$, $C_{in} \leq 5$ pF.

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



OUTPUT CURRENT WAVEFORM

FIGURE 4—REVERSE RECOVERY TIME

NOTES: c. The input pulse is supplied by a generator with the following characteristics: $t_f \leq 1$ ns, $Z_{out} = 50\ \Omega$, $t_w = 200$ ns, duty cycle $\leq 1\%$.

d. *The output waveform is monitored on an oscilloscope with the following characteristics:* $t_r \leq 0.4$ ns, $R_{in} = 50\ \Omega$.

TYPICAL CHARACTERISTICS

FORWARD CONDUCTION CHARACTERISTICS

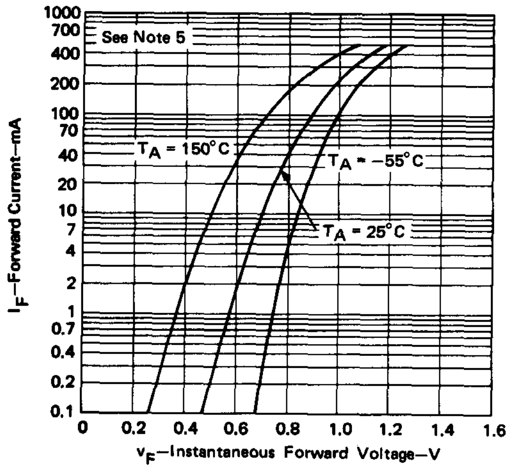


FIGURE 5

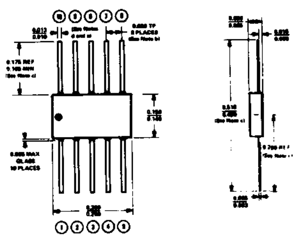
NOTE 5: This parameter is measured using pulse techniques. t_w = 300 μs, duty cycle = 2%. Read time is 90 μs from the leading edge of the pulse.

MECHANICAL DATA

F flat packages

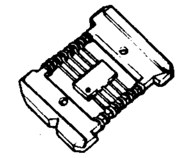
These hermetic packages feature glass-to-metal seals and welded construction in 10-pin and 14-pin configurations. Package body and leads are gold-plated F-15‡ glass-sealing alloy. Approximate weight is 0.1 gram. All external surfaces are metallic. Devices are shipped mounted in a Mech-Pak carrier.

TID21A, TID22A, TID23A, TID24A, TID25A, TID26A

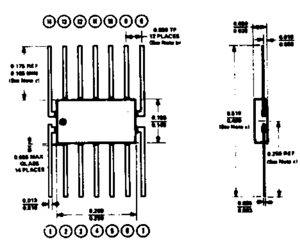


Falls within TO-89 dimensions

NOTES: a. All dimensions in inches.
b. Lead centerlines are located within ±0.005 of their true positions relative to body centerlines. This is measured along lines located within 0.030 from (and parallel to) the sides of the package.
c. Not applicable in Mech-Pak carrier.

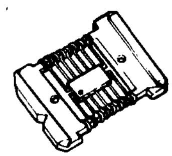


TID29A, TID30A, TID131, TID132



Falls within TO-84 dimensions

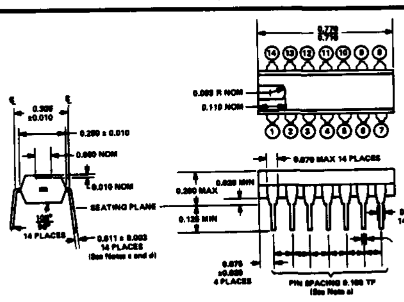
NOTES: a. All dimensions in inches.
b. Lead centerlines are located within ±0.005 of their true positions relative to body centerlines. This is measured along lines located within 0.030 from (and parallel to) the sides of the package.
c. Not applicable in Mech-Pak carrier.



N plastic dual-in-line package

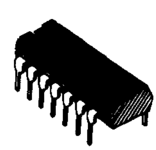
The compound used to mold the dual-in-line package will withstand soldering temperature with no deformation and circuit performance characteristics remain stable when operated in high-humidity conditions. These packages are intended for insertion in mounting-hole rows on 0.300-inch centers. Once the leads are compressed to 0.300-inch separation and inserted, sufficient tension is provided to secure the package in the board during soldering. The silver-plated leads require no additional cleaning or processing when used in soldered assembly.

TID121, TID122, TID123, TID124, TID125, TID126, TID129, TID130, TID133, TID134



NOTES: a. The true-position pin spacing is 0.100 between centerlines. Each pin centerline is located within ±0.010 of its true longitudinal position.
b. All dimensions are in inches unless otherwise noted.

Falls Within JEDEC TO-116 and MO-001AA Dimensions



‡F-15 is the ASTM designation for an iron-nickel-cobalt alloy containing nominally 53% iron, 29% nickel, and 17% cobalt.

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TYPES TID31 THRU TID37
SILICON SWITCHING DIODES

BULLETIN NO. DL-S 738102, OCTOBER 1965—REVISED MARCH 1973

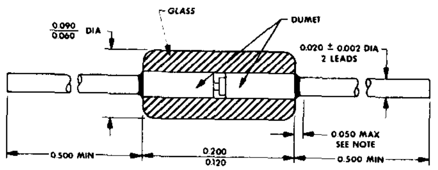
FAST SWITCHING DIODES

- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		TID31	TID32	TID33	TID34	TID35	TID36	TID37	UNIT
$V_{RM(wkg)}$	Working Peak Reverse Voltage from −65°C to 150°C Free-Air Temperature (See Note 1)	50	75	50	75	50	75	50	v
I_O	Average Rectified Forward Current (See Note 1)	150	150	150	150	150	150	150	ma
I_F	Continuous Forward Current	225	225	225	225	225	225	225	ma
$I_{FM(surge)}$	Surge Current, One Second (See Note 2)	500	500	500	500	500	500	500	ma
$T_{A(opr)}$	Operating Free-Air Temperature Range	−65 to 150							°C
T_{stg}	Storage Temperature Range	−65 to 200							°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TID31	TID32	TID33	TID34	TID35	TID36	TID37	UNIT	LIMIT
$V_{(BR)}$	Reverse Breakdown Voltage	I_R = 100 μa	75	100	75	100	75	100	75	v	MIN
I_R	Static Reverse Current	V_R = 75 v		5		5		5		μa	MAX
		V_R = 50 v	0.1	0.1	0.1	0.1	0.1	0.1	0.1	μa	MAX
		V_R = 50 v, T_A = 150°C	100	100	100	100	100	100	100	μa	MAX
V_F	Static Forward Voltage	I_F = 100 ma						1	1	v	MAX
		I_F = 150 ma				1	1			v	MAX
		I_F = 200 ma	1	1	1					v	MAX
C_T	Total Capacitance	V_R = 0, f = 1 Mc	2.5	4	4	4	4	4	4	pf	MAX

switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TID31	TID32	TID33	TID34	TID35	TID36	TID37	UNIT	LIMIT
t_{rr}	Reverse Recovery Time	I_F = 200 ma, I_R = 200 ma, i_{rr} = 20 ma, R_L = 100 Ω	6	10	10	10	10	10	6	nsec	MAX

NOTES: 1. These values may be applied continuously under single-phase, 60-cps, half-sine-wave operation with resistive load. Above 25°C, derate I_O and I_F linearly to 0 at 150°C free-air temperature.
2. These values apply for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.

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TYPES TID38, TID39
SILICON SWITCHING DIODES

BULLETIN NO. DL-S 7011243, OCTOBER 1969–REVISED FEBRUARY 1970

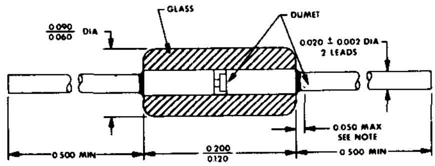
DESIGNED FOR TV APPLICATIONS WHERE HIGH SPEED AND MEDIUM CURRENT AND VOLTAGE ARE REQUIRED

- Horizontal Phase Comparator
- Convergence Circuitry
- AGC Diode
- Video Blocking
- Horizontal Limiting
- Video Clamp

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Peak Reverse Voltage	75 V
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 1)	500 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	250°C

electrical characteristics at 25°C free-air temperature

	PARAMETER	TEST CONDITIONS	TID38		TID39		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	75		75		V
I_R	Static Reverse Current	$V_R = 50$ V		100		100	nA
V_F	Static Forward Voltage	$I_F = 1$ mA	0.5	0.75	0.5	0.75	V
		$I_F = 10$ mA	0.6	0.9	0.6	0.9	
		$I_F = 100$ mA	0.9	1.2	0.9	1.2	
C_T	Total Capacitance	$V_R = 0$, f = 1 MHz		3		5	pF
r_f	Small-Signal Forward Resistance	$I_F = 1$ mA, $I_f = 0.1$ mA, f = 1 kHz		100		100	Ω

switching characteristics at 25°C free-air temperature

	PARAMETER	TEST CONDITIONS	TID38		TID39		UNIT
			MIN	MAX	MIN	MAX	
t_{rr}	Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 10$ mA, $i_{rr} = 1$ mA, $R_L = 100\ \Omega$, See Figure 1		5		20	ns

NOTE: 1. Derate linearly to 200°C at the rate of 2.87 mW/°C.

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PARAMETER MEASUREMENT INFORMATION

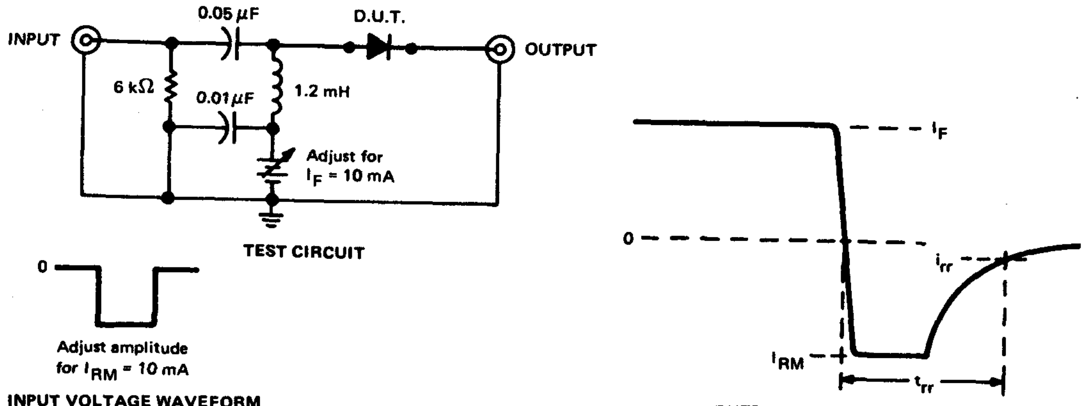

FIGURE 1 – REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq 0.25$ ns, $t_p \geq 200$ ns.
b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.35$ ns, Z_{in} = 50 Ω.

TYPICAL CHARACTERISTICS

STATIC FORWARD CONDUCTION CHARACTERISTICS

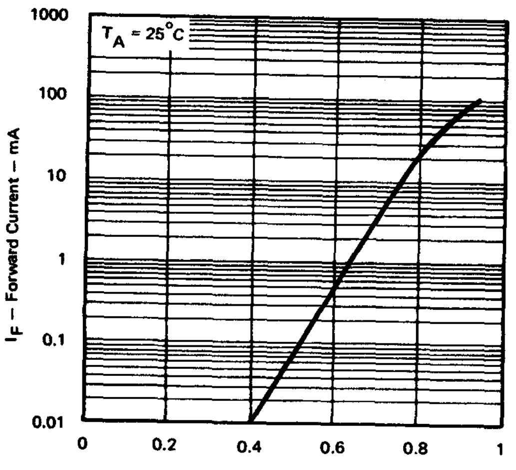

FIGURE 2

TEMPERATURE COEFFICIENT OF STATIC FORWARD VOLTAGE vs FORWARD CURRENT

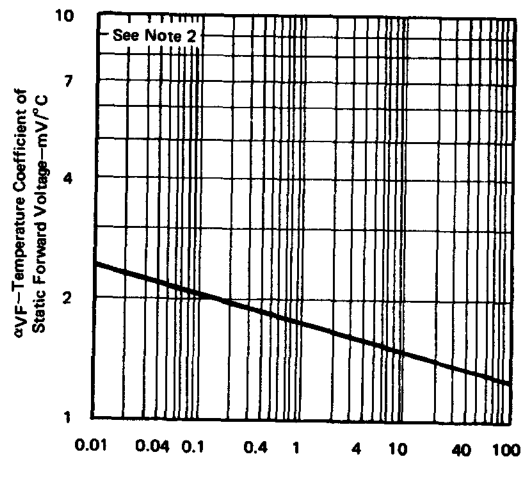

FIGURE 3

NOTE 2: Temperature coefficient, α_{VF}, is determined by the following formula:

$$\alpha_{VF} = \frac{(V_F @ 150°C) - (V_F @ -55°C)}{150°C - (-55°C)}$$

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BULLETIN NO. DL-S 738605, MARCH 1966—REVISED MARCH 1973

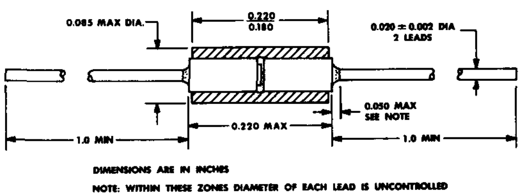
HIGH-VOLTAGE SWITCHING DIODES

- Rugged Double-Plug Construction

mechanical data

Double-plug construction affords integral positive contacts by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

CATHODE END IS DENOTED BY COLOR BAND



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		TID40	TID41	TID42	TID43	TID44	UNIT
V_{RM}	Peak Reverse Voltage	250	200	150	150	100	V
$V_{RM(wkg)}$	Working Peak Reverse Voltage	100					V
I_{FM}	Peak Forward Current at (or below) 25 °C Free-Air Temperature (See Note 1)	225					mA
$I_{FM(surge)}$	Surge Current, One Second (See Note 2)	500					mA
P	Continuous Power Dissipation at (or below) 25 °C Free-Air Temperature (See Note 3)	250					mW
$T_{A(opr)}$	Operating Free-Air Temperature Range	−65 to 150					°C
T_{stg}	Storage Temperature Range	−65 to 200					°C
	Lead Temperature 1/16 Inch from Case for 10 Seconds	250					°C

electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TID40	TID41	TID42	TID43	TID44	UNIT	LIMIT
$V_{(BR)}$ Reverse Breakdown Voltage	$I_R = 100\ \mu A$	250	200	150	150	100	V	MIN
I_R Static Reverse Current	V_R = Rated $V_{RM(wkg)}$	0.1	0.1	0.1	0.1	0.1	μA	MAX
	$V_R = 20\ V$, $T_A = 150°C$	50	50	50	50	50	μA	MAX
V_F Static Forward Voltage	$I_F = 50\ mA$	1					V	MAX
	$I_F = 100\ mA$		1	1			V	MAX
	$I_F = 150\ mA$				1		V	MAX
	$I_F = 200\ mA$					1	V	MAX
C_T Total Capacitance	$V_R = 0$, $f = 1\ MHz$	5	5	5	5	5	pF	MAX

switching characteristics at 25°C free-air temperature

PARAMETER	TEST CONDITIONS	TID40	TID41	TID42	TID43	TID44	UNIT	LIMIT
t_{rr} Reverse Recovery Time	$I_F = 10\ mA$, $I_{RM} = 10\ mA$, $i_{rr} = 1\ mA$, $R_L = 100\ \Omega$	30	30	30	30	30	ns	MAX

NOTES: 1. This value applies for $t_p \leq 8.3$ ms, duty cycle $\leq 50\%$. Above 25°C, derate linearly to 150°C free-air temperature at the rate of 1.8 mA/deg.
2. This value applies for a one-second square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. Derate linearly to 150°C free-air temperature at the rate of 2 mW/deg.

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TYPE TID45
SILICON SWITCHING DIODE

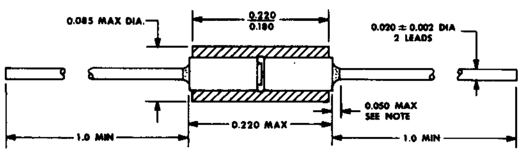
BULLETIN NO. DL-S 7311242, JULY 1969—REVISED MARCH 1973

DESIGNED FOR USE IN VIDEO AND COLOR PROCESSING CIRCUITRY OF TV RECEIVERS WHERE LOW CAPACITANCE AND HIGH BREAKDOWN VOLTAGE ARE REQUIRED

- Color Killer
- Color-Phase Comparator
- AFC
- Gated AGC Amplifier
- Blanking Restorer
- Video Clamp

mechanical data

Double-plug construction affords integral positive contacts by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Peak Reverse Voltage	250 V
Peak Surge Current, One Second (See Note 1)	500 mA
Peak Surge Current, One Microsecond (See Note 1)	2 A
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 2)	250 mW
Storage Temperature Range	−65°C to 200°C
Lead Temperature 1/16 Inch from Case for 2 Seconds	250°C

NOTES: 1. These values apply for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
2. For operation above 25°C free-air temperature, refer to Dissipation Derating Curve, Figure 5.

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electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 0.1$ mA	250		V
I_R	Static Reverse Current	$V_R = 200$ V		2	μA
V_F	Static Forward Voltage	$I_F = 1$ mA	0.55	0.8	V
		$I_F = 50$ mA	0.75	1	
r_f	Small-Signal Forward Resistance	$I_F = 10$ mA, $I_f = 1$ mA, f = 1 kHz		10	Ω
C_T	Total Capacitance	$V_R = 0$, f = 1 MHz	0.5	1.5	pF

operating characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_{rr}	Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 10$ mA, $i_{rr} = 1$ mA, $R_L = 100\,\Omega$, See Figure 1		50	ns
Q_s	Stored Charge	$I_F = 10$ mA, See Figure 2 and Note 3		300	pC

NOTE: 3. Stored charge is measured in accordance with JEDEC Suggested Standard No. 1 (June, 1966), using the test circuit of Figure 2.

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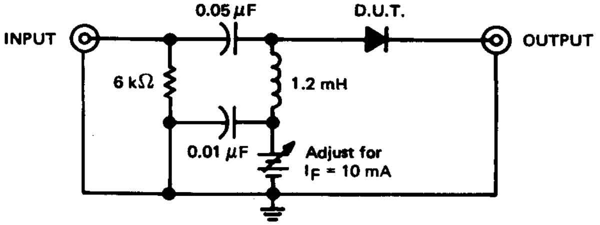
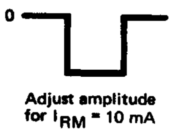
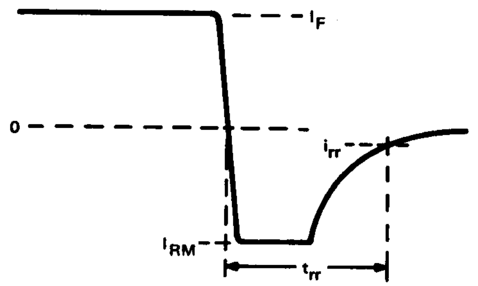
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



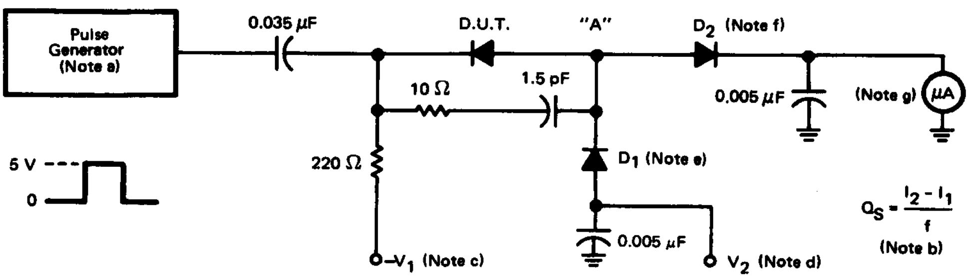
INPUT VOLTAGE WAVEFORM



OUTPUT CURRENT WAVEFORM

NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 50 Ω, $t_r \leq 0.25$ ns, $t_p \geq 500$ ns.
b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.35$ ns, Z_{in} = 50 Ω.

FIGURE 1 – REVERSE RECOVERY TIME



NOTES: a. The input pulse is supplied by a generator with the following characteristics: Z_{out} = 10 Ω, t_r(1% to 50%) ≤ 5 ns, t_p = 50 ns.
b. I_1 is the reading of the meter with zero voltage across the diode under test (hence zero current through the diode under test). I_2 is the reading of the meter when the specified forward current (10 mA) flows.
c. V_1 is adjusted for I_F = 10 mA.
d. V_2 is adjusted so that the voltage between point A and ground is −0.6 V when the diode under test is conducting forward current.
e. The stored charge of diode D_1 is small compared to the stored charge of the diode under test.
f. The reverse recovery time of diode D_2 is short relative to the 50-ns input pulse.
g. The resistance of the current meter is sufficiently low that doubling it does not affect the reading by more than the required accuracy.

FIGURE 2 – STORED CHARGE TEST CIRCUIT

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TYPICAL CHARACTERISTICS

STATIC FORWARD CONDUCTION CHARACTERISTICS

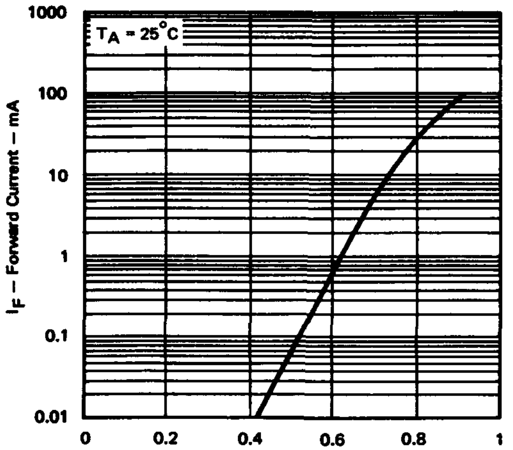

FIGURE 3

TEMPERATURE COEFFICIENT OF STATIC FORWARD VOLTAGE
vs
STATIC FORWARD CURRENT

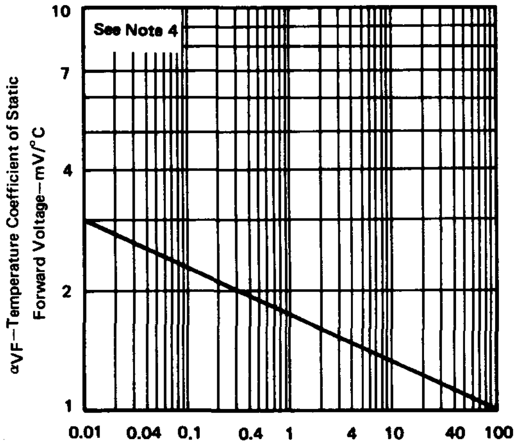

FIGURE 4

THERMAL CHARACTERISTICS

DISSIPATION DERATING CURVE

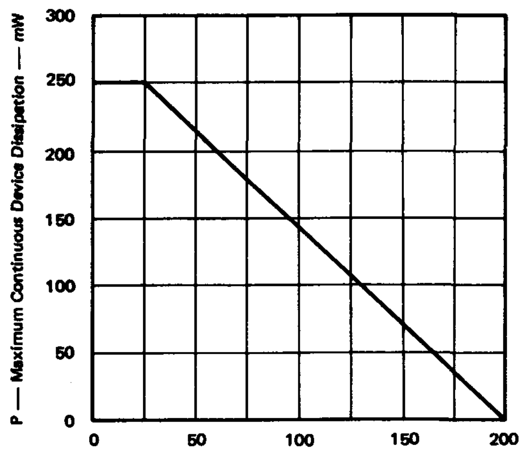

FIGURE 5

NOTE 4: Temperature coefficient, α_{VF}, is determined by the following formula: $\alpha_{VF} = \frac{(V_F \text{ @ } 150°C) - (V_F \text{ @ } -55°C)}{150°C - (-55°C)}$.

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TYPES TID135, TID136, TID139 THRU TID144
SILICON DIODE ARRAYS

BULLETIN NO. DL-S 7311707, APRIL 1972—REVISED MARCH 1973

LOGIC AND CORE-DRIVER DIODE ARRAYS

For Application With

- Magnetic Cores
- Thin-Film Memories
- Plated-Wire Memories
- Decoding or Encoding Applications

For Use In

- Airborne Computers
- Industrial Computers
- Military Computers
- Peripheral Equipment

description

These diode arrays are multiple diode junctions fabricated by a planar process and mounted in integrated circuit packages for use in logic and core-driver applications. These arrays offer many of the advantages of integrated circuits such as high-density packaging and improved reliability. These advantages result from such factors as fewer connections, more uniform device parameters, smaller size, less weight, fewer glass-to-metal seals, and the elimination of pressure contacts and whiskers.

These arrays are available in heremtically sealed welded flat packages (F) or in dual-in-line plastic packages (N).

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

		FLAT PACKAGE			DUAL-IN-LINE PACKAGE			UNIT
		EACH DIODE		TOTAL DEVICE	EACH DIODE		TOTAL DEVICE	
16-DIODE ARRAY 7 INDEPENDENT DIODES DUAL 4-DIODE ARRAY (COMMON CATHODE) DUAL 4-DIODE ARRAY (COMMON ANODE)		TID139F TID141F TID143F	TID140F TID142F TID144F	ALL TYPES	TID135N TID139N TID141N TID143N	TID136N TID140N TID142N TID144N	ALL TYPES	
Peak Reverse Voltage (See Note 1)		60	40		60	40		V
Steady-State Reverse Voltage, V_R		40	20		40	20		V
Continuous Forward Current at (or below) 25°C Free-Air Temperature (See Note 2)		300†			400‡			mA
Peak Forward Current at (or below) 25°C Free-Air Temperature (See Notes 1 and 2)		500§			500¶			mA
Peak Surge Current (See Note 2)	1 s	1			1			A
	1 μs	2			2			A
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature				500◇			600□	mW
Operating Free-Air Temperature Range		−65 to 150			−65 to 125			°C
Storage Temperature Range		−65 to 200			−65 to 150			°C
Lead Temperature 1/16 Inch from Case for 10 Seconds		300			260			°C

NOTES: 1. These values apply for $t_w \leq 100\ \mu s$, duty cycle $\leq 20\%$.
2. These values apply for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.

† Derate linearly to 150°C free-air temperature at the rate of 2.4 mA/°C.
‡ Derate linearly to 125°C free-air temperature at the rate of 4 mA/°C.
§ Derate linearly to 150°C free-air temperature at the rate of 4 mA/°C.
¶ Derate linearly to 125°C free-air temperature at the rate of 5 mA/°C.
◇ Derate linearly to 150°C free-air temperature at the rate of 4 mW/°C.
□ Derate linearly to 125°C free-air temperature at the rate of 6 mW/°C.

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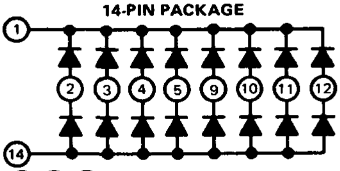
ORDERING INSTRUCTIONS

TID135 and TID136 diode arrays are available in the plastic dual-in-line package (outline N) and TID139 through TID144 diode arrays are available in both the N package and the hermetically sealed metal flat package (outline F). Orders for these arrays should include the package outline letter (F or N) at the end of the type number.

PLASTIC DUAL-IN-LINE PACKAGES

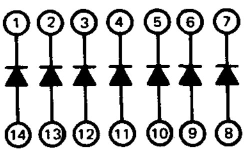
TID135N, TID136N
16-DIODE ARRAY
14-PIN PACKAGE



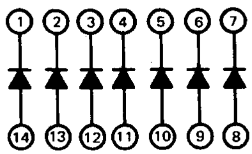
6 7 8 13 No internal connection

METAL FLAT PACKAGES

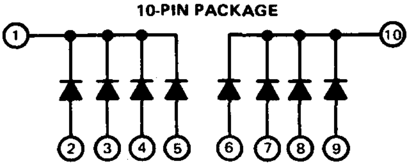
TID139F, TID140F
7 INDEPENDENT DIODES
14-PIN PACKAGE



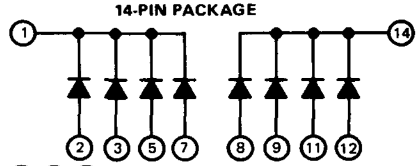
TID139N, TID140N
7 INDEPENDENT DIODES
14-PIN PACKAGE



TID141F, TID142F
DUAL 4-DIODE ARRAY (COMMON CATHODE)
10-PIN PACKAGE

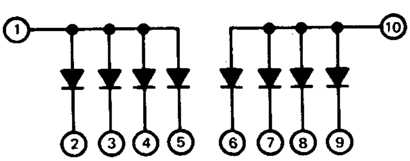


TID141N, TID142N
DUAL 4-DIODE ARRAY (COMMON CATHODE)
14-PIN PACKAGE

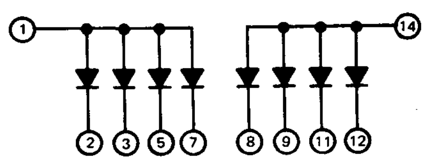


4 6 10 13 No internal connection

TID143F, TID144F
DUAL 4-DIODE ARRAY (COMMON ANODE)
10-PIN PACKAGE



TID143N, TID144N
DUAL 4-DIODE ARRAY (COMMON ANODE)
14-PIN PACKAGE



4 6 10 13 No internal connection

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electrical characteristics at 25°C free-air temperature

single-diode operation (see note 3)

PARAMETER		TEST CONDITIONS		TID139 TID141 MIN	TID139 TID141 MAX	TID140 TID142 MIN	TID140 TID142 MAX	TID135 TID143 MIN	TID135 TID143 MAX	TID136 TID144 MIN	TID136 TID144 MAX	UNIT
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 10\ \mu A$		60		40		60		40		V
I_R	Static Reverse Current	$V_R = 40$ V	See Note 4		100				100			nA
		$V_R = 40$ V, $T_A = 125°C$			100				100			μA
		$V_R = 20$ V					50				50	nA
		$V_R = 20$ V, $T_A = 125°C$					50				50	μA
V_F	Static Forward Voltage	$I_F = 10$ mA					1				1	V
		$I_F = 100$ mA			1		1.3		1		1.3	
v_F	Instantaneous Forward Voltage	$I_F = 500$ mA,	See Note 5		1.3				1.3			V
V_{FM}	Peak Forward Voltage	$I_F = 500$ mA,	See Note 6		5				5			V
C_T	Total Capacitance†	$V_R = 0$,	f = 1 MHz		4		4		8		8	pF

multiple-diode operation

PARAMETER		TEST CONDITIONS	ALL TYPES MIN	ALL TYPES MAX	UNIT
I_R	Static Reverse Current	V_R = rated V_R, See Note 7		10	μA
V_F	Static Forward Voltage	$I_F = 25$ mA, See Note 7		1	V

switching characteristics at 25°C free-air temperature

single-diode operation (see note 3)

PARAMETER		TEST CONDITIONS	TID139 TID141 MIN	TID139 TID141 MAX	TID140 TID142 MIN	TID140 TID142 MAX	TID135 TID143 MIN	TID135 TID143 MAX	TID136 TID144 MIN	TID136 TID144 MAX	UNIT
t_{fr}	Forward Recovery Time	$I_F = 50$ mA, See Figure 3				20				20	ns
		$I_F = 500$ mA, See Figure 3		40				40			
t_{rr}	Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 10$ mA, $R_L = 100\ \Omega$, $i_{rr} = 1$ mA, See Figure 4				6				6	ns
		$I_F = 200$ mA, $I_{RM} = 200$ mA, $R_L = 100\ \Omega$, $i_{rr} = 20$ mA, See Figure 4		20				20			

NOTES: 3. Test conditions and limits apply separately to each of the diodes. The diodes not under test are open-circuited during the measurement of these characteristics except for the measurement of I_R on arrays having both common-cathode and common-anode diodes (see Figures 1 and 2).

4. For arrays having both common-anode and common-cathode diodes see Figures 1 and 2, Parameter Measurement Information section.

5. *This parameter is measured using pulse techniques.* t_w = *300 µs, duty cycle = 2%. Read time is 90 µs from the leading edge of the pulse.*

6. The initial instantaneous value is measured using pulse techniques. t_w = 150 ns, duty cycle ≤ 2%, pulse rise time ≤ 10 ns. The total capacitance shunting the diode is 19 pF maximum and the equipment bandwidth is 80 MHz.

7. These parameters are measured with each of the other diodes in the section simultaneously conducting 25 mA forward current. Each diode is individually tested after the device reaches operating thermal equilibrium. Test conditions apply separately to common-anode and common-cathode sections.

†C_T is the total pin-to-pin capacitance measured across any of the diodes. For arrays having both common-anode and common-cathode sections, the interaction of the other diodes cannot easily be separated out unless three-terminal guarded measurement techniques are used. The actual capacitance of a single isolated diode will typically be 30% of the measured pin-to-pin value for the common-cathode diodes, and 75% of the measured value for the common-anode diodes.

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PARAMETER MEASUREMENT INFORMATION

When measuring the reverse current of an individual diode of a device having both common-anode and common-cathode sections, the current meter must be placed so that the shunt current through the other diodes is bypassed around the meter. To obtain accurate readings, the voltage drop across the current meter must be less than 10 mV.

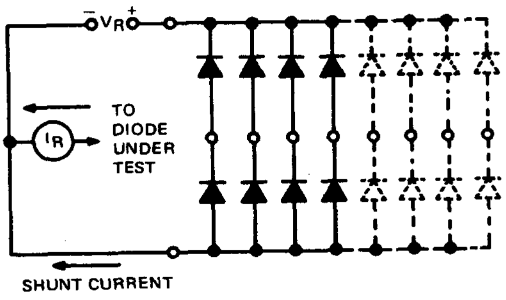


FIGURE 1—TEST CIRCUIT FOR COMMON-CATHODE DIODES

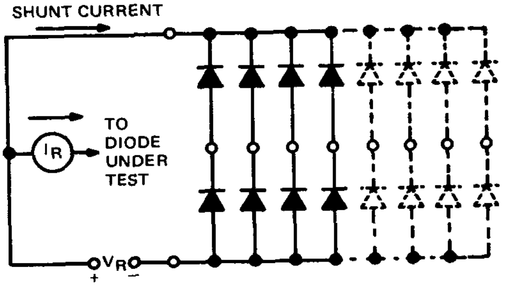
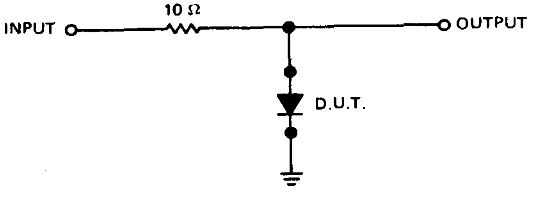
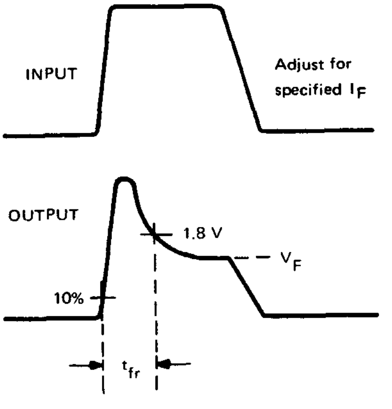


FIGURE 2—TEST CIRCUIT FOR COMMON-ANODE DIODES



TEST CIRCUIT



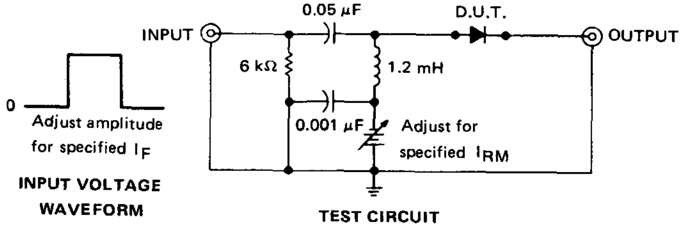
VOLTAGE WAVEFORMS

FIGURE 3—FORWARD RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $t_r \leq 15$ ns, $Z_{out} = 50\ \Omega$, $t_w = 150$ ns, duty cycle $\leq 2\%$.

b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 4.5$ ns, $R_{in} \geq 1\ M\Omega$, $C_{in} \leq 5$ pF.

PARAMETER MEASUREMENT INFORMATION



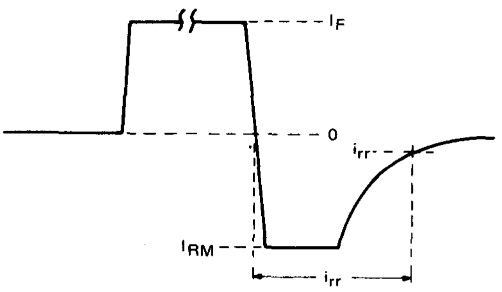


FIGURE 4—REVERSE RECOVERY TIME

NOTES: c. The input pulse is supplied by a generator with the following characteristics: $t_f \leq 1$ ns, $Z_{out} = 50\ \Omega$, $t_w = 200$ ns, duty cycle $\leq 1\%$.

d. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.4$ ns, $R_{in} = 50\ \Omega$.

TYPICAL CHARACTERISTICS

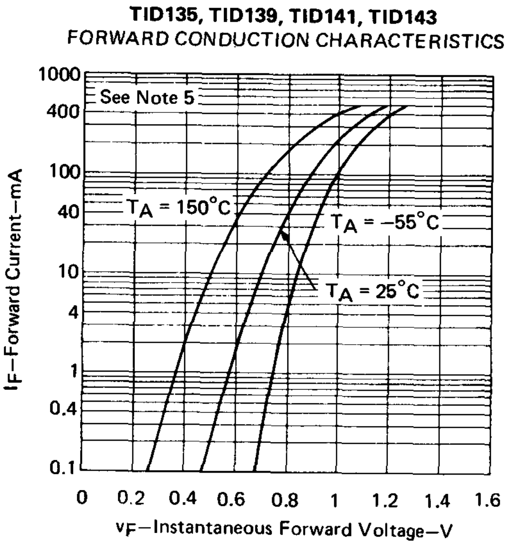


FIGURE 5

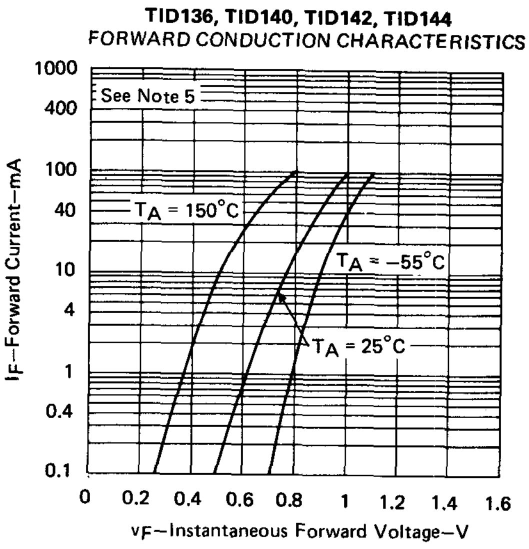


FIGURE 6

NOTE 5: This parameter is measured using pulse techniques. t_w = 300 μs, duty cycle = 2%. Read time is 90 μs from the leading edge of the pulse.

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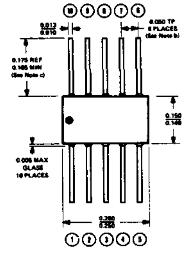
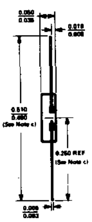
MECHANICAL DATA

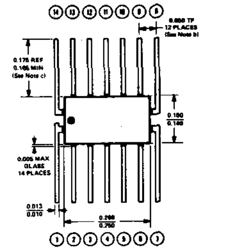
F flat packages

These hermetic packages feature glass-to-metal seals and welded construction in 10-pin and 14-pin configurations. Package body and leads are gold-plated F-15‡ glass-sealing alloy. Approximate weight is 0.1 gram. All external surfaces are metallic. Devices are shipped mounted in a Mech-Pak carrier.

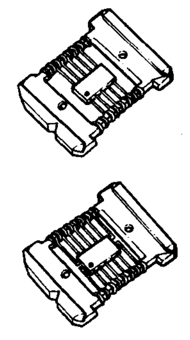


Falls within TO-89 dimensions





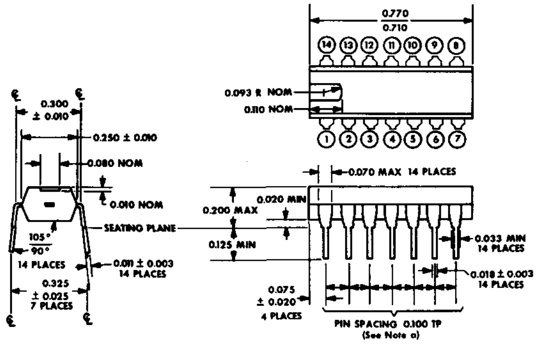
Falls within TO-84 dimensions

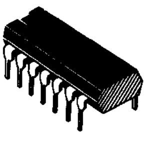


NOTES: a. All dimensions in inches.
b. Lead centerlines are located within ±0.005 of their true positions relative to body centerlines. This is measured along lines located within 0.030 from (and parallel to) the sides of the package.
c. Not applicable in Mech-Pak carrier

N plastic dual-in-line packages

The compound used to mold the dual-in-line packages will withstand soldering temperature with no deformation and circuit performance characteristics remain stable when operated in high-humidity conditions. These packages are intended for insertion in mounting-hole rows on 0.300-inch centers. Once the leads are compressed to 0.300-inch separation and inserted, sufficient tension is provided to secure the package in the board during soldering. The silver-plated leads require no additional cleaning or processing when used in soldered assembly.





Falls Within JEDEC TO-116 and MO-001AA Dimensions

NOTES: a. The true-position pin spacing is 0.100 between centerlines. Each pin centerline is located within ±0.010 of its true longitudinal position.
b. All dimensions are in inches unless otherwise noted.

‡F-15 is the ASTM designation for an iron-nickel-cobalt alloy containing nominally 53% iron, 29% nickel, and 17% cobalt.

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TYPES TID381 THRU TID385
SILICON RECTIFIERS

BULLETIN NO. DL-S 7311963, MARCH 1973

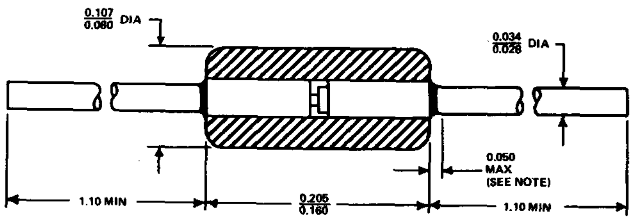
50-600 VOLTS • 1 AMP AVERAGE

- **Rugged Double-plug Construction**
- **Hermetic Case**
- **50-Amp Surge Rating**
- **TID383 thru TID385 Electrically Similar to 1N4383 thru 1N4385 (DO-29)**

description and mechanical data

These one-amp rectifier diodes are the product of combining the best of both silicon material processing and packaging technologies. The silicon die is a mesa oxide-passivated structure which has additional nitride passivation and glass passivation over the junction. Years of volume production have shown the double-plug package to have the highest inherent mechanical integrity of all hermetic-case diodes. Hot-solder-dipped leads are standard.

ALL JEDEC DO-41 DIMENSIONS AND NOTES ARE APPLICABLE



ALL DIMENSIONS ARE IN INCHES

NOTE: Within this zone lead diameter is uncontrolled.

CATHODE END IS DENOTED BY A COLOR BAND

*absolute maximum ratings at specified ambient† temperature (unless otherwise noted)

		TID381	TID382	TID383	TID384	TID385	UNIT
V_{RM}	Peak Reverse Voltage from −65°C to 175°C (See Note 1)	50	100	200	400	600	V
V_R	Steady State Reverse Voltage from 25°C to 75°C	50	100	200	400	600	V
I_O	Average Rectified Forward Current from 25°C to 100°C (See Note 1 and 2)			1			A
I_{FSM}	Peak Surge Current, One Cycle, at (or below) 100°C (See Note 3)			50			A
$T_{A(opr)}$	Operating Ambient Temperature Range			−65 to 175			°C
T_{stg}	Storage Temperature Range			−65 to 200			°C
	Lead Temperature 3/8 Inch from Case for 10 Seconds			300			°C

NOTES: 1. These values may be applied continuously under single-phase, 60-Hz, half-sine-wave operation with resistive load. Above 100°C derate I_O according to Figure 1.

2. This rectifier is a lead-conduction-cooled device. At (or above) ambient temperatures of 100°C, the lead temperature 3/8 inch from case must be no higher than 5°C above the ambient temperature for these ratings to apply.

3. These values apply for 60-Hz half sine waves when the device is operating at (or below) rated values of peak reverse voltage and average rectified forward current. Surge may be repeated after the device has returned to original thermal equilibrium.

†The ambient temperature is measured at a point 2 inches below the device. Natural air cooling is used.

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electrical characteristics at specified ambient† temperature

PARAMETER		TEST CONDITIONS		MAX	UNIT
I_R	Static Reverse Current	V_R = Rated V_R,	T_A = 25°C	10	μA
		V_R = Rated V_R,	T_A = 150°C	250	
$I_{R(av)}$	Average Reverse Current	V_{RM} = Rated V_{RM}, f = 60 Hz,	I_O = 1 A, T_A = 100°C	225	μA
V_F	Static Forward Voltage	I_F = 1 A,	T_A = 25°C to 100°C	1.1	V
V_{FM}	Peak Forward Voltage	V_{RM} = Rated V_{RM}, f = 60 Hz,	I_O = 1 A, T_A = 100°C	1.3	V

THERMAL INFORMATION

FORWARD CURRENT DERATING CURVE

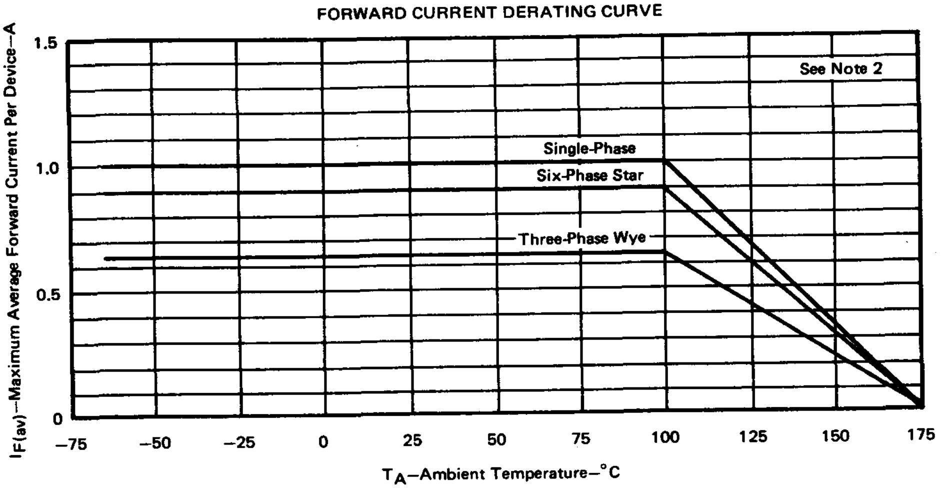


FIGURE 1

NOTE 2: This rectifier is a lead-conduction-cooled device. At (or above) ambient temperatures of 100°C, the lead temperature 3/8 inch from case must be no higher than 5°C above the ambient temperature for these ratings to apply.

†The ambient temperature is measured at a point 2 inches below the device. Natural air cooling is used.

BULLETIN NO. DL-S 7311745, JANUARY 1973

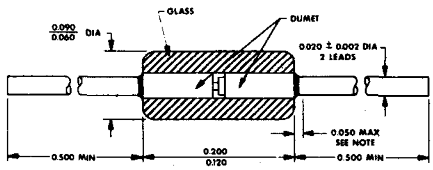
VERY-HIGH-SPEED SWITCHING DIODES

- Pico-Second Switching Times
- Small-Size, Double-Plug Construction
- Very Low Junction Capacitance

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

	TID777	TID778	UNIT
Working Peak Reverse Voltage	10	20	V
Average Rectified Current (See Note 1)	50		mA
Peak Surge Current, One Second (See Note 2)	250		mA
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Note 3)	250		mW
Storage Temperature Range	−65 to 175		°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260		°C

NOTES:
1. This value may be applied continuously under single-phase 60-Hz half-sine-wave operation with resistive load.
2. This value applies for the specified square-wave pulse with the device at nonoperating thermal equilibrium immediately prior to the surge.
3. Derate linearly to 150°C free-air temperature at the rate of 2 mW/°C.

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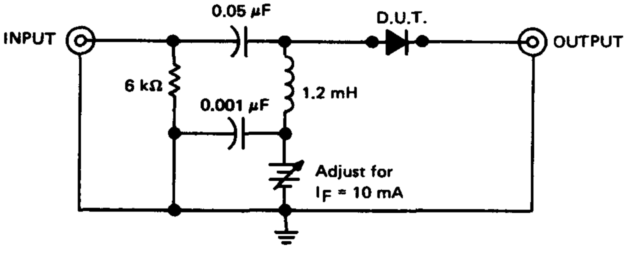
electrical characteristics at 25°C free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	TID777 MIN	TID777 MAX	TID778 MIN	TID778 MAX	UNIT
$V_{(BR)}$	Breakdown Voltage	$I_R = 5\ \mu A$	20		30		V
I_R	Static Reverse Current	$V_R = 20\ V$				0.1	μA
		$V_R = 20\ V$, $T_A = 150°C$				100	
		$V_R = 10\ V$		0.1			
		$V_R = 10\ V$, $T_A = 150°C$		50			
V_F	Static Forward Voltage	$I_F = 10\ \mu A$	0.42	0.53	0.42	0.53	V
		$I_F = 0.1\ mA$	0.52	0.64	0.52	0.64	
		$I_F = 1\ mA$	0.64	0.79	0.64	0.79	
		$I_F = 10\ mA$	0.76	0.94	0.76	0.94	
		$I_F = 20\ mA$	0.81	1	0.81	1	
		$I_F = 50\ mA$	0.89	1.35	0.89	1.35	
C_T	Total Capacitance	$V_R = 0$, $f = 1\ MHz$		1.3		1	pF

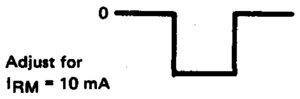
switching characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	BOTH TYPES MAX	UNIT
t_{rr}	Maximum Reverse Recovery Time	$I_F = 10\ mA$, $I_{RM} = 10\ mA$, $i_{rr} = 1\ mA$, $R_L = 100\ \Omega$, See Figure 1	750	ps

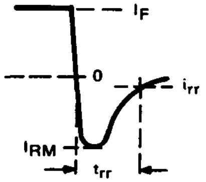
PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT



INPUT VOLTAGE WAVEFORM



OUTPUT CURRENT WAVEFORM

FIGURE 1—REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $t_r \leq 0.25$ ns, $Z_{out} = 50\ \Omega$, $t_w = 100$ ns, duty cycle $\leq 1\%$.

b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.4$ ns, $R_{in} = 50\ \Omega$.

TEXAS INSTRUMENTS
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SERIES TIDM100, TIDM200
SILICON DIODE MATRICES

BULLETIN NO. DL-S 7311434, JANUARY 1971–REVISED MARCH 1973

MONOLITHIC DIODE MATRICES

For Application As

- **Programmable Read-Only Memories**
- **Alphanumeric Character Generators**
- **Frequency Generators**
- **Logic Interface Circuits**

For Use In

- **CRT Displays**
- **Minicomputers**
- **Peripheral Equipment**
- **Solid-State Memories**

description

These monolithic dielectrically isolated diode matrices are fabricated using epitaxial techniques. The desired matrix patterns are programmed by selectively opening the fusible link in series with each diode. This may be done by the user by following the fusing procedure described herein, or custom-programmed matrices may be ordered by sending in a schematic diagram with circles around the diodes to be deleted. Automatic equipment at Texas Instruments can provide instantaneous code-pattern customizing of devices. Only unprogrammed matrices will be symbolized with the type numbers shown in the table below. Circuits custom-programmed to a particular pattern will be assigned a special device number by Texas Instruments, and this number will appear on the device.

Both the high-speed Series TIDM100 and medium-speed Series TIDM200 matrices are available in hermetically sealed metal flat packages (F) or ceramic dual-in-line packages (J).

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

5 X 5 MATRICES 6 X 6 MATRICES 6 X 8 MATRICES 8 X 5 MATRICES 8 X 6 MATRICES	TIDM155 TIDM166 TIDM168 TIDM185 TIDM186	TIDM255 TIDM266 TIDM268 TIDM285 TIDM286	UNIT
Peak Reverse Voltage (See Note 1)	45	35	V
Steady-State Reverse Voltage, V_R	25		V
Peak Forward Current per Diode at (or below) 25°C Free-Air Temperature (See Note 1)	100		mA
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (See Notes 2 and 3)	400		mW
Operating Free-Air Temperature Range	−65 to 150		°C
Storage Temperature Range	−65 to 200		°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	300		°C

NOTES: 1. These values apply for 100-μs pulses, duty cycle ≤ 20%.
2. The values shown for total device apply for any combination provided the ratings of individual diodes are not exceeded.
3. Derate linearly to 150°C free-air temperature at the rate of 3.2 mW/°C.

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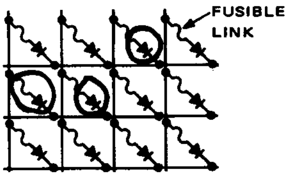
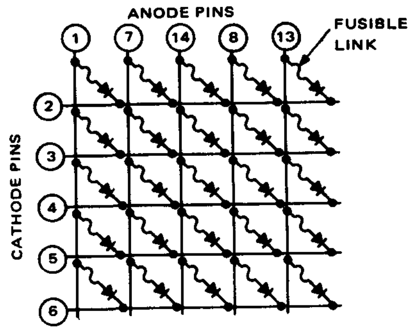
CUSTOMIZED CIRCUITS

To order custom programmed circuits, circle the diodes to be elimated in the appropriate schematic as shown in the example below.

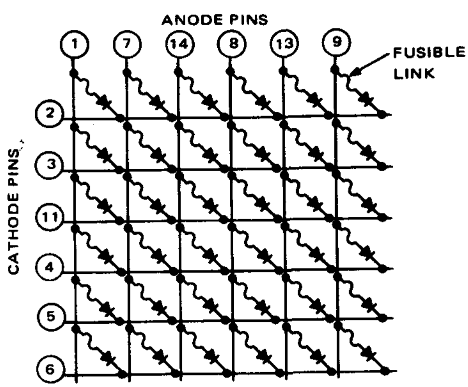


TIDM155, TIDM255 5 X 5 MATRICES



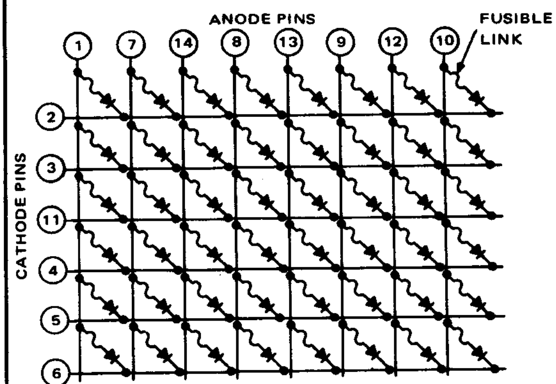
9 10 11 12 Make no external connection

TIDM166, TIDM266 6 X 6 MATRICES

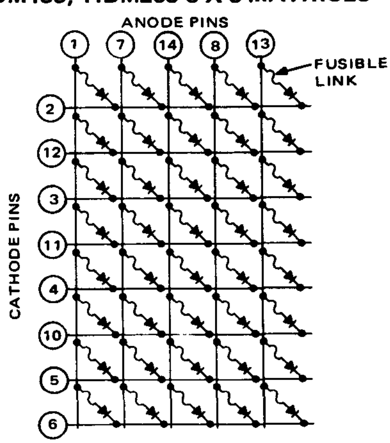


10 12 Make no external connection

TIDM168, TIDM268 6 X 8 MATRICES

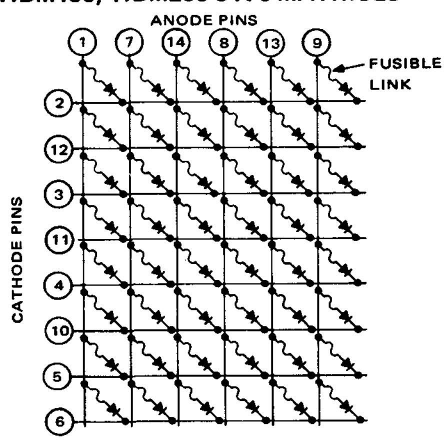


TIDM185, TIDM285 8 X 5 MATRICES



9 Make no external connection

TIDM186, TIDM286 8 X 6 MATRICES



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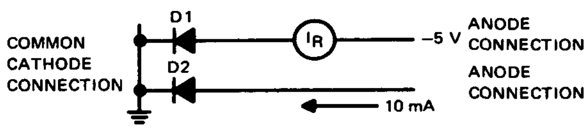
electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	SERIES TIDM100			SERIES TIDM200			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{(BR)}$	Reverse Breakdown Voltage	$I_R = 100\ \mu A$	45			35			V
I_R	Static Reverse Current	$V_R = 25$ V			20			50	nA
I_R	Static Reverse Current (with Adjacent Diode Conducting)	See Figure 1		20			50		nA
V_F	Static Forward Voltage	$I_F = 1$ mA			0.8			0.9	V
		$I_F = 20$ mA			1.5			1.7	
C_T	Total Capacitance between Any Anode Terminal and Any Cathode Terminal	$V_R = 5$ V, f = 1 MHz			4			4	pF

switching characteristics at 25°C free-air temperature

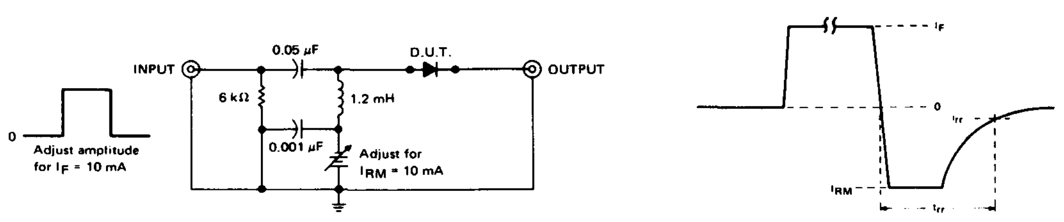
PARAMETER		TEST CONDITIONS	SERIES TIDM100			SERIES TIDM200			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
t_{rr}	Reverse Recovery Time	$I_F = 10$ mA, $I_{RM} = 10$ mA, $R_L = 100\ \Omega$, $i_{rr} = 1$ mA, See Figure 2			10			25	ns

PARAMETER MEASUREMENT INFORMATION



NOTE: D1 and D2 are any two adjacent diodes with a common cathode connection.

FIGURE 1



INPUT VOLTAGE WAVEFORM **TEST CIRCUIT** **OUTPUT CURRENT WAVEFORM**

FIGURE 2—REVERSE RECOVERY TIME

NOTES: a. The input pulse is supplied by a generator with the following characteristics: $t_f \leq 1$ ns, $Z_{out} = 50\ \Omega$, $t_w = 200$ ns, duty cycle $\leq 1\%$.
b. The output waveform is monitored on an oscilloscope with the following characteristics: $t_r \leq 0.4$ ns, $R_{in} = 50\ \Omega$.

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FUSING PROCEDURE

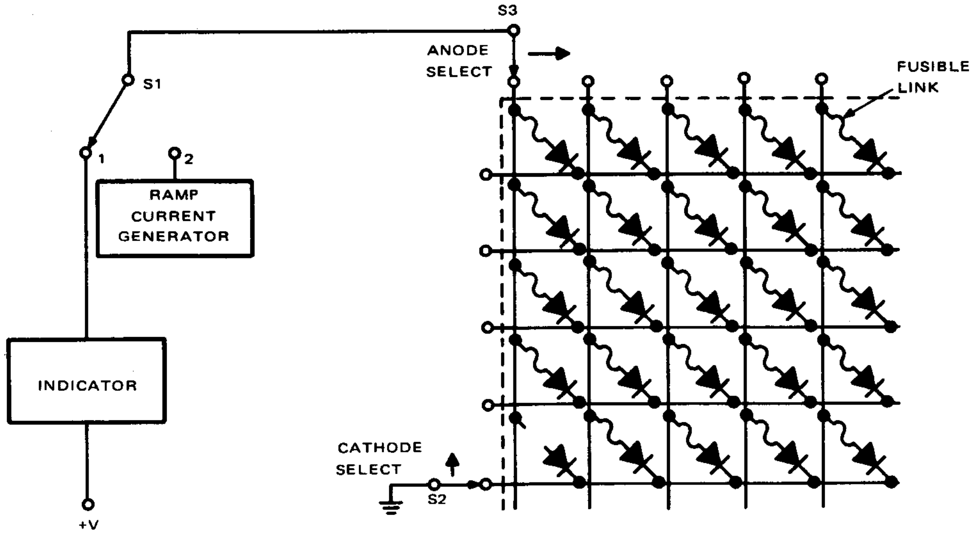

FIGURE 3

A ramp current generator provides the fusing current. The diode to be eliminated is selected by setting switches S2 and S3. When S1 is activated to position 2, current through the fusible link opens the link in series with the selected diode. The peak fusing current required to open a fusible link is approximately 750 milliamperes. Switch S1 in position 1 gives a visual indication of the condition of the selected diode before and after fusing.

TYPICAL CHARACTERISTICS

REVERSE CURRENT vs FREE-AIR TEMPERATURE

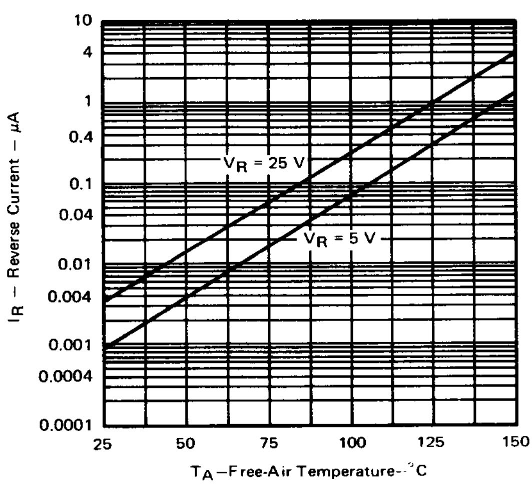

FIGURE 4

FORWARD CONDUCTION CHARACTERISTICS

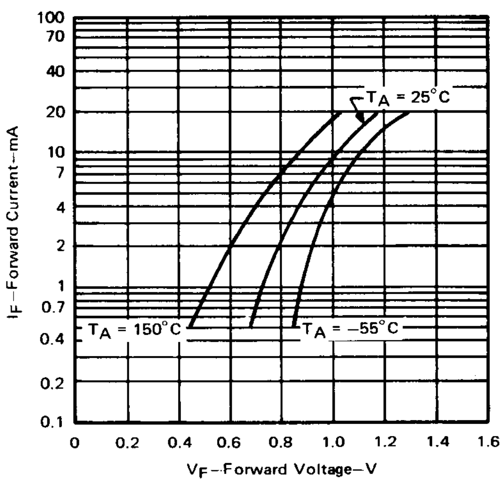

FIGURE 5

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SERIES TIDM100, TIDM200
SILICON DIODE MATRICES

ORDERING INSTRUCTIONS AND MECHANICAL DATA

general

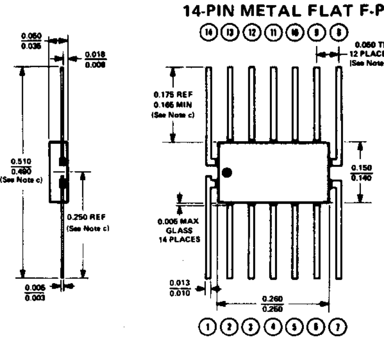
Series TIDM100 and Series TIDM200 diode matrices are available in the hermetically sealed metal flat package (outline F) or the ceramic dual-in-line package (outline J). Orders for these circuits should include the package outline letter (F or J) at the end of the circuit type number.

Examples: TIDM155F, TIDM268J

F package

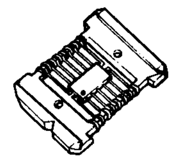
This hermetic package features glass-to-metal seals and welded construction. Package body and leads are gold-plated F-15‡ glass-sealing alloy. Approximate weight is 0.1 gram. All external surfaces are metallic. Devices are shipped mounted in a Mech-Pak carrier.

14-PIN METAL FLAT F-PACKAGE OUTLINE



NOTES: a. All dimensions in inches.
b. Lead centerlines are located within ±0.005 of their true positions relative to body centerlines. This is measured along lines located within 0.030 from (and parallel to) the sides of the package.
c. Not applicable in Mech Pak carrier

FALLS WITHIN TO-84 DIMENSIONS

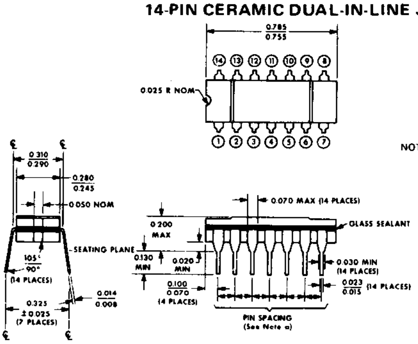


THE DIODE MATRIX IS DIELECTRICALLY ISOLATED FROM THE CASE

J package

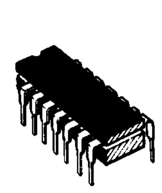
This hermetically sealed, dual-in-line package consists of a ceramic base, ceramic cap, and 14-lead frame. The circuit bar is alloy-mounted to the base and hermetic sealing is accomplished with glass. This package is intended for insertion in mounting-hole rows on 0.300-inch centers. Once the leads are compressed to 0.300-inch separation and inserted, sufficient tension is provided to secure the package in the board during soldering. Tin-plated ("bright-dipped") leads require no additional cleaning or processing when used in soldered assembly.

14-PIN CERAMIC DUAL-IN-LINE J-PACKAGE OUTLINE



NOTES: a. The true-position pin spacing is 0.100 between center lines. Each pin centerline is located within 0.010 of its true longitudinal position relative to pins 4 and 11.
b. All dimensions are in inches unless otherwise noted.

FALLS WITHIN JEDEC TO-116 AND MO-001AA DIMENSIONS



‡F-15 is the ASTM designation for an iron-nickel-cobalt alloy containing nominally 53% iron, 29% nickel, and 17% cobalt.

SILICON VOLTAGE-VARIABLE-CAPACITANCE DIODES

BULLETIN NO. DL-S 7211742, JUNE 1972

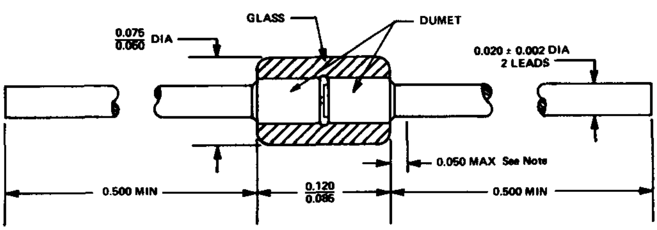
UHF TUNING DIODES

- Small Size, Double-Plug Construction
- Extremely Stable and Reliable
- Available in Matched Sets†

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

ALL JEDEC DO-34 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Peak Reverse Voltage . . . . 30 V
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (see Note 1) . . . . 250 mW
Storage Temperature Range . . . . −65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds . . . . 260°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIV21		TIV22		TIV23		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
$V_{(BR)}$	Breakdown Voltage	$I_R = 10\ \mu A$	30		30		30		V
I_R	Reverse Current	$V_R = 25$ V		100		100		100	nA
C_t	Total Capacitance	$V_R = 3$ V, f = 1 MHz	9	14	9	14	9	14	pF
		$V_R = 25$ V, f = 1 MHz	2	2.5	2.3	2.8	1.8	2.8	
Q	Figure of Merit (See Note 2)	$V_R = 3$ V, f = 100 MHz	150		150		100		
$\frac{C_{t1}}{C_{t2}}$	Capacitance Ratio	$V_1 = 3$ V, $V_2 = 25$ V, f = 1 MHz	4.5	6	4	5	4	6	

†The capacitance of diodes in matched sets is matched at all voltages between 3 and 25 volts to within 1.5 % or 0.1 pF, whichever is greater. For ordering matched sets, add dash number to basic part number to indicate the quantity of diodes in the set. For example, TIV21-4 indicates a matched set of 4 diodes.

NOTES: 1. Derate linearly to 150°C at the rate of 2 mW/°C.
2. Figure of Merit, Q, is defined by the equation $Q = \frac{1}{2\pi f\ C_t\ r_s}$ where r_s is the equivalent series resistance.

10

TYPICAL CHARACTERISTICS

REVERSE CURRENT
vs
FREE-AIR TEMPERATURE

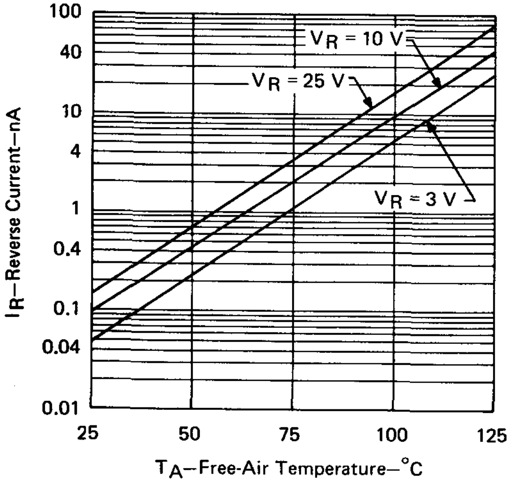


FIGURE 1

FIGURE OF MERIT (Q)
vs
FREQUENCY

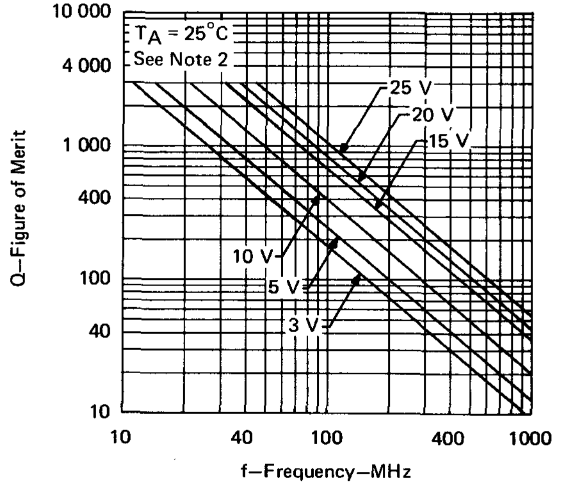


FIGURE 2

NORMALIZED TOTAL CAPACITANCE
vs
FREE-AIR TEMPERATURE

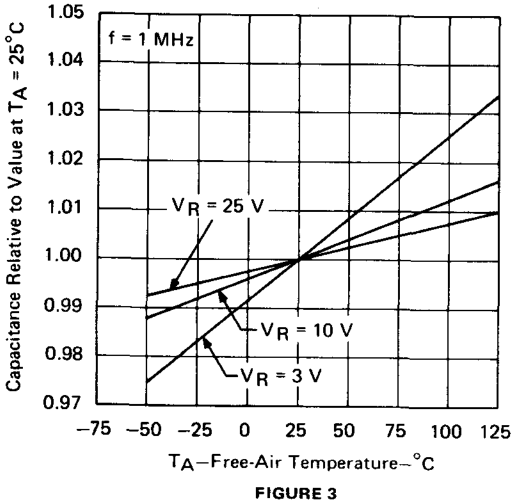


FIGURE 3

AVERAGE TEMPERATURE COEFFICIENT
OF CAPACITANCE
vs
REVERSE VOLTAGE

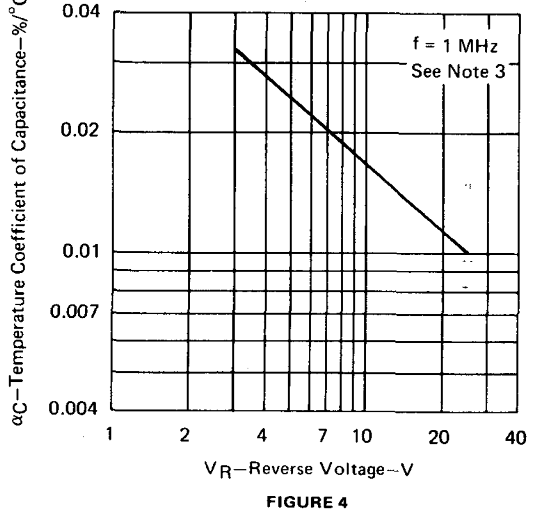


FIGURE 4

NOTES: 2. Figure of Merit, Q, is defined by the equation $Q = \frac{1}{2 \pi f \, C_t \, r_s}$ where r_s is the equivalent series resistance.

3. Average temperature coefficient, α_C, is determined by the formula: $\alpha_C = \left[\frac{(C_t \text{ @ } 125°C) - (C_t \text{ @ } -50°C)}{C_t \text{ @ } 25°C}\right] \frac{100\%}{175°C}$

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INCORPORATED
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BULLETIN NO. DL-S 7211743, JUNE 1972

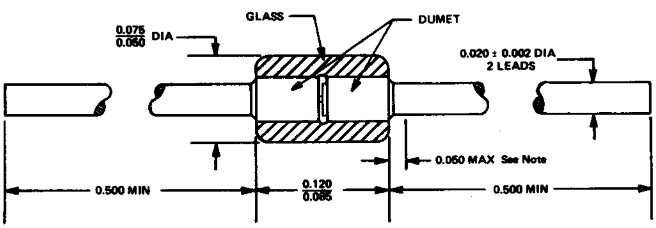
VHF TUNING DIODES

- **Small Size, Double-Plug Construction**
- **Extremely Stable and Reliable**
- **Available in Matched Sets†**

mechanical data

Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

ALL JEDEC DO-34 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND

absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Peak Reverse Voltage	30 V
Continuous Power Dissipation at (or below) 25°C Free-Air Temperature (see Note 1)	250 mW
Storage Temperature Range	−65°C to 150°C
Lead Temperature 1/16 Inch from Case for 10 Seconds	260°C

electrical characteristics at 25°C free-air temperature

PARAMETER		TEST CONDITIONS	TIV24		TIV25		UNIT
			MIN	MAX	MIN	MAX	
$V_{(BR)}$	Breakdown Voltage	$I_R = 10\ \mu A$	30		30		V
I_R	Reverse Current	$V_R = 25$ V		100		100	nA
C_t	Total Capacitance	$V_R = 3$ V, f = 1 MHz	22	34	23	34	pF
		$V_R = 25$ V, f = 1 MHz	5.2	7.5	4.2	6.5	
Q	Figure of Merit (See Note 2)	$V_R = 3$ V, f = 100 MHz	80		80		
$\frac{C_{t1}}{C_{t2}}$	Capacitance Ratio	$V_1 = 3$ V, $V_2 = 25$ V, f = 1 MHz	3.5	6	4.5	6	

†The capacitance of diodes in matched sets is matched at all voltages between 3 and 25 volts to within 1.5 % or 0.1 pF, whichever is greater. For ordering matched sets, add dash number to basic part number to indicate the quantity of diodes in the set. For example, TIV24-4 indicates a matched set of 4 diodes.

NOTES: 1. Derate linearly to 150°C at the rate of 2 mW/°C.

2. Figure of Merit, Q, is defined by the equation $Q = \frac{1}{2\pi f C_t r_s}$ where r_s is the equivalent series resistance.

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TYPICAL CHARACTERISTICS

REVERSE CURRENT
vs
FREE-AIR TEMPERATURE

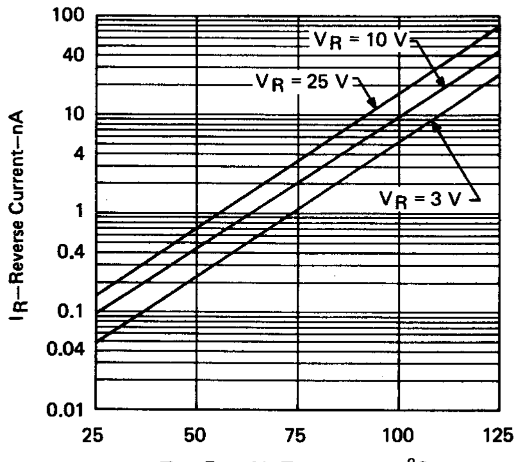

FIGURE 1

FIGURE OF MERIT (Q)
vs
FREQUENCY

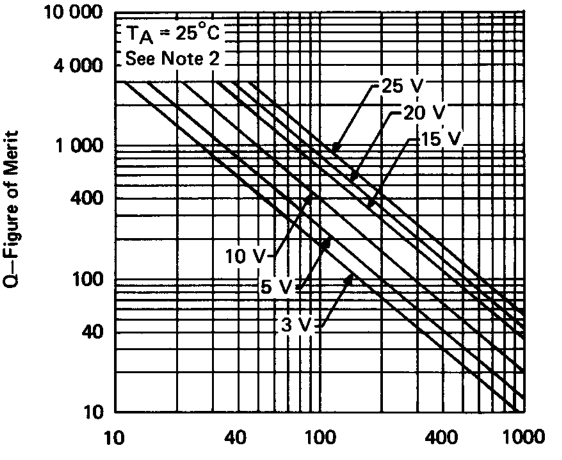

FIGURE 2

NORMALIZED TOTAL CAPACITANCE
vs
FREE-AIR TEMPERATURE

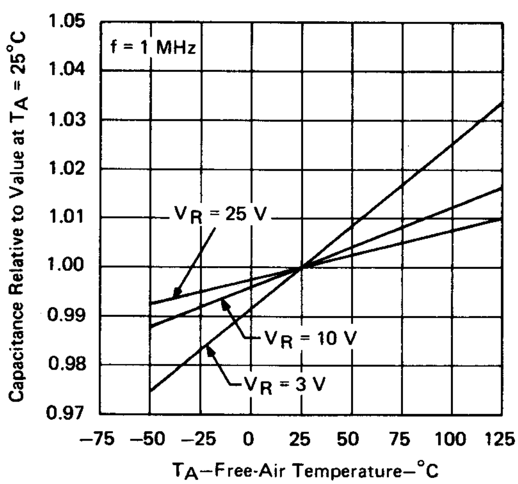

FIGURE 3

AVERAGE TEMPERATURE COEFFICIENT
OF CAPACITANCE
vs
REVERSE VOLTAGE

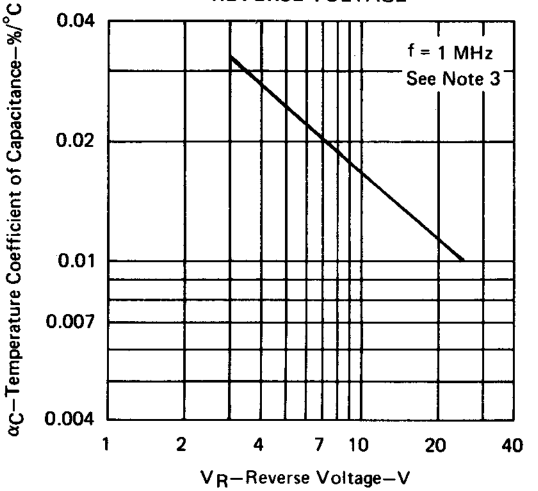

FIGURE 4

NOTES: 2. Figure of Merit, Q, is defined by the equation $Q = \dfrac{1}{2\pi f\, C_t\, r_s}$ where r_s is the equivalent series resistance.

3. Average temperature coefficient, α_C, is determined by the formula: $\alpha_C = \left[\dfrac{(C_t\ @\ 125°C) - (C_t\ @\ -50°C)}{C_t\ @\ 25°C}\right] \dfrac{100\%}{175°C}$

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SILICON VOLTAGE-VARIABLE-CAPACITANCE DIODES

BULLETIN NO. DL-S 6810196, MAY 1968

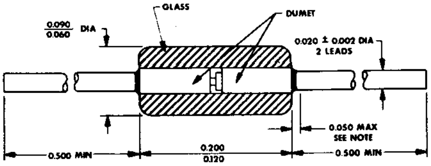
AFC TUNING DIODES
(Replaces TIV300 and TIV301)

- Small Size, Double-Plug Construction
- Extremely Stable and Reliable

mechanical data

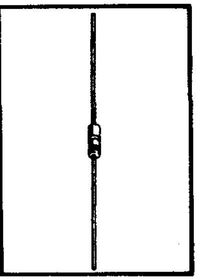
Double-plug construction affords integral positive contact by means of a thermal compression bond. Moisture-free stability is ensured through hermetic sealing. The coefficients of thermal expansion of the glass case and the dumet plugs are closely matched to allow extreme temperature excursions. Hot-solder-dipped leads are standard.

ALL JEDEC DO-35 DIMENSIONS AND NOTES ARE APPLICABLE



DIMENSIONS ARE IN INCHES
NOTE: WITHIN THIS ZONE DIAMETER OF EACH LEAD IS UNCONTROLLED

CATHODE END IS DENOTED BY COLOR BAND



absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)

Peak Reverse Voltage . . . . 20 V
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature (See Note 1) . . . . 250 mW
Operating Free-Air Temperature Range . . . . −65°C to 150°C
Storage Temperature Range . . . . −65°C to 200°C

electrical characteristics at 25°C free-air temperature

	PARAMETER	TEST CONDITIONS	TIV306 MIN	TIV306 MAX	TIV307 MIN	TIV307 MAX	TIV308 MIN	TIV308 MAX	UNIT
$V_{(BR)}$	Breakdown Voltage	$I_R = 100\ \mu A$	20		20		20		V
I_R	Reverse Current	$V_R = 15\ V$		50		50		50	nA
C_t	Total Capacitance	$V_R = 4\ V,\ f = 1\ MHz$	5	9	7	11	9	14	pF
Q	Figure of Merit (Note 2)	$V_R = 4\ V,\ f = 50\ MHz$	200		200		200		
$\frac{C_{t1}}{C_{t2}}$	Capacitance Ratio	$V_1 = 1\ V,\ V_2 = 12\ V,\ f = 1\ MHz$	2.2		2.3		2.4		

NOTES: 1. Derate linearly to 150°C free-air temperature at the rate of 2 mW/deg.

2. Figure of Merit, Q, is defined by the equation $Q = \frac{1}{2\pi f C_t r_s}$ where r_s is Equivalent Series Resistance, as measured on a Boonton RF Admittance Bridge, Model 33A or equivalent.

 PRINTED IN U.S.A.

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Sensistors®

TYPES TG 1/8, TM 1/8 POSITIVE-TEMPERATURE-COEFFICIENT SILICON THERMISTORS

BULLETIN NO. DL-S 7312014, MARCH 1973

TEMPERATURE-SENSING, TEMPERATURE-COMPENSATING

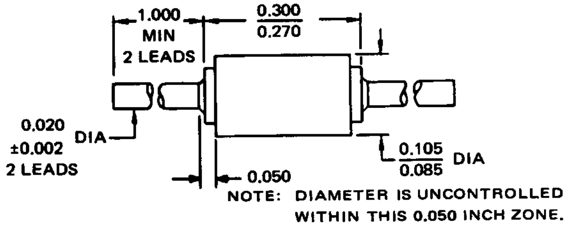
- **Designed to Meet or Exceed all Electrical Requirements of MIL-T-23648A for Positive-TC Thermistors**
- **TG1/8 . . . Similar to RTH42 (MIL-T-23648A/19)**
- **TM1/8 . . . Similar to RTH22 (MIL-T-23648A/9)**
- **Large Positive Temperature Coefficient of Resistance (Approx 0.7%/°C)**
- **Wide Resistance Value Ranges Available in ± 5% or ± 10% Tolerances**

mechanical data

The TG1/8 thermistor is encapsulated in a glass, hermetically sealed package with hot-solder-dipped leads.

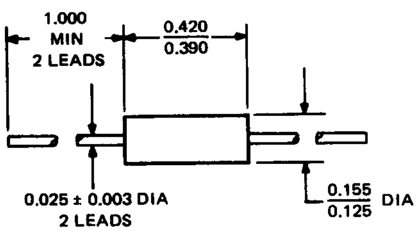
The TM1/8 thermistor is encapsulated in a molded package with hot-solder-dipped leads

TG 1/8



DIMENSIONS ARE IN INCHES

TM 1/8



DIMENSIONS ARE IN INCHES

maximum ratings

	TG 1/8	TM 1/8
Power Dissipation at (or below) 25°C Free-Air Temperature (See Figures 1 and 2)	300 mW	500 mW
Power Dissipation at (or below) 100°C Free-Air Temperature (See Figures 1 and 2)	125 mW	125 mW
Operating Free-Air Temperature Range	−55°C to 125°C	
Storage Temperature Range	−65°C to 150°C	

electrical and thermal characteristics

PARAMETER		TG 1/8	TM 1/8	UNIT
$R_{25°C}/R_{125°C}$	Zero-Power Resistance Ratio	0.55 ± 15%	0.55 ± 15%	
τ	Thermal Time Constant	35 typ 60 max	35 typ 40 max	s

Replaces TG 1/8, TM 1/8, TM 1/4 data sheet, Bulletin No. DL-S 6910909, revised August 1969

dissipation derating curves

TG 1/8

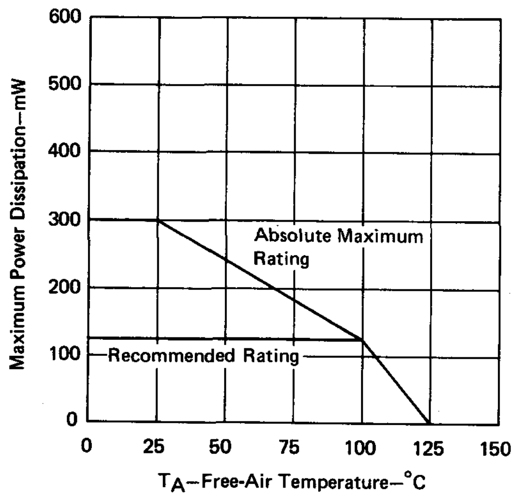


FIGURE 1

TM 1/8

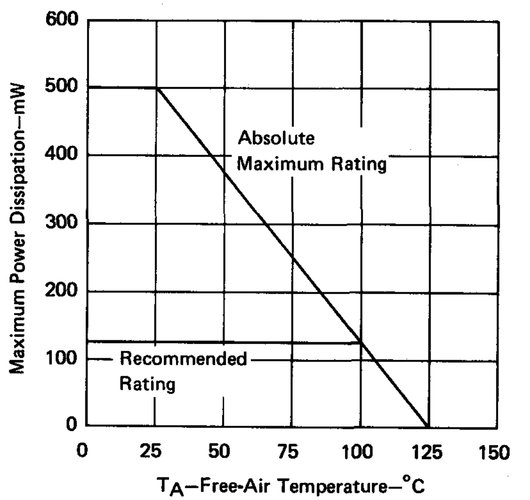


FIGURE 2

factors for determining nominal resistance at various temperatures

TABLE I – TG 1/8

Temperature (°C)	10 Ω-68 Ω	82 Ω-150 Ω	180 Ω-470 Ω	560 Ω-1.2 kΩ	1.5 kΩ-5.6 kΩ	6.8 kΩ-10 kΩ
−55	0.615	0.582	0.560	0.550	0.515	0.510
−15	0.790	0.770	0.755	0.740	0.730	0.730
0	0.863	0.847	0.838	0.835	0.825	0.825
25	1.000	1.000	1.000	1.000	1.000	1.000
50	1.160	1.170	1.180	1.200	1.230	1.190
75	1.350	1.370	1.400	1.420	1.450	1.400
100	1.545	1.584	1.623	1.656	1.670	1.610
125	1.750	1.800	1.860	1.920	1.960	1.830

TABLE II – TM 1/8

Tempeatture (°C)	10 Ω-68 Ω	82 Ω-150 Ω	180 Ω-560 Ω	680 Ω-1.5 kΩ	1.8 kΩ-12 kΩ	15 kΩ-39 kΩ
−55	0.615	0.582	0.560	0.550	0.515	0.481
−15	0.790	0.770	0.755	0.740	0.730	0.712
0	0.863	0.847	0.838	0.835	0.825	0.814
25	1.000	1.000	1.000	1.000	1.000	1.000
50	1.160	1.170	1.180	1.200	1.230	1.210
75	1.350	1.370	1.400	1.420	1.450	1.430
100	1.545	1.584	1.623	1.656	1.670	1.670
125	1.750	1.800	1.860	1.920	1.960	1.900

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using tables I and II

Factors for determining the resistance of *Sensistor* thermistors at temperatures other than 25°C are tabulated in Table I and II. To determine the resistance of a thermistor at a temperature other than 25°C, first select the appropriate table (Table I for TG 1/8, Table II for TM 1/8), then select the column that is headed by the resistance range that includes the nominal resistance at 25°C of the thermistor in question. The resistance at 25°C of the thermistor is then multiplied by the factor in that column that corresponds with the temperature in question to determine the new resistance.

EXAMPLES: Given a TG1/8221J* *Sensistor* thermistor whose zero-power resistance value at 25°C is 228 Ω, find the resistance value for 75°C. The proper table is Table I and the proper column is the one headed "180 Ω-470 Ω". The factor in the 75°C row of this column is 1.400, which when multiplied by the zero-power resistance value at 25°C gives 1.400 x 228 Ω = 319 Ω (at 75°C).

effects of tolerances

In the previous example a 228-ohm *Sensistor* thermistor is computed to have a nominal resistance of 319 ohms at 75°C. The actual resistance of the thermistor at 75°C may vary from the calculated value by an amount not exceeding the tolerances tabulated in Table III.

TABLE III
RESISTANCE TOLERANCE vs TEMPERATURE

TEMPERATURE (°C)	± 5% (J)	± 10% (K)
−55	± 15%	± 20%
−15	± 9%	± 14%
0	± 7%	± 12%
25	± 5%	± 10%
50	± 7%	± 12%
75	± 9%	± 14%
100	± 12%	± 17%
125	± 15%	± 20%

*See "Part Number Designation" on last page.

typical characteristics with power applied

To determine resistance value with power applied, obtain a multiplying factor from the applicable curve below. The free-air curve is for the condition of heat removal by free-air convection only. The heat-sink curve is for the maximum-cooling-rate condition of a heat-sink strap, with leads attached to an infinite heat sink. Actual conditions encountered will be between these two extremes. After selecting an applicable multiplying factor from Figure 3 or 4, multiply this by the 25°C zero-power resistance. This product is then corrected for the actual ambient temperature by use of the appropriate factor from Table I or II.

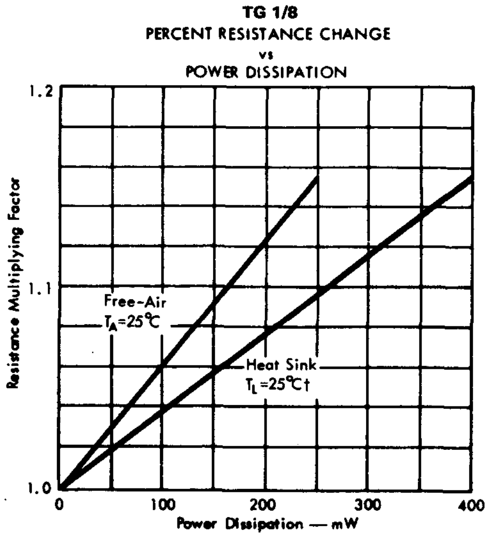

FIGURE 3

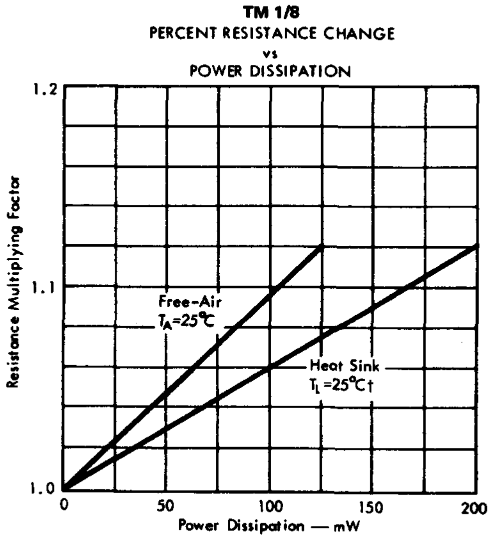

FIGURE 4

†T_L is lead temperature measured 1/16 inch from the body.

standard zero-power resistance values (ohms) at 25°C free-air temperature

10	12	15	18	22	27	33	39	47	50	56	68	82
100	120	150	180	220	270	330	390	470	500	560	680	820
1 000	1 200	1 500	1 800	2 200	2 700	3 300	3 900	4 700	5 000	5 600	6 800	8 200
10 000	12 000*	15 000*	18 000*	22 000*	27 000*	33 000*	39 000*					

*These values apply to types TM 1/8 only.

part-number designation

TM1/8272K

TM 1/8 272 K

STYLE	WATTAGE	RESISTANCE VALUE CODE	TOLERANCE
TM	1/8	270 = 27 Ω	J = 5%
TG		271 = 270 Ω	K = 10%
		272 = 2 700 Ω	
		273 = 27 000 Ω	

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Solid-State Electronics Technology from the Texas Instruments Learning Center Library

The Texas Instruments Learning Center Library offers a wide variety of textbooks spanning the field of solid-state electronics — from fundamentals for the layman through advanced semiconductor technologies. Each publication has been written by one or more authorities on the subject, bringing a completely objective viewpoint to the material. Texts have been carefully prepared and edited, and numerous diagrams and illustrations help achieve maximum clarity and understanding. In an industry as dynamic as electronics, it is important for engineers and technicians to keep abreast of the latest solid-state technologies. The Texas Instruments Learning Center Library will continue to be a viable source for this important information.

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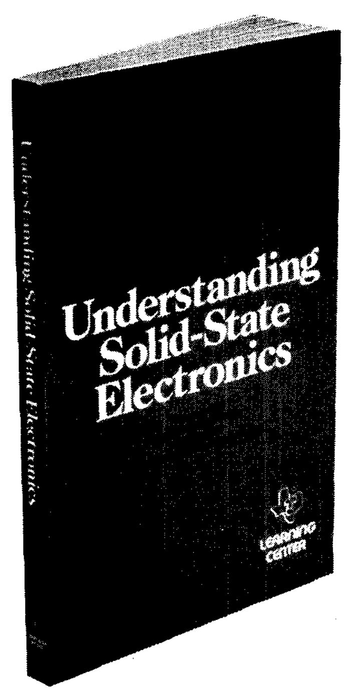
Understanding Solid-State Electronics

250 pages • 168 illustrations • Shipping weight 14-oz • $2.95

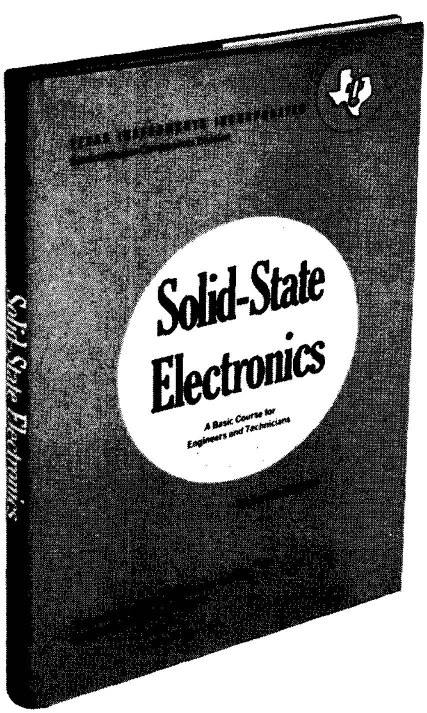
This book was created for anyone who wants to understand solid-state electronics, but can't devote years to the study. It has been prepared for non-technical individuals, and tens of thousands of copies now in use prove its effectiveness. Engineering concepts and theory are explained without using mathematics — just some simple arithmetic. Technical terms are used, but each one is explained in layman's language. The book is a 12-lesson, self-teaching course complete with quizzes and glossaries. Whether you're an engineer, technician, hobbyist . . . or just curious about what goes on inside computers, radios, calculators or appliances . . . this book will interest you. *Chapter titles: What Electricity Does in Every Electrical System, Basic Circuit Functions in the System, How Circuits Make Decisions, Relating Semiconductors to Systems, Diodes: What They Do and How They are Made, The PNP Transistor and Transistor Specifications, Thyristors and Optoelectronics, Introduction to Integrated Circuits, Digital Integrated Circuits, and MOS and Linear Integrated Circuits.*



Solid-State Electronics: A Basic Course

170 pages • 90 illustrations • Shipping weight 1-lb 12-oz • $9.50

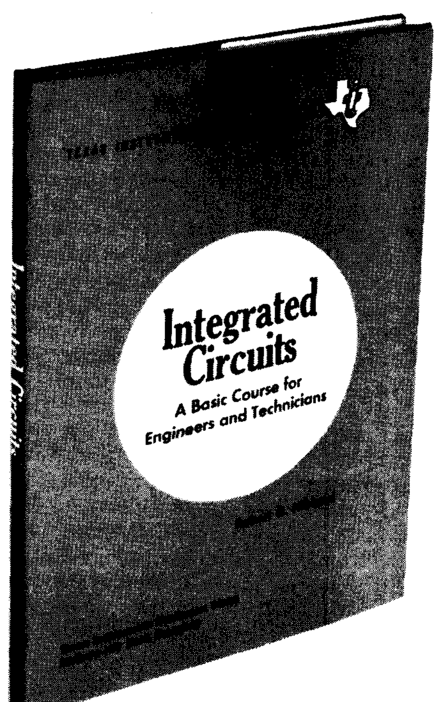
Presents the principles of semiconductors in a programmed-learning manner. Explains semiconductor behavior; describes operation and electrical characteristics of diodes and transistors; considers concept, processes and fabrication of integrated circuits; surveys the advantages and application of integrated circuits, and their future. Down to earth in its approach, this book can be used by engineers and technicians in other disciplines to obtain a working familiarity with the subject. Each chapter features a glossary and includes questions to answer and problems to solve. *Chapter titles: Introduction to Semiconductors, Properties of Semiconductors, Preparation of Semiconductor Materials, The p-n Junction, The Junction Transistor, Characteristics and Ratings, Basic Transistor Amplifier Circuits, Manufacture and Testing of Transistors, Compound Semiconductor Materials, Other Semiconductor Devices, An Introduction to Integrated Circuits, and Trends in Integrated Circuits.*



Integrated Circuits: A Basic Course

177 pages • 133 illustrations • Shipping weight 1-lb 10-oz • $9.95

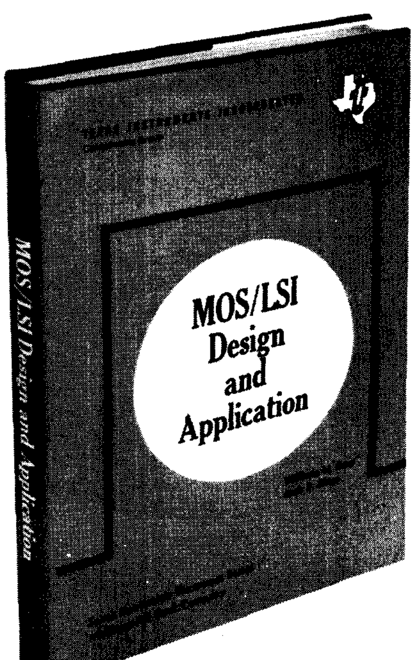
It is becoming more and more essential for engineers and technicians to have a basic understanding of solid-state electronics and integrated circuits. They need to be generally informed on I/C technology so that they can "talk the same language" as the integrated-circuits expert, and convert the full potential of integrated circuitry into efficient and profitable end equipments. This book meets this requirement — a ten-lesson course forming a sequel to Solid-State Electronics: A Basic Course. With this text, engineers and technicians in any industry can master the structures of various integrated circuits — digital, linear, bipolar, MOS, LSI, MSI — and see how they are used. *Chapter Titles: The Impact of Integrated Circuits, Solid-State Technology, Integrated-Circuit Technology, Digital Logic Circuits, Digital Integrated Circuits, Basic Aspects of Linear Integrated Circuits, Standard Catalog Integrated Circuits, Integrated Electronic Components, The Application of Integrated Circuits, and The Use of Integrated Circuits in Electronic Control.*



MOS/LSI Design and Application

331 pages • 270 illustrations • Shipping weight 2-lb 7-oz • $18.50

Specifically written for electronic system engineers and technicians, this practical volume provides instantly usable state-of-the-art information on one of the latest developments in solid-state electronics — MOS/LSI. All aspects of this technology, from principles to applications, are covered. Advances discussed include: N-channel device technology, nitrite-oxide sandwich structures, one-chip calculator, two- three- and four-phase shift registers, semiconductor memories, and much more. Major applications examined include inverters, static logic, flip-flops, shift registers, memories, and programmable logic arrays. This book will help (1) evaluate the usefulness of MOS/LSI in specific applications, (2) weigh the advantages of its many options, and (3) plan cost-effective system designs. *Chapter titles: MOS Device Physics, The MOS Technology Arsenal, Reliability Aspects of MOS Integrated Circuits, Inverters, Static Logic, and Flip-Flops, Shift Registers for Data Delay, Logic, and Memory, The MOS/Bipolar Interface, Memory Applications, Programmable Logic Arrays, MOS Analog Circuitry, The Economics of MOS/LSI.*



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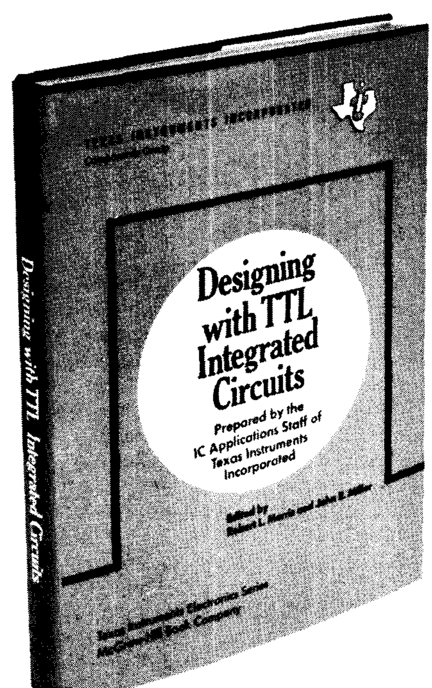
A thoroughly comprehensive and practical volume, the first to explore the entire family of TTL integrated circuits. Written for electronics engineers, computer designers, systems analysts and managers who want information on the best uses of this family of circuits. Covers not only design philosophy, economics, basic descriptions, and electrical performance of TTL, but also the full range of application of these circuits in digital systems. *Chapter titles: Introduction to Digital Logics, Series 54/74 Overview, Circuit Analysis and Characteristics of Series 54/74, Extended-Range Operation, Noise Considerations, Combinational Logic Design, Flip-Flops, Decoders, Arithmetic Elements, Counters, Shift Registers, and Other Applications.*



Solid-State Communications

366 pages • 417 illustrations • Shipping weight 2-lb 9-oz • $13.75

If you're engaged in any phase of communications from RF to UHF and from CQ to QC, you'll be interested in this book. It's the ideal complement to the high-frequency design section of the very popular Transistor Circuit Design. Directed chiefly to circuit designers, it provides a detailed discussion of communication components for a large variety of applications — in industry, in the military and in consumer products. Devices covered include field-effect transistors, dual transistors, high-frequency silicon planar epitaxial transistors, and germanium planar transistors. *Chapter titles: New Communications Devices, Dependence of Transistor y Parameters on Bias, Frequency and Temperature, Typical y Parameter Data, Power Gain and Stability in Linear Active Two-Ports, High-Frequency Amplifier Design Using Admittance Parameters Low-Level Operation of the 2N929 and 2N930, High Input Impedance Techniques, Noise Characterization, Transistor Gain Control, RF Harmonic Oscillators, Transistors in Wide-Band Low-Distortion Amplifiers, VHF and UHF Amplifiers and Oscillators Using Silicon Transistors, Causes of Noise, Transistor Noise Figure, Communications Circuit Applications, Device Nomenclature and Standard Test Circuits, Noise Figure Measurement, and Power Oscillator Test Procedure.*

Design and Application of Transistor Switching Circuits

278 pages • 315 illustrations • Shipping weight 2-lb 2-lb • $17.50

Engineers and technicians involved with circuit design and construction will find this discussion of transistor circuits invaluable. It details the basic mechanism of transistor action and shows how the elements of an a-c model transistor are related to the basic mechanism. It discusses how to select a transistor which has the desired electrical characteristics. Circuit performance of linear and non-linear circuit elements, the binary number system and Boolean algebra, and diode gates are also discussed. Technology aspects covered include the method of statistical design, principles of transistor-coupled logic stages, design of the emitter-coupled logic stage, and certain forms of flip-flop counters. *Chapter titles: Transistor Physical Characteristics, Small-Signal Equivalent Circuit of Junction Transistor, Fabrication and Characteristics of Various Transistor Types, The Transistor as a Switch, The Transistor Data Sheet, Saturated-Inverter Design, Graphical Circuit Analysis, Emitter-Follower Operation and Design, Symbolic Logic, Transistors and Diodes as Logic Elements, Current-Mode Switching Circuits, Flip-Flop Circuits, Registers, Counters, and Diode Decoders, and Pulse-Generating and Pulse-Shaping Networks.*

MOSFET in Circuit Design

136 pages • 100 illustrations • Shipping weight 1-lb 10-oz • $11.75

This book is a single source of information that is geared to the needs of the practicing engineer and circuit designer and is an authoritative volume that provides the basic principles and background required in MOSFET device and circuit engineering. The result of actual work with MOSFET devices and complex integrated circuits, the book has discussions covering basic theory and operation of MOS field effects, descriptive equations for device behavior, MOSFET usage in analog circuits and MOSFET-bipolar combinations, and a highly detailed description of an actual MOSFET complex integrated circuit. *Chapter titles: An Introduction to the World of the MOSFET, Theory of Operation, MOS Characteristics and Equation Interrelationships, Transient Response, Basic MOS Integrated-Circuit Concepts, and Analog Circuits.*

Transistor Circuit Design

532 pages • 526 illustrations • Shipping weight 3-lb 4-oz • $16.50

The most popular book ever written on semiconductors, discusses common problems that confront circuit designers, from interpretation of data-sheet information to design procedures for VHF power stages. A practical work-a-day book, it presents detailed design procedures for a great variety of circuits. Nearly 100,000 copies of this book have been purchased. *Chapter titles: Classification of Junction Transistors, Device and Circuit Symbology, Transistor Specifications, Nature of Transistor Quantities, Measurement of Electrical Quantities and Parameters, Equivalent Circuits and Parameter Interrelationships, Logic Circuits, Transistorized Timers, High-Level Switching, Light Flashers, Blocking Oscillators, D-C Converters, Inverters, Switching-Mode Voltage Regulators, Switching-Mode Motor Control, Switching-Mode Servo Amplifier, and Digital Servo System.*

Field-Effect Transistors

138 pages • 137 illustrations • Shipping weight 1-lb 10-oz • $10.00

The first text devoted exclusively to field-effect transistors. It contains a comprehensive coverage of theory, design philosophy, and practical applications of FETs. Beginning with a presentation of physical theory based on Maxwell's Equations, the book uses a lumped linear model to describe the circuit behavior of the FET. Much attention is devoted to detailed explanations of the electrical characteristics. Most of the typical applications for FETs are described and illustrated by circuit diagrams. Although the field-effect transistor was invented before the point-contact transistor, it was not a commercial reality until many years after, and its peculiar characteristics — more similar to the characteristics of a vacuum tube than to those of a bipolar transistor — are still widely employed. *Chapter titles: Theory of the Unipolar Field-Effect Transistor, FET Characteristics, FETs in Low-Level Linear Circuits, FETs in Non-Linear Circuits, Blue Skies Dept.: The Power FET, Further Applications, and FETs in Integrated Circuits.*

Characterization of Semiconductor Materials

351 pages • 221 illustrations • Shipping weight 2-lb 9-oz • $18.50

Here in one volume are collected all the compositional and structural techniques presently applied in assessing quality throughout the many stages of producing semiconductor devices, from raw material to finished devices. Descriptions and evaluations of the techniques cover not only germanium, silicon, and the III-V compounds, but their surfaces, oxides, and films as well. This book is especially valuable to production engineers, quality control engineers, analytical chemists, and materials scientists. *Chapter titles: Introduction, Semiconductor Principles, Bulk-Material Characterization, Materials Characterization in Single-Crystal Growth, Analysis of Single Crystals for Chemical Imperfections, Characterization of Semiconductor Surfaces, Characterization of Epitaxial Films, Diffusion, and Characterization of Thin Films.*

Circuit Design for Audio, AM/FM and TV

352 pages • 145 illustrations • Shipping weight 2-lb 8-oz • $14.50

Design examples in this intensely practical guide have been chosen to suggest the broad application of the procedures. In the TV section, specific design examples are given for each major system comprising a TV receiver. In the AM/FM section, the stress is on the practical design of IF strips. Examples of both neutralized and unneutralized amplifiers are given. In the audio section, the more common coupling schemes for both Class A and Class B operation are discussed in detail along with audio design procedures, design examples, and derivations of the key equations used in audio design. *Chapter titles: Audio Design Considerations, Class A Output and Driver Design Procedures, Class B Output and Driver Design Procedures, Class A Design Examples, Class B Design Examples, Audio Design Equation Derivations, AM IF Amplifier Design, FM Tuner Design, FM IF Amplifier Design, AM/FM Amplifier Circuit Applications, FM IF Amplifier Circuit Applications, UHF TV Tuners, VHF TV Tuners, Video IF Amplifiers, TV Automatic Gain Control, Video Amplifier System, Sound IF Amplifier System, Sync Separator, Vertical Oscillator and Sweep Output, Horizontal AFC and Oscillator, and Horizontal Driver and Sweep Circuit.*

Silicon Semiconductor Technology

256 pages • 301 illustrations • Shipping weight 2-lb 9-oz • $17.50

If you're a creative designer, you're probably not content to just string black boxes together. You want the "inside story" so you can exploit the potential of every component. This book gives you that inside story — it's the first book in the field to present comprehensive and authoritative discussions on every aspect of silicon as a semiconductor. This book is a valuable asset to the semiconductor device engineer and to the designer of circuits and systems as well. *Chapter titles: An Historical Note, Silicon Manufacturing Processes, Silicon Casting Processes, Crystal Growth, Crystal Habit and Orientation, Doping Processes, Diffusion, Electrical Properties, Optical Properties, Miscellaneous Physical Properties and Processes, and Metallurgy.*

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The Transistor and Diode Data Book

for

Design

Engineers