Tektronix®

DC 510 UNIVERSAL COUNTER/TIMER With Options

INSTRUCTION MANUAL

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DC 510 UNIVERSAL COUNTER/TIMER With Options

INSTRUCTION MANUAL

Tektronix, Inc.
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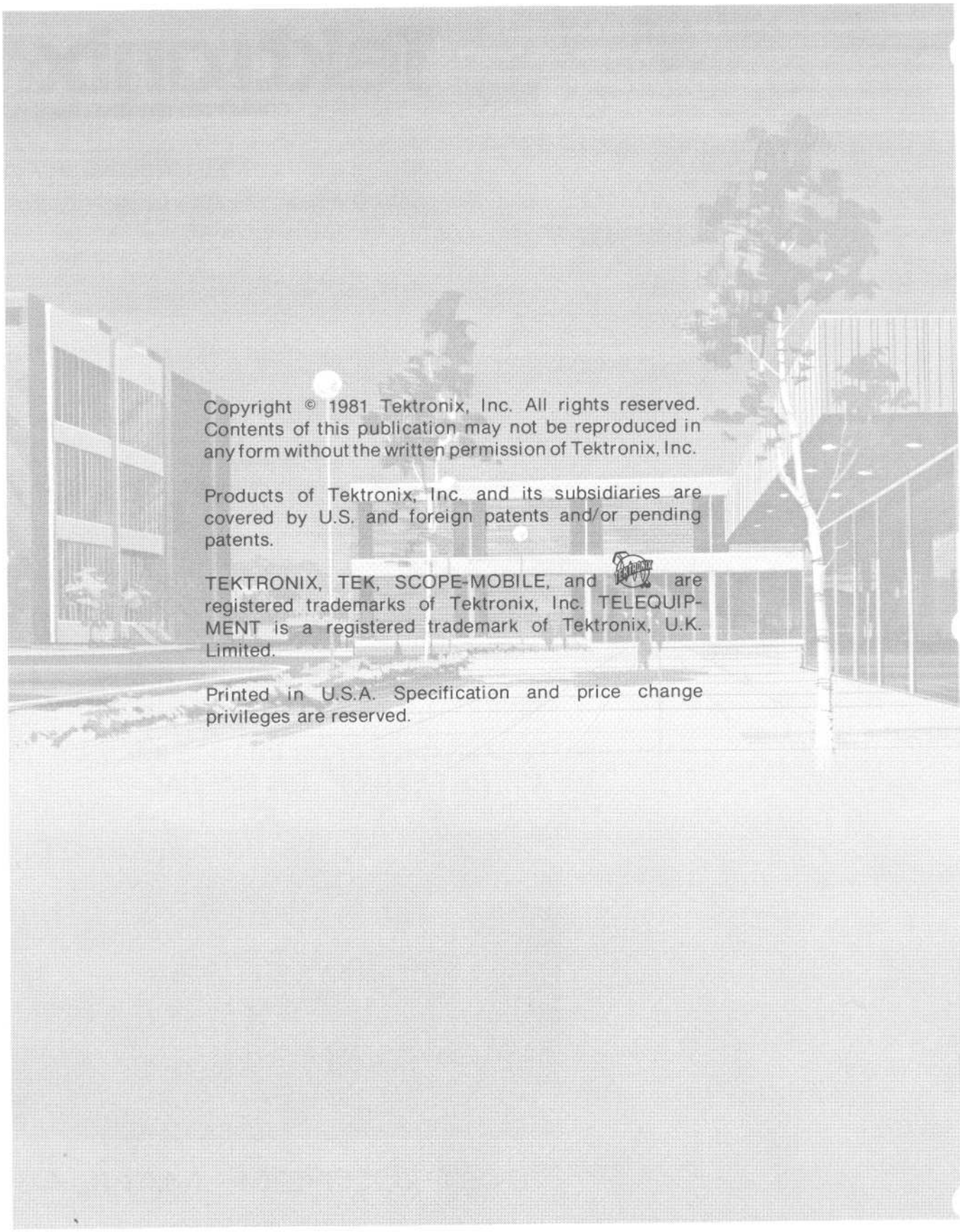

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WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

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OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

TERMS

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

SYMBOLS

In This Manual

This symbol indicates where applicable cautionary or other information is to be found.

As Marked on Equipment

DANGER — High voltage.

Protective ground (earth) terminal.

ATTENTION — refer to manual.

Power Source

This product is intended to operate from a power module connected to a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power module power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power module power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating and current rating as specified in the parts list for your product.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Operate Without Covers

To avoid personal injury, do not operate this product without covers or panels installed. Do not apply power to the plug-in via a plug-in extender.

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SERVICE SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators Safety Summary.

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

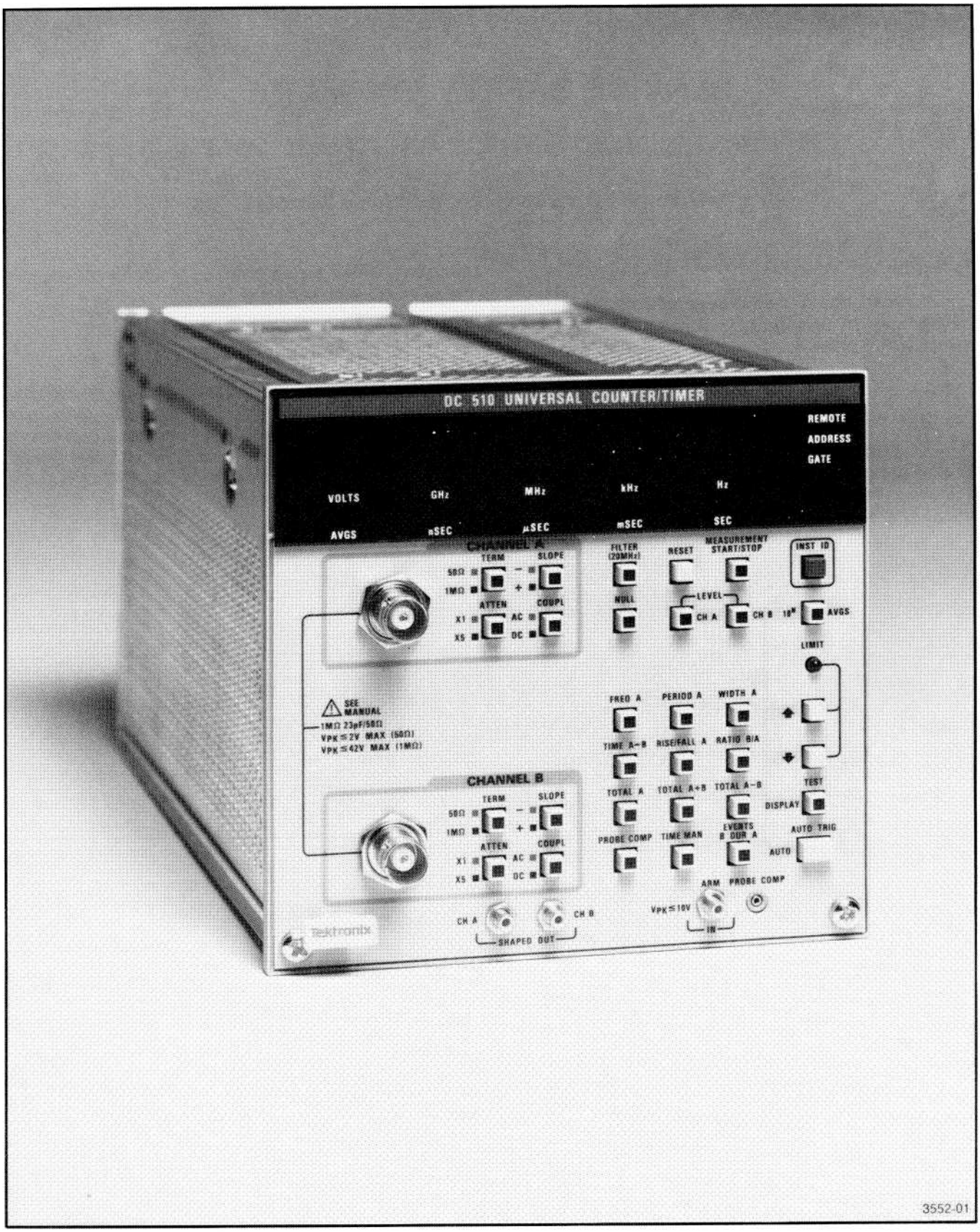
Use Care When Servicing With Power On

Dangerous voltages may exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

This product is intended to operate in a power module connected to a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.



DC 510 Universal Counter/Timer.

SPECIFICATION

Instrument Description

The TEKTRONIX DC 510 is a universal counter/timer plug-in. It features reciprocal Frequency, Period, Ratio, and Events B During A measurements to 350 MHz. For timing measurements, the Time Interval, Width, Risetime and Falltime functions feature 3.125 nsec single-shot resolution. For these measurements, averaging and identical A and B channels provide increased accuracy. Also included is a time manual mode, as well as three 350 MHz Totalize modes (A, A+B, and A−B). The DC 510 also has an auto-trigger feature, a probe-compensation feature, an auto averages function, and an extensive set of automatic power-up self tests.

The DC 510 has a DVM mode that reads out the channel A and channel B trigger level voltages. Shaped outputs and an arming input are available at the front panel. Also available at the front panel is a signal for use with the probe compensation function.

The DC 510 can be equipped with an optional, oven-controlled, 10 MHz crystal oscillator to obtain an even more stable and precise internal time base.

A GPIB conversion kit (Field Modification Kit 040-1023-00) for the DC 510 is available from Tektronix, Inc.

Instrument Options

Option 01 replaces the internal 10 MHz time base (clock) circuit with a self-contained proportional temperature controlled oven oscillator for increased accuracy and stability.

Standard Accessories

1 Instruction Manual

1 Cable Assembly, bnc-to-slide on connector

1 Reference Guide

NOTE

Refer to the tabbed Accessories page at the rear of this manual for more information.

Performance Conditions

The limits stated in the Performance Requirements columns of the following tables are valid only if the DC 510 has been calibrated at an ambient temperature between +20°C and +30°C and is operating at an ambient temperature between 0°C and +50°C, unless otherwise stated.

Information given in the Supplemental Information and Description columns of the following tables is provided for user information only and should not be interpreted as Performance Check requirements.

The DC 510 must be operated or stored in an environment whose limits are described under Environmental Characteristics.

Allow at least 30 minutes warm-up time for operation to specified accuracy, 60 minuites after storage in a high-humidity environment.

Safety Certification

This instrument is listed with Underwriters Laboratories, Inc. under UL Standard 1244 (Electrical and Electronic Measuring and Testing Equipment).

Table 1-1
ELECTRICAL CHARACTERISTICS

Characteristics		Performance Requirements		Supplemental Information
CHANNEL A and CHANNEL B INPUTS (also see Rise/Fall MEASUREMENT MODE INPUT SPECIFICATION)				
Input Frequency Range				
Coupling		50 Ω	1 MΩ	
DC		>0 to ⩾350 MHz	>0 to ⩾300 MHz	
AC		100 kHz to ⩾350 MHz	16 Hz to ⩾300 MHz	
Input Sensitivity				1 MΩ performance is from a 25 Ω source impedance.
Sinewave		50 Ω (Term low)	1 MΩ (Term high)	
Coupling	Attenuation			Typical sensitivity is 50 mV p-p ±20 mV.
DC	X1	⩽25 mV rms	⩽25 mV rms to 200 MHz ⩽42 mV rms from 200 MHz to 300 MHz	
		⩽70 mV p-p pulse	⩽70 mV p-p pulse (<200 MHz)	
	X5	⩽125 mV rms	⩽125 mV rms to 200 MHz ⩽210 mV rms from 200 MHz to 300 MHz	
		⩽350 mV p-p pulse	⩽350 mV p-p pulse	
AC	X1	⩽25 mV rms	⩽25 mV rms to 200 MHz 42 mV rms to 300 MHz	
		+3 dB at ⩽100 kHz ⩽70 mV p-p pulse	+3 dB at ⩽16 Hz ⩽70 mV p-p pulse (<200 MHz)	
	X5	⩽125 mV rms	⩽125 mV rms to 200 MHz 210 mV rms to 300 MHz	
		+3 dB at ⩽100 kHz ⩽350 mV p-p pulse	+3 dB at ⩽16 Hz ⩽350 mV p-p pulse (⩽200 MHz)	
Dynamic Range				
Attenuation				
X1				70 mV p-p to 4 V p-p
X5				350 mV p-p to 20 V p-p
Trigger Level Range				
Attenuator				
X1		⩾+2 V to ⩽−2 V		In approximately 4 mV steps.
X5		⩾+10 V to ⩽−10 V		In approximately 20 mV steps.
Trigger Level Accuracy		±1% of full scale trigger level range, plus ±2% of reading for a dc input voltage.		Trigger level is calibrated in + slope and is firmware compensated in − slope.

Table 1-1 (cont)

Characteristics		Performance Requirements	Supplemental Information
CHANNEL A and CHANNEL B INPUTS (also see Rise/Fall MEASUREMENT MODE INPUT SPECIFICATION) (cont)			
Auto Trigger Range (A or B)		10 Hz to ≥350 MHz Minimum signal required for Auto Trigger is 100 mV p-p.In Ratio mode, with Channel B frequency ≥200 MHz, the Auto Trigger will provide a CHA B level within ±24 mV of the 50% point.	Trigger point is set (once) to a nominal 50% of the p-p input signal. For signals dc to 10 Hz (inclusive), level will still be set between 0% and 100%, but not necessarily near 50%. A ten-bit DAC is used, giving nominal 4 mV steps (X attenuation factor).
Operating Range Attenuation X1		+2 V to −2 V (dc + peak ac)	
X5		+10 V to −10 V (dc + peak ac)	
AC Coupling		50 Ω input dc ≤±2 V (dc plus peak ac) times attenuator 1 MΩ input ≤42 V dc + peak ac	
Maximum Allowable Input (Damage Level)			In 50 Ω input mode, 50 Ω overvoltage protection trips in 1 M input impedance for signals greater than approximately ±2 V times attenuator dc + peak ac to 200 kHz.
Attenuation	Impedance		
X1	50 Ω	V_{pk} ≤2 V	dc to 350 MHz
	1 MΩ		±42 V dc + peak ac, dc to 200 kHz ±2 V dc + peak ac, 2 MHz to 300 MHz
X5	50 Ω	V_{pk} ≤10 V	±10 V dc + peak ac, dc to 350 MHz
	1 MΩ		±42 V dc + peak ac, dc to 1 MHz ±10 V dc + peak ac, 1 MHz to 300 MHz
Input Impedance	50 Ω	50 Ω approximately ±3% dc	VSWR approximately 1.5:1, dc to 350 MHz
	50 Ω ac		Bleeder resistor results in ≈390 kΩ dc input resistance.
	1 MΩ	1 MΩ approximately ±1% 23 pF approximately ±10% (2.2 pF)	For inputs greater than ±5 Vdc + peak ac, input impedance becomes approximately 300 kΩ 1000 pF, X1. Input C from X1 to X5 are equal by approximately ±1%.

Table 1-1 (cont)

Characteristics	Performance Requirements		Supplemental Information
CHANNEL A and CHANNEL B INPUTS (also see Rise/Fall MEASUREMENT MODE INPUT SPECIFICATION) (cont)			
Bandwidth Limit			Above 20 MHz minimum signal increases 40 dB/decade to ≈1 V p-p. Above approximately 80 MHz no amount of input signal can cause triggering.
Channel Isolation, Crosstalk			A ≤4 volt p-p signal into CH A will not cause triggering in CH B and vice versa.
RISE/FALL MEASUREMENT MODE INPUT SPECIFICATION			
Range			In this mode, the input amplifiers are commoned to the CH A bnc. CH B bnc is an open circuit.
Coupling	50 Ω	1 MΩ	
DC	4.0 nsec to 2.5 × 10^4 sec	5 nsec to 2.5 × 10^4 sec	
AC	4.0 nsec to 18 μsec	5 nsec to 22 msec	AC measurements near the slower limit are not recommended, because they become duty cycle dependent.
Frequency	50 Ω	1 MΩ	Upper frequency limit is essentially a limit on the repetition rate at which rise/fall edges may occur.
DC	>0 to >80 MHz	>0 to >80 MHz	
AC	100 kHz to >80 MHz	16 Hz to >80 MHz	
Input Sensitivity	50 Ω	1 MΩ	1 MΩ response is from 25 Ω source impedance.
Coupling / Attenuation			
DC X1	50 mV rms 140 mV p-p pulse	25 mV rms 70 mV p-p pulse	Both channel modes set the same.
DC X5	250 mV rms 700 mV p-p pulse	125 mV rms 350 mV p-p pulse	50 Ω input impedance is maintained via an internal power-splitter causing X2 attenuation.
AC X1	50 mV rms +3 dB at 20 kHz 140 mV p-p pulse	25 mV rms +3 dB at 16 Hz 70 mV p-p pulse	These specifications apply when both channels have the same setup.
AC X5	250 mV rms +3 dB at 20 kHz 700 mV p-p pulse	125 mV rms +3 dB at 16 Hz 350 mV p-p pulse	

Table 1-1 (cont)

Characteristics		Performance Requirements		Supplemental Information
RISE/FALL MEASUREMENT MODE INPUT SPECIFICATION (cont)				
Dynamic Range				
Attenuation	X1	50 Ω 140 mV p-p to 8 V p-p	1 MΩ 70 mV p-p to 4 V p-p	Maxima are centered at zero volts. Minimum measurable rise/fall signal amplitude is ten times greater than minimum dynamic range.
	X5	700 mV p-p to 10 V p-p	350 mV p-p to 20 V p-p	
Trigger Level Range		50 Ω	1 MΩ	50 Ω, ×5, only ±5 V of the trigger level range is usable because only ±5 V is allowed as an input.
Attenuation	X1	+4 V to −4 V ≈8 mV steps	+2 V to −2 V ≈4 mV steps	When using 50 Ω input mode, the displayed trigger level is 1/2 true trigger level due to 50 Ω power splitter divider action.
	X5	(+5 V to −5 V) +20 V to −20 V ≈40 mV steps	+10 V to −10 V ≈20 mV steps	
Operating Range		50 Ω	1 MΩ	For 10% and 90% trigger point. For inputs less than minimum, 10% and 90% points are not achievable due to sensitivity. Mimimum signal is 10 times minimum dynamic range.
Attenuation	X1	1.4 V p-p minimum, +4 V to −4 V dc + peak ac max	700 mV p-p minimum, +2 V to −2 V dc + peak ac max	
	X5	7.0 V p-p minimum, +5 V to −5 V dc + peak ac max	3.5 V p-p minimum, +10 V to −10 V dc + peak ac max	
Maximum Allowable Input (Damage Level)				
Attenuation	Impedance			
X1	50 Ω			±4 V dc + peak ac, dc to 80 MHz
	1 MΩ			See CHANNEL A and CHANNEL B inputs
X5	50 Ω			±5 V dc + peak ac, dc to 80 MHz[a]
	1 mΩ			See CHANNEL A and CHANNEL B inputs
Input Impedance Channel A				Channel B is an open circuit.
	1 MΩ	500 kΩ, ±2% 47 pF, ±10%		X5 probe becomes X9 X10 probe becomes X19
	50 Ω	50 Ω, ±3%		

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
	GENERAL	
Probe Compensation Output Jack		5 V p-p nominal. 110 Hz nominal. 1 ms width nominal.
Arming Input Required Signal Input	low ≤0.4 volts high ≥2.4 volts (TTL)	Maximum voltage V_{pk} <10 volts.
Pulse Response	Pulse width ≥100 ns	
Shaped Output		≥100 mV typically to 350 MHz into 50 Ω load. Delay from front-panel input to shaped output. CH A 7.2 nsec typically CH B 7.0 nsec typically CH B commoned from CH A 7.6 nsec typically.
External Clock Input	≥500 mV rms into 1 kΩ (ac coupled) 1, 5, or 10 MHz	
10 MHz Clock Output	low ≤0.4 V high ≥2.4 V (TTL) (pins 15B and 15A (gnd))	Drives 1 TTL load.
Phase Modulated Clock (time interval functions)		≥3 ns p-p jitter induced onto 1 MHz reference. (Test point on rear of Auxiliary board.)
	STANDARD INTERNAL TIME BASE	
Frequency at calibration	10 MHz $\pm 1 \times 10^{-7}$	10 MHz
Error Terms Temperature Stability (0°C to +50°C)	$\pm 5 \times 10^{-6}$	
Aging	≤1 X 10^{-6}/year	
Adjustment Resolution	$\pm 5 \times 10^{-8}$	

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
OPTIONAL INTERNAL TIME BASE		
Frequency at calibration	10 MHz $\pm 2 \times 10^{-8}$	With proportional oven
Error terms:		
Temperature Stability (0°C to +50°C)	$\pm 2 \times 10^{-7}$ after warmup	
Warm-up Time	Within $\pm 2 \times 10^{-7}$ of final frequency in less than 10 minutes when cold started at 25°C ambient.	
Aging		
At time of shipping	1×10^{-8}/day maximum.	
After 30 days of continuous operation	4×10^{-8}/week maximum	
After 60 days of continuous operation.	$<1 \times 10^{-6}$/year maximum	
Short Term Stability		$\leq 1 \times 10^{-9}$ rms based on 60 consecutive 1 second measurements.
Adjustment Resolution	$\pm 2 \times 10^{-8}$	
Adjustment Range		Sufficient for 8 years of aging.
FUNCTIONS		
Frequency A		
Range	≤ 36 μHz to ≥ 350 MHz	
Resolution		$\pm$LSD $\pm 1.4 \times \frac{\text{Trigger Jitter Error}}{\text{N}}$ X (Freq. A)^2
Accuracy		Resolution $\pm$(Timebase Error $\times$ Freq. A)
Period A		
Range	3.125 ns to 7.6 hours	
Repetition Rate	≥ 350 MHz	
Clock Period Counted		3.125 ns
Resolution		$\pm$LSD[b] $\pm \frac{1.4 \times \text{B Trig Jitter Error}}{\text{N}}$
Accuracy		Resolution $\pm$(Timebase Error) $\times$ Period A

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
	FUNCTIONS (cont)	
Ratio B/A		Averaged by A
Range	10^{-8} to 10^{9} with correct decimal point displayed. (10^{-11} to 10^{12} without decimal point.)	
Frequency Range (A & B)	≤36 μHz to ≥350 MHz	
Resolution		$\pm LSD \pm \frac{1.4 \times B\ Trig\ Jitter\ Error \times Freq.\ B}{N}$
Accuracy		Same as Resolution
Time A → B		
Range	2.0 nsec[c] to 7.6 hours	
Resolution		$\pm LSD + \frac{1}{\sqrt{N}}$ (±A Trigger Jitter Error ±B Trigger Jitter Error)
Accuracy		Resolution ±(Timebase Error × Time Interval) ±Channel Delay Mismatch[d] + B Trigger slew error-A Trigger slew error
Clock Period counted		3.125 nsec
Minimum Time A → B	0.0 ± 2.0 nsec[c]	
Minimum Time B → A	≤12.5 nsec	(≥70 MHz Rep. Rate)
Channel Delay Mismatch		
Internal	≤2 nsec nominal, without null	
Front Panel (Shaped Out)		≤500 ps
Events B Dur A		Averaged by A
Range	10^{-8} to 10^{9}	
Maximum B Frequency	≥350 MHz	
Maximum A Frequency	≥80 MHz	
Minimum A Pulse Width	≤4.0 nsec	
Minimum A Pulse Width	≤8.5 nsec	
Resolution		$+LSD + \frac{Freq\ B}{\sqrt{N}}$ (±A Start Trigger Jitter error ± A Stop Trigger Jitter Error)
Accuracy		Resolution + Freq B (Stop Slew Rate Error −Start Slew Rate Error) + Freq B × (5 ±2 nsec)

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
	FUNCTIONS (cont)	
Width A Range	≤4 nsec to 7.6 hours	
Repetition Rate	≥80 MHz	
Resolution		$\pm$LSD + $\frac{1}{\sqrt{N}}$ ($\pm$Start edge Trigger Jitter Error $\pm$ Stop Edge Trigger Jitter Error)
Accuracy		Resolution $\pm$Timebase Error × Width A + (Stop Slew Rate − Start Slew Rate Error) $\pm$2 nsec
Clock period counted		3.125 nsec
Minimum Time Stop Edge to Start Edge	≤8.5 nsec	
Totalize A Range	0 to 10^9 counts	(to 8.7×10^{12} with no decimal point.)
Repetition Rate	0 to ≥350 MHz	See CHANNEL A and CHANNEL B INPUTS for pulse specifications.
Totalize[e] A+B Range	0 to 10^9 (A + B ≤10^9)	(to 8.7×10^{12} with no decimal point.)
Repetition Rate (A or B)	0 to ≥350 MHz	See CHANNEL A and CHANNEL B INPUTS for pulse specifications.
Totalize[e] A−B Range	-10^8 to 10^9	(-8.7×10^{12} to 8.7×10^{12} with no decimal point or minus indication.) Note: either A ≥10^{12} or B ≥^{12} will lead to overflow, independent of the value of (A−B). See CHANNEL A and CHANNEL B INPUTS for pulse specifications.
Rise/Fall A Range	4.0 ns → 7.6 hrs. (dc coupling) 50 Ω 5.0 ns → 7.6 hrs. (dc coupling) "1 MΩ".	Risetime of "1 MΩ" is ≈4.5 ns
Repetition Rate	Minimum time between rising (falling) edges is 12.5 ns (80 MHz)	
Trigger Points	Trigger levels are automatically set to the 90% and 10% points of the incoming signal, to a resolution that depends on the incoming signal amplitude.	In this mode Channels A and B are commoned. This changes the input characteristics. See RISE/FALL MEASUREMENT MODE INPUT SPECIFICATION.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
FUNCTIONS (cont)		
Resolution		$\pm$LSD + $\frac{1}{\sqrt{N}}$ ($\pm$Start Trig Jitter Error $\pm$Stop Trigger Jitter Error)
Accuracy		Resolution $\pm$(Timebase Error $\times$ TI) $\pm$2 nsec $\pm$4 mV $\times$ slew rate A (near 10%) $\pm$4 mV $\times$ slew rate A (near 90%)
Time Manual		
Range	3.125 ns to 3.125 $\times$ 10^4 sec ($\approx$8 hours)	
Resolution		3.125 nsec clock is counted, but usable resolution is $\approx \pm$10 ms due to START/STOP buttons.
Probe Comp Accuracy		$\times$5 probe, 1.5% nominal. $\times$10 probe, 3% nominal. $\times$100 probe, 30% nominal.

Resolution and Accuracy Definitions

$$\text{Trigger Jitter Error (seconds rms)} = \frac{\sqrt{({}^{e}n^{1})^2 + ({}^{e}n^{2})^2}\ \text{Volts rms}}{\left|\text{Input slew rate at trigger point}\right|\ \text{(volts/sec)}}$$

where ${}^{e}n^{1}$ = 140 μV rms typical counter input noise for 1 MΩ filter on; 240 μV rms typical for 1 MΩ filter off; 340 μV rms typical for 50 Ω.

${}^{e}n^{2}$ = V rms noise voltage of users input signal at trigger point, measured with the appropriate bandwidth.

Note: Best usable resolution is $\pm$1 psec in Time Interval (TI) modes.

$$\text{Slew Rate Error (seconds)} = \frac{\text{*trigger level error (Volts)}}{\left|\text{Input slew rate at trigger point}\right|\ \text{(volts/sec)}}$$

*Trigger level error =

All functions except WIDTH A and EVENTS B DUR A	pos slope	trigger accuracy times attenuation factor
	neg slope	(trigger accuracy $\pm$10 mV) times attenuation factor
WIDTH A, ⎍	start edge	trigger accuracy times attenuation
	stop edge	factor (trigger accuracy + hyst) times attenuation factor
⎏	start edge	(trigger accuracy + hyst) times attenuation factor
	stop edge	trigger accuracy times attenuation factor

@

Table 1-1 (cont)

FUNCTIONS (cont)	
EVENTS B DUR A	Same as WIDTH A, except each number is multiplied by Freq B
Note:	Trigger Accuracy, (see CHANNEL A and CHANNEL B INPUTS) Input hysteresis is typically 50 mV p-p times attenuation, maximum 70 mV p-p times attenuation. Internal slew rate = 800 ps (50 Ω) 1.3 nsec (1 MΩ) 18 nsec (20 MHz filter)

N = Number of Averages

The minimum number of averages is selected by the AVERAGES button and the ▲ ▼ buttons in decade steps from 1 to 10^9. At Channel A repetition rates above approximately 250 Hz the actual number of averages will be:

$N \approx [\text{FREQ A (Hz)} \times 4 \text{ msec}] + \text{AVGS}$

N = AVGS setting (below 250 Hz)

This typically leads to better than expected resolution in the displayed answer for small N with only minimal impact on measurement time. Arming must be used when measuring only one event out of a pulse train (multiple events) with signals ≥250 Hz.

In the AUTO mode the counter measures with a fixed measurement time of about 300 msec (or the time for one event, whichever is greater).

$N \leq \text{Freq A (Hz)} \times .3 \text{ seconds (N always} \geq 1)$

LSD:

FREQ	$\frac{(\text{Freq A})^2}{N \times 3.2 \times 10^8}$
PER	$\leq$3.125 nsec for N $\leq$10, $\leq \frac{10 \text{ nsec}}{N}$ for N >10
RATIO	$\frac{\text{Freq A}}{\text{Freq B} \times N}$
TIME A→B & RISE/FALL A	$\leq$3.125 nsec for N $\leq$10, $\frac{10 \text{ nsec}}{\sqrt{N}}$ for N $\geq$10
WIDTH A	$\leq$3.125 nsec for N $\leq$10, $\frac{10 \text{ nsec}}{\sqrt{N}}$ for N > 10
EVENTS B DUR A	$\frac{\text{Period B}}{\text{Width A} \times N} \times$ Events B dur A

Time Base Error: The sum of all the errors specified for the time base used.

[a]Over voltage protection still functions, but in rise/fall, (50 Ω and ×5) it may not always protect the 25 Ω series input resistor.

[b]With 10^9 Averages selected, LSD can be 31.25 atto sec.

[c]Can be set to 0.0 ns by use of "NULL" function.

[d]Can be removed by use of "NULL".

[e]The B channel will not count events until after the first valid A channel count.

Table 1-2
MISCELLANEOUS

Characteristics	Description	
Power Requirements	TM 500 series power module	TM5000 series power module
DC 510	14.6 W	14.0 W
DC 510 Opt 01	18.9 W	18.2 W
Recommended Calibration Interval		2000 hours or 6 months whichever occurs first
Minimum Display Time		100 msec (typical)
Auto Averages Measurement Time		300 msec (typical)

Table 1-3
ENVIRONMENTAL[a]

Characteristics	Description	
Temperature		Meets MIL-T-28800B, class 5.
Operating	0°C to +50°C	
Non-operating	−55°C to +75°C	
Humidity	95% RH, 0°C to 30°C 75% RH to 40°C 45% RH to 50°C	Exceeds MIL-T-28800B, class 5.
Altitude		Exceeds MIL-T-28800B, class 5.
Operating	4.6 km (15,000 ft)	
Non-operating	15 km (50,000 ft)	
Vibration	0.38 mm (0.015") peak to peak, 5 Hz to 55 Hz, 75 minutes.	Exceeds MIL-T-28800B, class 5 when installed in qualified power modules.[b]
Shock	30 g's (1/2 sine), 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks.	Meets MIL-T-28800B, class 5 when installed in qualified power modules.[b]
Bench Handling[c]	12 drops from 45°, 4" or equilibrium, whichever occurs first.	Meets MIL-T-28800B, class 5.
Transportation[c]	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.	
EMC	Within limits of MIL-461A, with exceptions [d], and F.C.C. Regulations, Part 15, Subpart J, Class A. Unused plug-in compartments must be filled with blank plug-ins.	
Electrical Discharge	20 kV maximum charge applied to instrument case.	

[a]With power module.
[b]Refer to TM 5000-Series power module specifications.
[c]Without power module.
[d]Within 4 dB of REO2 at 130 MHz and 960 MHz. Within 8 dB of RE02 at 320 MHz.

Table 1-4
PHYSICAL CHARACTERISTICS

Characteristics	Description
Finish	Anodized aluminum chassis.
Net Weight (nominal)	
DC 510	3 lb. 5 oz.
Option 01	3 lb. 9 oz.
Nominal Overall Dimensions	
Height	126.0 mm (4.96 inches)
Width	134.5 mm (5.29 inches)
Length	278.8 mm (10.98 inches)
Enclosure Type and Style per MIL-T-28800B	
Type	III
Style	E (Style F in rackmount power module)

OPERATING INSTRUCTIONS

INTRODUCTION

First Time Inspection

Inspect the instrument for visible damage (dents, scratches, etc.). Keep the original shipping container and packing material for future use. If the instrument is damaged, notify the carrier and the nearest Tektronix Service Center or representative.

Repackaging for Shipment

Should it become necessary to return the instrument to a Tektronix Service Center for service or repair, attach a tag to the instrument showing the owner (with address) and the name of the individual to be contacted, complete instrument serial number, option number, and a description of the service required.

If the original container and packaging material is unfit for use or not available, repackage the instrument as follows:

1. Obtain a carton of corrugated cardboard having inside dimensions no less than six inches more than the instrument dimensions; this will allow for cushioning. The shipping carton test strength for your instrument is 200 pounds.

2. Surround the instrument with polyethylene sheeting to protect the finish.

3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between carton and instrument, allowing at least three inches on all sides.

4. Seal the carton with shipping tape or industrial staples.

5. Mark the shipping carton "FRAGILE INSTRUMENT" to indicate special handling.

Operating and Non-Operating Environments

The instrument may be operated, stored, or shipped within the environmental limits stated in the Specification section of this manual. However, the counter should be protected at all times from temperature extremes which can cause condensation to occur within the instrument.

PREPARATION FOR USE

Rear Interface Considerations

A slot between pins 21 and 22 on the rear connector identifies this instrument as a member of the TM 500 counter family. If you desire to use your counter to build a system, insert a family barrier key (Tektronix Part No. 214-1593-02) in the corresponding position of the selected power module jack in order to prevent plug-ins belonging to a different family from being used in that compartment of the power module.

WARNING

To avoid electric shock, disconnect the power module power cord before inserting the family barrier key in the power module jack. Refer the barrier key insertion to qualified service personnel.

The DC 510 has the following rear interface input and output features:

Arming Input

10 MHz Clock Output

External Clock Input (1, 5, 10 MHz)

Prescaler Function

Reset Input

NOTE

Rear interface information will be found in the Maintenance section of this manual. Refer the interface connections to qualified service personnel.

Installation and Removal

The DC 510 can be used in the TM 5000-Series or TM 500-Series power modules.

NOTE

Refer to the Operator's Safety Summary in the front of this manual before installing this instrument in the power module.

Refer to the power module instruction manual and make sure that the line jumpers are positioned correctly for the line voltage in use. Check the counter and the power module for the proper fuses. Be certain that the power plug for the power module has the proper grounding conductor.

CAUTION

To prevent damage to the instrument, turn the power module off before installation or removal from the power module. Do not use excessive force to install or remove the instrument from the power module.

Check to see that the plastic barrier keys on the interconnecting jack of the selected power module compartment match the cutouts in the rear interface connector for the counter. If they do not match, do not insert the counter until the reason is investigated.

If the cutouts and barrier keys match, align the chassis of the counter with the upper and lower guides of the selected compartment. See Fig. 2-1. Insert the counter into the compartment and press firmly to seat the rear interface connector. Apply power by operating the POWER switch on the power module.

To remove the counter from the power module, turn off the POWER switch, pull the release latch knob (located in the lower left front corner) until the interconnecting jack disengages. Pull the counter straight out of the power module compartment.

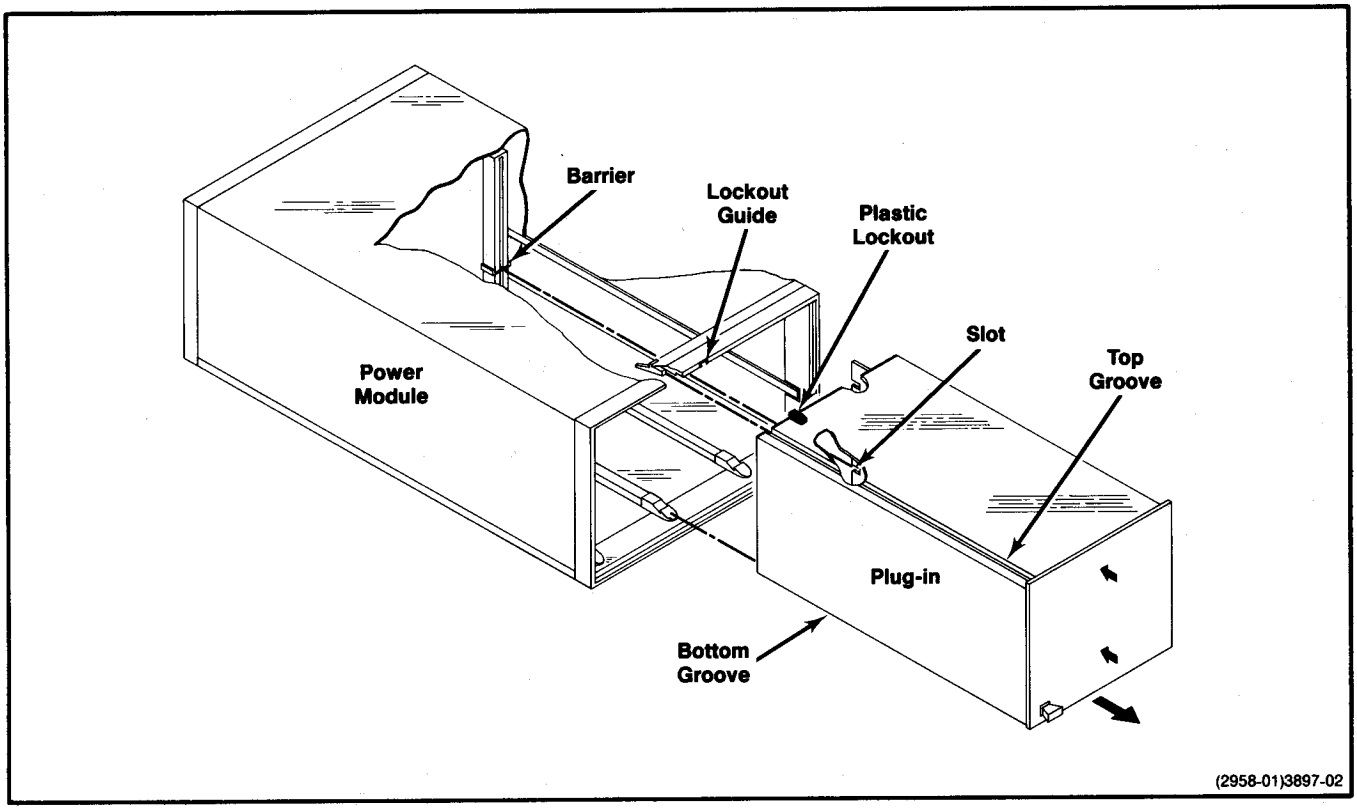


Fig. 2-1. Plug-in installation and removal.

FRONT PANEL OPERATION

The following information is a brief, functional description of the front panel display, controls, and connectors (See Fig. 2-2).

FRONT PANEL DISPLAY

(1) Display

The display contains nine seven-segments LEDS and eight annunciators. All measurement results are displayed with the best possible resolution. The readout (result) for the measurement is always displayed in a right-hand justified format with the decimal point automatically positioned. Displayed count overflow is indicated by a flashing display. In measurements such as Time A→B, where the number of resolved digits increases more slowly with an increase in averaging, only correct (resolvable) digits are displayed.

Five of the annunciators are used to indicate the units of measurements: Hz/SEC for Hertz or seconds, kHz/mSEC for kilohertz or milliseconds, MHz/μSEC for megahertz or microseconds, GHz/nSEC for gigahertz or nanoseconds, and VOLTS/AVGS for (trigger level) Volts, and (the exponent of) the number of Averages.

The GATE annunciator, when illuminated, indicates that the counter is in the process of accumulating counts for the measurement.

The REMOTE annunciator indicates the instrument is in a remotely-programmed state, when illuminated. The ADDRESS light indicates that the instrument is actually being addressed over the GPIB bus.

In addition to displaying the measurement results, the counter uses the extreme left three digits of the seven-segment LED display to indicate internal or operating error codes. The two digits (extreme left-digit Channel A and the extreme right-digit Channel B) on the display report the results of compensating external signal probes. See Self Test Display and Probe Compensation.

In addition, many of the front-panel pushbuttons are illuminated.

FRONT PANEL CONTROLS

(2) TERM, SLOPE, ATTEN, and COMPL (CHANNEL A and CHANNEL B)

TERM–50 Ω, 1 MΩ (termination). When unlighted, selects 1 MΩ, 23 pF; when lighted, selects 50 Ω. Allows user to properly terminate 50 Ω inputs when required. (Unit will automatically revert to 1 MΩ, 23 pF in the event of an overload.)

ATTEN–X1, X5. When unlighted, selects X5; when lighted, selects X1. Allows the signal to be applied directly to the amplifier without attenuation or attenuated by a factor of five. The attenuator effectively increases the input hysteresis and trigger level range by a factor of five.

SLOPE −,+. When unlighted, selects +; when lighted, selects −. This button selects the slope of the signal at the trigger level crossing, which is recognized as a countable event. CHANNEL A slope also selects between risetime (+ Slope) and fall time (− Slope); it must be set before the RISE/FALL A button is pushed.

COUPL–AC, DC. When unlighted selects DC; when lighted selects AC. DC is direct coupled. AC inserts a capacitor in series with the input which allows small signals with large dc offsets to be measured.

FRONT PANEL CONNECTORS

(3) CHANNEL A - CHANNEL B (Identical in performance)

1 MΩ 23 pF/50 Ω. Signal input conectors.
Vpk ≤2 V max (50 Ω)
Vpk ≤42 V max (1 MΩ)

(4) CH A, SHAPED OUT - CH B, SHAPED OUT (Shaped Out A/B/COM)

These outputs provide an exact replica of the internal signal that is being measured. It is an aid to proper triggering on complex waveforms. The outputs provide a 100 mV signal near ground from 50 Ω (200 mV unterminated). These are full bandwidth outputs, and function well beyond 350 MHz.

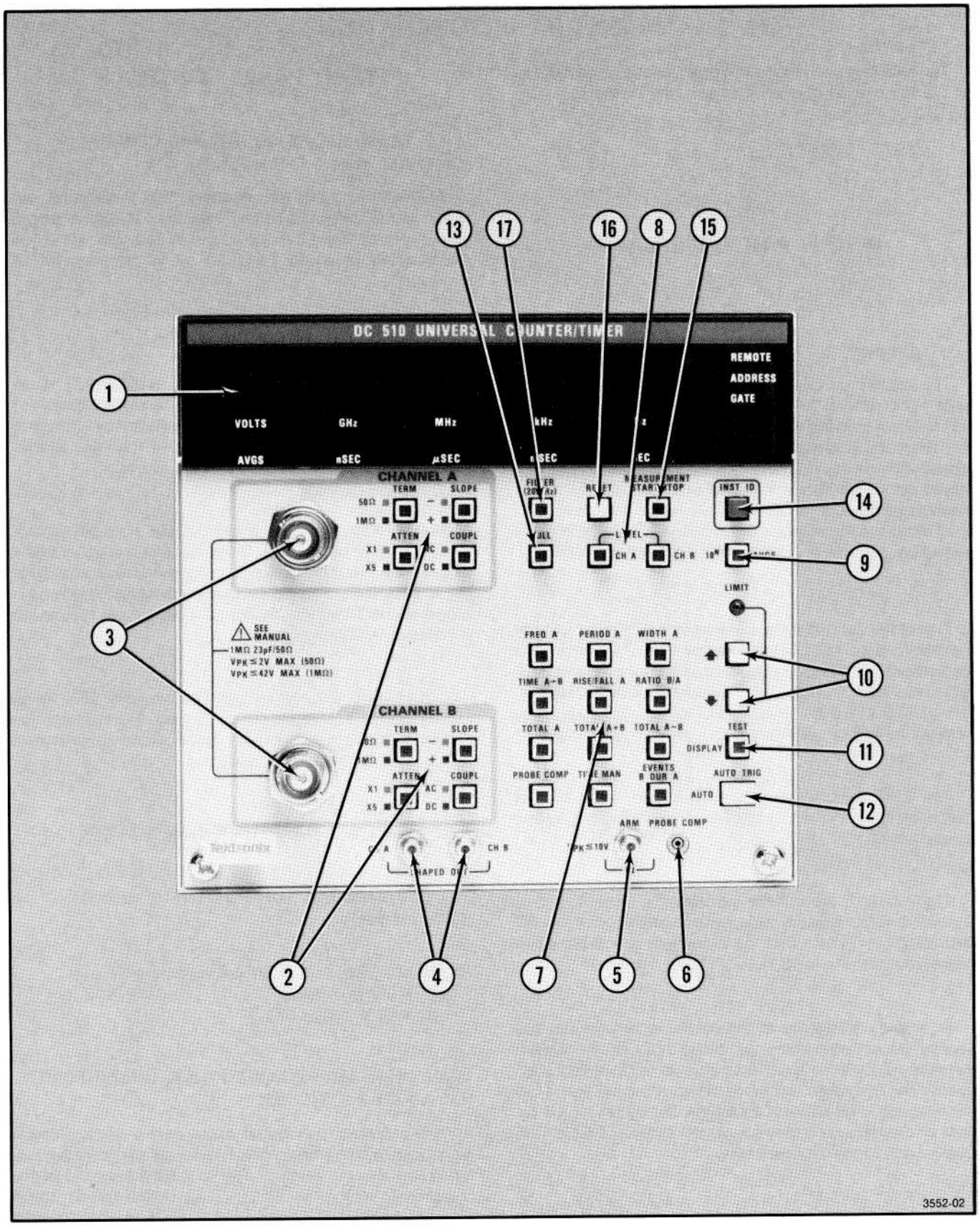


Fig. 2-2. DC 510 front panel display, controls and connectors.

(5) ARM, IN - Vpk ≤10 V (Arming TTL)

This input (normally high) allows the counter to measure only when in the high state. When in the low state, this input prevents the counter from measuring. (Alternatively, this input may be provided through the rear interface.)

(6) PROBE COMP

This test point provides a rectangular waveform (≈5 volts) that can be used in conjunction with the "PROBE COMP" function to compensate test probes (see Probe Compensation in this section.)

FRONT PANEL PUSHBUTTONS

(7) Function Pushbuttons

FREQ A (Frequency A). Measures the period of the Channel A signal, calculates and then displays frequency.

PERIOD A. Measures and displays the period of the Channel A signal.

WIDTH A. Measures the width of a pulse on Channel A. When CHANNEL A SLOPE is +, the positive pulse width is measured. When CHANNEL A SLOPE is negative, the negative pulse width is measured.

TIME A → B. Measures the time between the first occurrence of an event on Channel A and the first succeeding event on Channel B.

RISE/FALL A (Risetime A - Falltime A). Automatically measures the risetime/falltime (10% and 90%) of the signal appearing on CHANNEL A. The appropriate trigger levels are measured and calculated at the time the button is pressed. If the signal amplitude changes, the button may be pressed again. When CHANNEL A SLOPE is +, risetime is measured; for falltime, press CHANNEL A SLOPE =(−) before pressing RISE/FALL A. Since this measurement uses the B channel, its settings are automatically updated to match those of CHANNEL A. After pressing RISE/FALL A, the user is free to modify either CHANNEL A or CHANNEL B separately to suit special measurement needs, though the result may no longer be a traditional Rise/Fall time. (See Risetime A and Falltime A later in this section).

RATIO B/A. Measures and displays the ratio of events occurring on Channel B divided by the events occurring on Channel A over the same time interval.

The three totalize modes of operation count the events that are the occurrences of pulses on Channel A and B.

TOTAL A (Totalized A). In Total A, only Channel A events are displayed.

TOTAL A+B. Displays the total number of events on Channel A plus the total number of events on Channel B. Channel B events are counted only after the first valid Channel A event.

TOTAL A−B. Displays the total number of events on Channel A minus the total number of events on Channel B. Channel B events are counted only after the first valid Channel A event. If A-B is negative, a minus sign is lighted.

NOTE

After a TOTALIZE button is pushed, the START/STOP button lights to indicate a "STOPped" condition. It must then be pressed to start the Totalize process.

Also, the number of digits displayed is "scaled" by the AVGS setting. This scaling does not affect the actual count process, and therefore may be changed while counting without losing counts. Even when counting has been stopped, the display may be moved to the right or left.

PROBE COMP. When in this mode, a visual indication is given (in the display area) that allows the user to easily compensate attached high impedance probes. (See Probe Compensation in this section.)

TIME MAN (Time Manual). Measures time after pressing the MEASUREMENT START/STOP pushbutton (once to start and once to stop). The accumulated count (time) is not reset until the RESET pushbutton is depressed. Like the Totalize modes, this function defaults to the STOPped state when first selected, as indicated by the START/STOP button being illuminated.

EVENTS B DUR A (Events B During A). Measures the number of occurrences of pulses on Channel B during the time interval where the Channel A input signal is greater than (+ SLOPE) or less than (− SLOPE) the Channel A trigger level.

(8) LEVEL CH A, CH B

Displays the chosen trigger level. Trigger level settings may be set for either channel by depressing the appropriate LEVEL button and then using the increment or decrement buttons (labeled 10). To exit this mode, the user can press the LEVEL A (B) button a second time or press any function button.

(9) AVGS (Averages)

Pressing this button displays the current AVGS setting and readies the instrument for a new setting. The user can then choose between several modes.

AUTO - (push the AUTO button, a −1 will be displayed). This mode provides the best resolution possible with a measurement time of approximately 300 mS.

0 - (decrement exponent to zero). The selected measurement is made with at least one event. This is the mode to be used for single-shot measurements. At most frequencies, more than one event will actually be averaged; see the Specification section for further detail.

10^n, n=1 to 9 - Provides selection of minimum number of averages in decade steps.

▲▼ The increment/decrement keys are used to increase or decrease the exponent to the next legal setting.

NOTE

The AVGS settings affects the number of digits displayed for Totalize measurements. When in Auto on n=0, the first nine digits to the left of the decimal point are displayed. When n=1 to 9, the measurement result is "scaled" by 10^n and displayed.

(10)

▲ This button increments the appropriate trigger level if LEVEL CH A - CH B is selected, or the number of averages if AVGS has been selected. Voltage levels are incremented or decremented in steps of 4 mV × attenuating setting.

▼ This button decrements the appropriate trigger level if LEVEL CH A - CH B is selected, or the number of averages if AVGS has been selected.

LIMIT

This light goes on whenever either the increment (↑) or decrement (↓) button has incremented or decremented a setting to its limit. This light goes out when increment (↑) or decrement (↓) button is released.

(11) TEST/DISPLAY

When either of the LEVEL CH A, LEVEL CH B buttons or the AVGS button is lighted, this button alternates what is being displayed in the seven-segment readout. Pressing it once makes the readout revert back to displaying the functional results (frequency, period, etc.) while still leaving the increment/decrement buttons active. Pressing the button again will alternate the display back to showing the voltage level or averages exponent. This allows the user to view either the parameter being changed or the effect of that change on the functional results.

When the LEVEL buttons or the AVGS button is unlighted, the TEST/DISPLAY button is used to select the Test mode. In this mode a portion of the power up test (all but the RAM portion) is repeated. If an error is ever encountered, the test stops, with the appropriate error code displayed. To exit Test mode, push any other function key.

(12) AUTO TRIG/AUTO

If the LEVEL buttons or the AVGS button is unlighted, pressing this button causes an auto trigger on both Channel A and Channel B (the maximum and minimum peak values of the Channel A and B input signals are measured and the trigger levels are set at the midpoints). If LEVEL CH A is selected, pressing this button causes an Auto trigger on Channel A only, and similarly for LEVEL B lighted. If AVGS is lighted, pressing the button enters a −1, which is the code for Auto Averages.

(13) NULL

Pressing the NULL button stores the present measurement result and then subtracts that number from all subsequent measurements (while the button remains lighted). It is most useful in Time A→B measurements, where it can be used to null out systematic errors such as unequal cable lengths and channel mismatches; however, it is available in all measurement functions.

The averages setting may be changed without losing the NULL stored measurement. Now, the instrument will be subtracting two numbers of differing resolution. Since the result of such a subtraction actually has the resolution of the lesser resolution number, that is the one that the counter automatically uses to determine how many digits to display.

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Pressing the button again will re-null the result.

To exit the Null mode, press any function button (including that of the function already chosen).

(14) INST ID

This pushbutton, when pressed blanks the display. In the programmable instrument, this button (when pressed) displays the current GPIB address and message termination.

(15) MEASUREMENT START/STOP

This pushbutton can be used in all of the Function modes except Probe Comp and Test. When it's lighted, measurement is in the "STOPped" state. Pressing the button causes a "STOPped", Totalize, or Time Manual measurement to "Start" from the displayed result. Other measurements (except Probecomp and Test) will "Start" a new measurement. When "Started", pressing the button causes all measurements (except Probecomp and Test) to stop counting. When "STOPped", Totalize and Time Manual measurements read the final count in the count chains and update the display one more time.

(16) RESET

When a measurement has been stopped, this pushbutton, when pressed, will initiate another single measurement. If RESET is pressed while the counter is in the middle of a measurement, the current measurement will be aborted and a new measurement started. RESET, while pressed, also provides a segment test for all the front panel LEDs, including pushbuttons and annunciators.

(17) FILTER (20 MHz) (CHANNEL A and CHANNEL B)

When this button is lighted, the bandwidth of both channels is reduced to 20 MHz. This allows rejection of high frequency noise. It may also be used when initially setting Auto trigger levels or Rise/Fall levels for a signal with overshoot or undershoot.

OPERATORS FAMILIARIZATION

INTRODUCTION

General Operating Characteristics

The DC 510 is a programmable universal counter based on a microprocessor system. The counter is capable of 11 measurement functions with full nine-digit resolution, plus two specialized functions; probe compensations (PROBE COMP) and self-test (TEST).

The microprocessor system automatically sets the measurement gate interval, performs the necessary calculations on the acquired data, and causes the result to be displayed with the best possible resolution for the selected measurement FUNCTION, number of averages (AVGS), and operating conditions.

Self Test Display

When power is applied, one of the error codes listed in Table 2-1 may appear in the display window if the counter fails its self-test routine. Refer the error code condition to qualified service personnel.

NOTE

At power up, a signal with a large dc offset voltage connected to the input terminals for either channel may cause the entire input signal to be outside the triggering level range. If this condition exists, an error code may be displayed. If any of these conditions occur, disconnect all inputs and reapply power. This error condition can also be caused by a low level ARM input signal during power-up.

Table 2-1
FRONT-PANEL DISPLAY ERROR CODES

Serial I/O Fault	313
Channel A	
Counter Integrity	320-324, 329
Channel B	
Counter Integrity	330-334, 339
System RAM Error U1410	340
System RAM Error U1311	342
ROM placement error U1610	361
ROM placement error U1410	380
ROM checksum error U1610	381

NOTE

Refer error code conditions to qualified service personnel.

INPUT CONSIDERATIONS

Maximum Safe Input Voltage Limits ⚠

CAUTION

To avoid instrument damage, make certain that the input voltages to the front panel connectors or rear interface inputs do not exceed their specified limits. See Specification section.

The outer shell of the front panel bnc connectors is connected to earth ground through the ground connection for the power module power cord.

Always use a step-down isolation transformer (less than 15 V output) when measuring power line frequencies (50 or 60 Hz).

Be careful with high-frequency, high-amplitude signals (above 80 MHz). The front panel maximum safe input voltage at these high frequencies is 4 V, peak-to-peak times attenuator setting.

Connecting External and Internal Signal Sources

The DC 510 can be used to measure input signals to either channel from the front panel. The SLOPE, TERM, ATTEN, and COUPL pushbuttons are effective in conditioning the signal.

If a high impedance signal probe is to be used between the front panel bnc connectors and the measurement source, use a probe capable of compensating for the input capacitance of the counter (less than 24 pF). A probe is recommended for all digital logic applications; the TEKTRONIX P6125 has been designed specifically for these counters, and its use is recommended. The counter has been designed, however, to properly trigger on ECL signals even when a X10 attenuator probe is used.

MEASUREMENT CONSIDERATIONS

Input Coupling, Noise, and Attenuation

You can use either the ac coupling (AC COUPL) or dc coupling (DC COUPL) mode to couple the input signal to the CHANNEL A or CHANNEL B input amplifiers. If the signal to be measured is riding on a dc level, its amplitude limits may not fall within the triggering level range. The AC COUPL mode should be used for repetitive signals having a fixed frequency and a constant duty cycle, or for signals riding on a large dc level. Slope selection is relatively unimportant when measuring the frequency or period of sine-waves. The 50 Ω Termination is selected for high frequency 50 Ω systems, while 1 MΩ is selected for high impedance probes and for other high impedance situations. When in 50 Ω, the internal termination resistor could be damaged if the user accidentally applied an overly large signal. To prevent this, the DC 510 automatically reverts to 1 MΩ for most signals that might damage the 50 Ω resistor. See the Specification section for more detail.

If the signal frequency or duty cycle changes, the triggering point may shift, stopping the measurement process. Use the DC COUPL mode for low frequency ac signals, signals with a low duty cycle, and during any time interval measurement (Time A→B, Rise/Fall A, Events B Dur A, and Width A).

Noise may be coupled to the input amplifiers along with the signal to be measured. Noise may originate from the operating environment, the signal source, or be caused by improper connections. If the noise is of sufficient amplitude, it can result in inaccurate measurements due to false triggering. See Fig. 2-3. The DC 510 has a 20 MHz low pass filter (FILTER) that is helpful in removing or reducing noise.

The linear operating range describes the voltage limits that will allow proper triggering without distortion. The minimum signal amplitudes are defined by the input sensitivity requirements for the AC COUPL and DC COUPL modes for either the 1 MΩ or 50 Ω Termination selection (see the Specification section). Proper use of the ATTEN (attenuation) controls will ensure operation within the maximum limits; ±2.0 V for X1 ATTEN, ±10 V for X5 ATTEN.

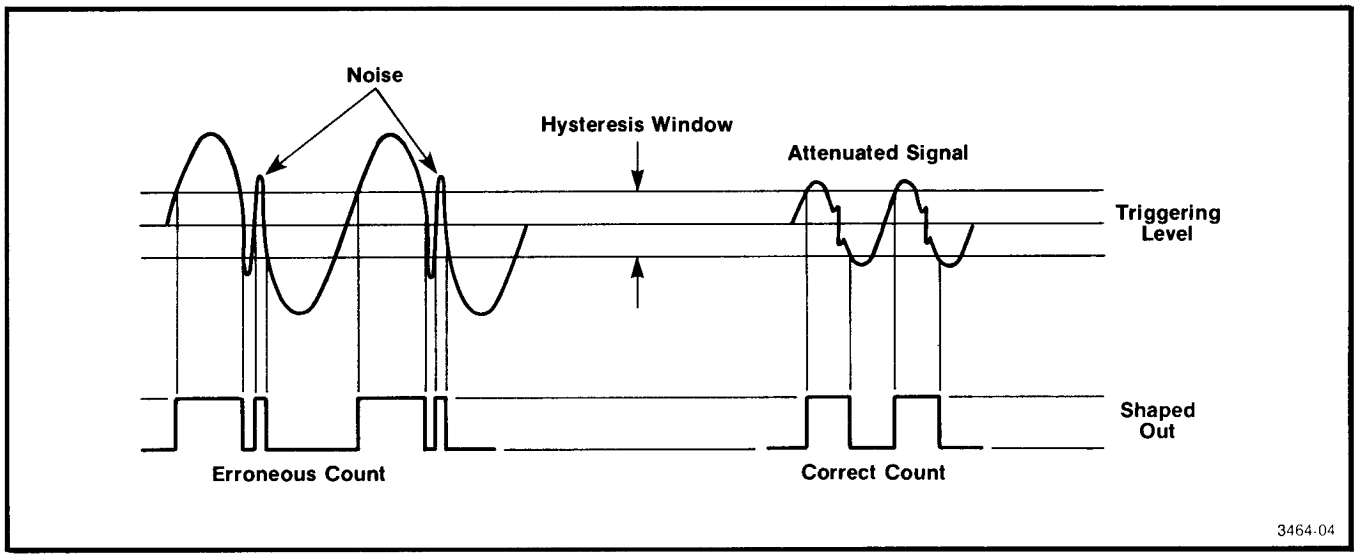


Fig. 2-3. Advantages in signal attenuation.

Triggering the Counter

The dc triggering level is determined by the SLOPE and LEVEL selection, or by the AUTO TRIG button.

The LEVEL CH A and CH B buttons, in conjunction with the increment (↑), and decrement (↓) buttons, are used to move the triggering hysteresis window continuously up or down through a ±2.0 V range in 4 mV steps. The hysteresis window is typically 50 mV peak-to-peak. To determine the exact trigger level settings, push LEVEL CH A (or LEVEL CH B); the respective levels will be displayed. To return to the measurement cycle, press the LEVEL CH A or LEVEL CH B button again (whichever is lighted); pressing any function button will also return the instrument to the measurement mode.

When the AUTO TRIG button is activated, the microprocessor performs a software routine to determine the maximum and minimum limits of the Channel A and Channel B input voltage swings in Channel A and Channel B. Then the routine automatically sets the triggering levels of each channel to 50% (+24 mV for + slope, −24 mV for − slope) of its respective measured minimum and maximum values when making frequency, period, and totalize measurements. AUTOTRIG is also useful for pulse width measurements (WIDTH A mode) and TIME A→B measurements. Successful use of the Auto Trig here requires signal amplitudes of at least twice the effective hysteresis. Thus, signals with amplitudes greater than 140 mV peak-to-peak are typically necessary. This is because the actual trip level of the hysteresis window is set exactly at the 50% point for Width and Time A→B.

Figure 2-4 illustrates typical trigger level settings and shows the importance of setting trigger levels properly in order to avoid errors due to input signal risetimes (falltimes), or where the transition times of the start and stop pulses are different (or just slow). Observation of the SHAPED OUT signals on an oscilloscope, while setting the trigger levels on slow but complex waveforms, aids in reducing trigger setting difficulties.

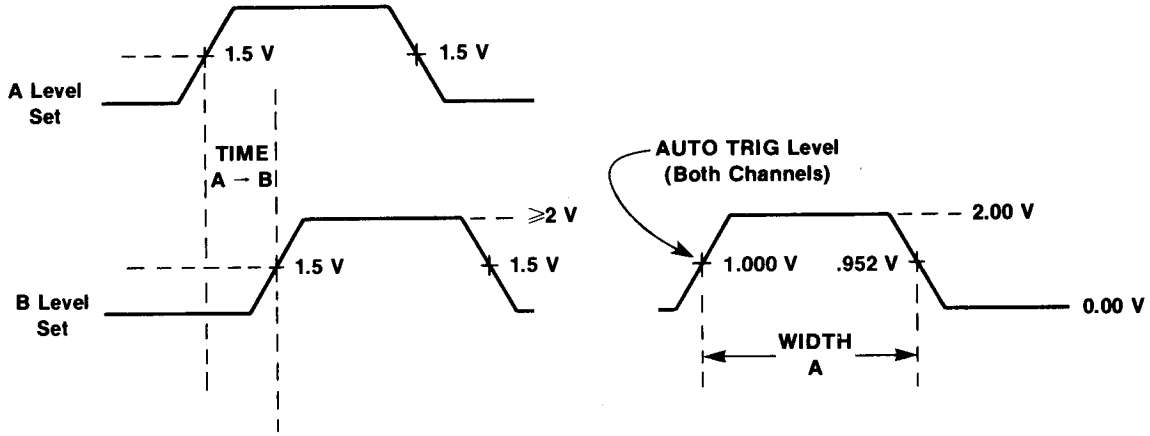
The use of the Auto Trig , though very convenient, does not reduce the need to consider input noise amplitudes, coupling, impedance matching, and attenuation factors. Large amounts of overshoot and ringing of the input signal may cause erroneous counts due to an undesirable level setting. The median value of the input signal may be displayed. For mid-point settings, the low frequency limit for the Auto Trig mode is 10 Hz. Below 10 Hz, the automatic triggering level will still be set between the signals maximum and minimum, but not necessarily at the 50% point. For dc inputs, the level determination provided by auto trigger once again becomes correct.

Reducing Measurement Errors

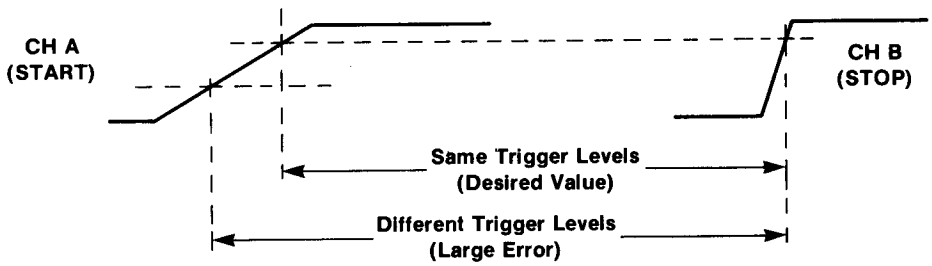
As an aid in reducing measurement errors, keep in mind the following factors.

- Use the ATTEN controls and high impedance, attenuator type probes when measuring signals from high impedance circuits.

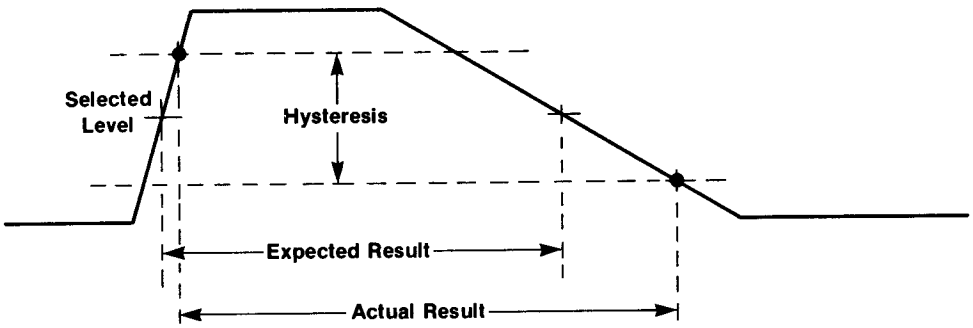
- Use the 50 Ω TERMination control for low impedance, high frequency 50 Ω systems.



(a) Typical TIME A→B and WIDTH A triggering levels.



TIME A → B measurement



WIDTH A measurement

(b) Sources of triggering errors.

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Fig. 2-4. Typical triggering levels and sources of triggering errors.

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- Consider trigger errors caused by input signals with slow rise or fall times.
- Use the 20 MHz FILTER to reduce high frequency noise.
- Average the measurement over a larger number of cycles of the input signal (greater number of AVGS)
- Maintain the counter environment at a constant temperature.
- For greater stability, allow extra instrument warm-up time (> 1/2 hour).
- Substitute the standard time base with the optional, higher stability time base.
- Apply a 1 MHz, 5 MHz, or 10 MHz external time reference standard (NBS) to the rear interface inputs.
- Recalibrate, if necessary.

MEASUREMENT EXAMPLES

Frequency A and Period A

When the counter is in either the FREQ A or PERIOD A modes, it always measures the period of the Channel A input signal. For FREQ A, the microprocessor computes the frequency as:

$$f = \frac{1}{T} \quad (T = \text{period})$$

and displays the answer in frequency units. For PERIOD A, the answer is displayed in units of time. The 320 MHz internal clock insures very high resolution in both frequency and period. For period measurements of fast signals with 10^9 Averages, this resolution is ± 31.25 attosecs (31.25×10^{-18} sec).

Ratio B/A

In Ratio B/A mode, the counter measures the number of events on both channels during the time it takes to accumulate the selected number of Channel A events (averaged by A events). The total number of Channel B events is then divided by the total number of Channel A events and the answer displayed without units of time or frequency.

The ratio range is from 10^{-8} to 10^9. Applying the higher frequency to Channel B produces a ratio greater than one; applying the lower frequency to Channel B produces a ratio less than one. For better resolution, apply the higher frequency signal to Channel B.

Width A and Time A → B (Time Interval)

Figure 2-5 illustrates measurements for the WIDTH A and TIME A → B functions. The WIDTH A function measures the time interval between the first selected positive or negative edge (± SLOPE) of the waveform applied to Channel A and the next opposite polarity edge.

The TIME A → B function measures the time interval between the first selected occurrence (± SLOPE) of an event on Channel A to the first selected occurrence (± SLOPE) of an event on Channel B. The measurement can be averaged (AVGS) by the selected number of Channel A events because there is one Channel B event per Channel A event.

When either the WIDTH A, TIME A → B, or RISE/FALL A function is activated, the microprocesor turns on an internal pseudo-random noise generator that phase modulates the internal 3.125 ns time base, allowing the counter to measure without error, input signals that otherwise would be synchronous with its time base. See Fig. 2-5.

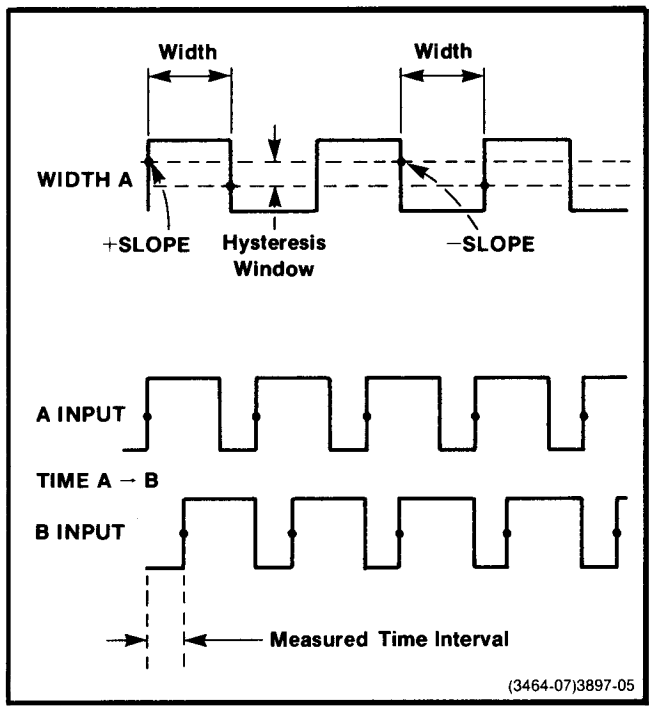


Fig. 2-5. Measurement examples for WIDTH A and TIME A → B.

In Fig. 2-6 the time interval (4.68525 ns, WIDTH A) will not be measured with a non-modulated time base any more accurately with averaging than it could have been by making a single-shot measurement (AVGS = 0). Using the pseudo-random phase-modulated clock pulses, and setting the AVGS switch greater than 1, causes the counter in this example to count one clock pulse one-half of the time and two clock pulses one-half of the time. For example, if AVGS is set to 10 (10^1) the total time for the count is at least 46.8525 ns. Ten averages yields 15 counts (5 counts + 10 counts). Dividing the total count by the number of averages, the average (count/interval) of each count corresponds to 3.125 nsec. The answer, is then ($15/10 \times 3.125 = 4.68525$, which on the DC 510 would be displayed as 4.6 nsec.

Null

Pressing the NULL button stores the present measurement result and then subtracts that number from all subsequent measurements (while the button remains lighted). It is most useful in Time A → B measurements, where it can be used to null out systematic errors (such as unequal cable lengths and channel mismatches); however, it is available in all measurement functions.

The averages setting may be changed without losing the Null stored measurement. If the instrument is subtracting two numbers of differing resolution, the result of such a subtraction has the resolution of the lesser resolution number. This is the number that the counter automatically uses to determine how many digits to display.

Pressing the button again will re-null the result.

To exit the Null mode, press any function button (including that of the function already chosen).

Events B During A

The EVENTS B DUR A function is basically the same as WIDTH A; except, instead of clock edges, the counter counts the selected number of positive-going or negative-going events (± SLOPE, CHANNEL B) occurring during a selected positive or negative pulse width occurring on Channel A (±SLOPE, CHANNEL A). Therefore, the internal time base is not counted for this function. See Fig. 2-7 for a measurement example. The Channel B events are averaged over the selected number (AVGS) of Channel A pulse widths.

Time Manual

The TIME MANUAL function measures and displays the time interval (to the closest one-hundredth of a second) between the first and second depressions of the MEASUREMENT START/STOP pushbutton. The time count can be reset to zero and restarted by pressing and then releasing the RESET pushbutton. The AVGS switch has no affect in the Time Manual mode. When first entering this function, the measurement is in the STOPped mode, as indicated by the lighted START/STOP button.

Totalize A

The Total A function is basically the same as TIME MANUAL except that instead of counting the internal time base pulses, the counter counts the total number of Channel A events occurring between two successive depressions of

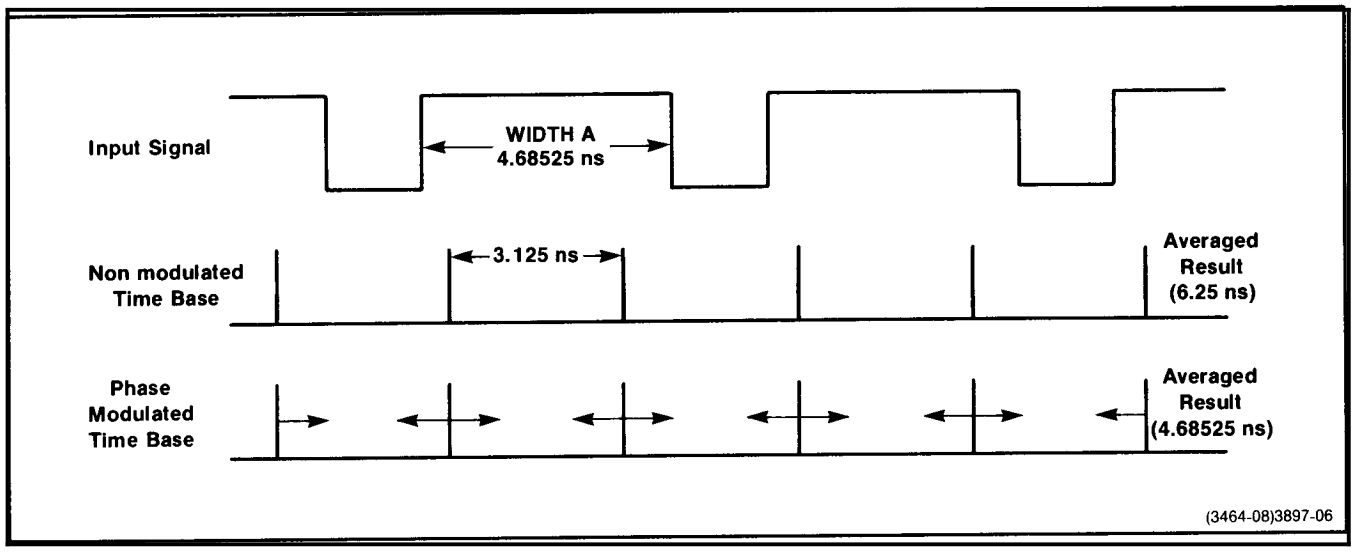


Fig. 2-6. Measurement example for synchronous input signals.

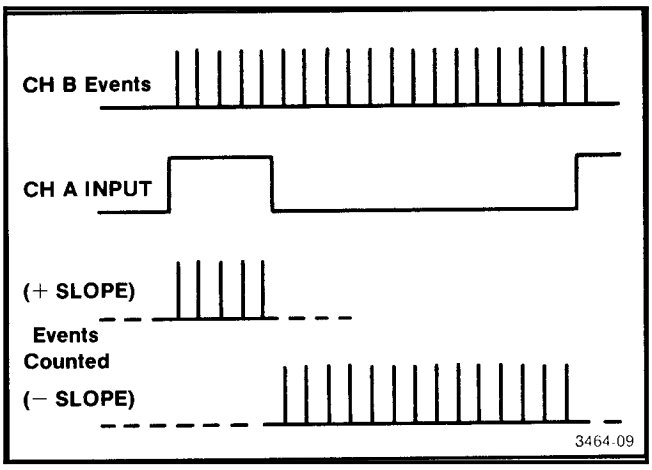


Fig. 2-7. Measurement example, EVENTS B DURING A.

the MEASUREMENT START/STOP pushbutton. The AVGS switch is active in this mode. With the AVGS exponent set to 0 or AUTO (−1), whole numbers are displayed. For other settings, AVGS operates as a power-of-ten scaling indicator (allowing totalizing to the full fourteen digits of the internal count chain). For example, with a 1 MHz input signal and the AVGS switch set to 10^6, the least significant digit displayed would represent 10^6 counts and would increment at one count per second (10^6 Hz/10^6 = 1 Hz). This scaling factor may be changed (Refer to Text) after a measurement is over, effectively moving the display. This allows the user to view all thirteen digits of the count chain.

Totalize A+B

The TOTAL A+B function is as described for TOTAL A with the exception that the counter counts the total number of Channel A events plus the total number of Channel B events. The B count does not begin until after the first valid A count.

Totalize A−B

The TOTAL A−B function is similar to the TOTAL A+B function with the exception that the counter counts the total number of Channel A events minus the total number of Channel B events. The B count does not begin until after the first valid A count.

Risetime A and Falltime A

The RISE/FALL A function allows the operator to automatically measure the 10% to 90% risetime (or falltime) of the counter's specified input signal appearing on Channel A. See Fig. 2-8a. Select the SLOPE (+ = risetime; − = falltime) before pressing the RISE/FALL A button. The input signal size is automatically measured and the 10% and 90% levels are automatically calculated and set.

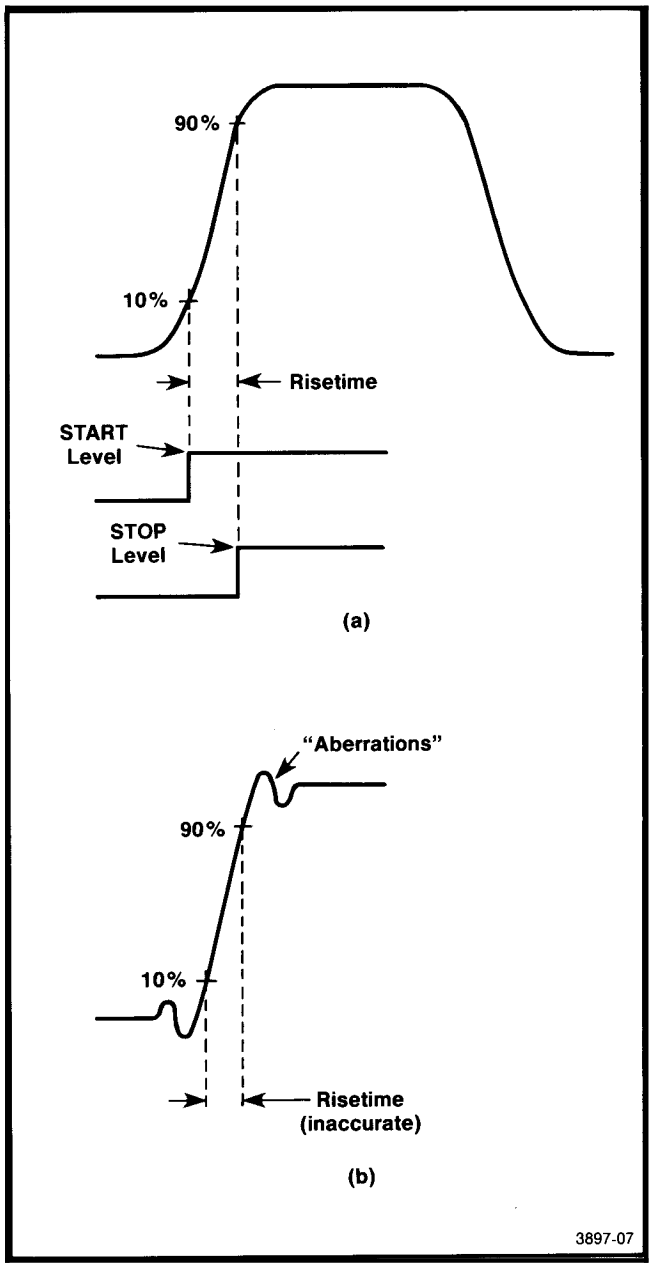


Fig. 2-8. Measurement example for risetime.

Internally, the A input is routed to both the A Channel and B Channel. The A Channel input conditioning is automatically duplicated (and indicated by the front panel lighted buttons) on the B Channel when the RISE/FALL A button is pressed. Although risetime measurements are simple to make, some operator problems can develop (even when using the automatic level setting capability of the counter). The signal being measured must satisfy the instrument requirements as detailed in the Specification section of this manual. The input signal amplitude must be greater than 1.4 V (50 Ω) or 700 mV (1 MΩ), have a risetime not less than 4 nsec (5 nsec for 1 MΩ), and not exceed 10% aberrations.

The DC 510 uses a true peak detector circuit and detects the highest signal peak, even if the peak is an aberration (see Fig. 2-8b). If this aberration is too severe (greater than 10%), the instrument will not measure the correct risetime. Before pressing the RISE/FALL A button, the front panel FILTER (20 MHz) button can sometimes be selected to limit the internal risetime (less than 18 nsec) of the input signal to reduce these aberrations. Effective use of the filter will depend on the signal width and aberrations. Press the RISE/FALL A button. After the signal peak is measured and the 10% to 90% levels are set, the filter would be removed so the DC 510 may display the actual unlimited risetime (without filter).

The counter front panel pushbuttons remain active after pressing the RISE/FALL A button, to enable the operator to modify signal input conditioning and trigger levels. The modified conditioning and levels must satisfy the instrument requirements as detailed in the Specification section of this manual.

For example, if the AUTO button is pressed (while in RISE/FALL A) the Channel A and Channel B levels will move from the 10% and 90% points to the 50% point.

Other specific signal levels such as TTL High or TTL Low can be programmed by the operator; however, consideration must be given for the termination setting. In the 50 Ω termination, the displayed trigger level is one-half the true trigger level due to the internal power splitter (not evident to the instrument). In the 1 MΩ termination the instrument does not take into account any attached probes (see Rise/Fall specification for level information with the use of probes).

Probe Compensation

The DC 510 has been specifically designed to be compatible with standard probes when in 1 MΩ termination; however, the operator must still be sure that the probe is properly compensated.

In the DC 510, a probe compensation (PROBE COMP) function is built into the counter. It allows the user to compensate the probe in place and without the use of an external oscilloscope.

A square-wave signal of approximately 1 kHz and an amplitude of approximately 5 V is provided at the front panel PROBE COMP tip jack.

Connect the probe tip to the PROBE COMP tip jack before entering the PROBE COMP mode.

The counter should display a zero for the most significant digit (far left) and a zero for the least significant digit (far right). The far left digit is for a probe connected to CHANNEL A and the far right digit for a probe connected to CHANNEL B. No decimal points or annunciators should be illuminated.

With the probe connected and the square-wave signal applied, perform the following steps.

1. Slowly rotate the probe adjustment in either direction until the display changes to a continuous 1 reading for the channel being compensated.

2. Slowly reverse the rotation of the probe adjustment until the display *just goes back to a 0.* At this point, the probe will be compensated. A 1 indicates that the probe is over compensated; a 0 indicates under compensation. Final adjustment should be made in the direction where the 1 just changes to a 0.

NOTE

If a display goes to a 1 and remains in that condition for one or more complete revolutions of the probe adjustment, press the RESET pushbutton to clear the condition. This can occur if the connection to the square-wave source became open during the adjustment procedure.

Test Function

A 000 display in the three MSD's for the TEST function is an indication that the microprocessor has checked itself. The test also checks the DC 510's internal serial data path, the integrity of the internal counter chain (accumulators), and, as a by-product, the operation of the digital-to-analog converter (trigger levels) and input amplifier circuits.

The random-access memory space (RAM) is not checked during this front panel self-test; the RAM is checked only at power-up.

NOTE

If the CHANNEL A or CHANNEL B inputs are connected, the peaks of the input signals must be within the triggering level range of the counter for the test function to operate properly. If a failure occurs, first disconnect any CHANNEL A or CHANNEL B inputs and repeat the test. A connection to the arming input may also cause improper operation.

The gate light will flash once each time a full test cycle has been completed. If a failure is ever noted, the error code of that failure will be displayed in the three extreme left digits of the seven-segment display and the cycling will halt. The DC 510 will stay in test mode until another function is selected.

Arming (ARM Input)

Arming provides a means by which single events or sets of events can be selected for measurement within a complex analog or digital signal. Figure 2-9 shows three different examples of arming.

The ARM input requires TTL signal levels. With no signal attached the ARM input is normally pulled high and is thus continuously armed. When the ARM input is pulled low, the counter is prevented from starting a measurement. Arming may be used in all measurement functions with the exception of TIME MANUAL, PROBE COMP, and TEST. In these three functions the ARM signal must be high.

When the arming signal changes to a high state, the first subsequent Channel A event will start the measurement process. When the arming signal changes to a low state, the next Channel A event will stop the measurement process. Therefore, the counter can be controlled as to when, in time, a measurement will be made (even in complex waveforms).

These armed measurements can then be averaged much like time interval averaging. The counter determines the number of digits to display (best possible resolution) based on the number of Channel A events averaged. Typically, each total measurement of Frequency, Period, and Ratio contains a 1 count error and the counter displays the number of digits that can be justified given this error. When using arming in the Frequency Period, or Ratio modes (non-time interval modes), each act of arming and disarming can introduce 1 count errors. The counter does not take this into account, however, and displays the number of digits based only on the total number of events per overall measurement, independent of the number of times the instrument was armed and disarmed.

The actual resolution for a period measurement using arming will be less than that displayed. It can be found using the following relationship:

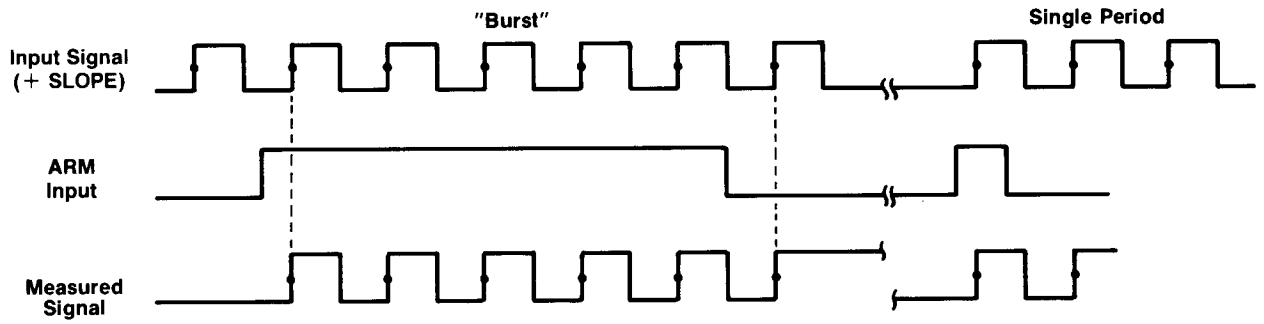
$$\text{Resolution} = \frac{T_c}{N}\sqrt{\frac{N\,T_p}{T_B}}$$

T_c = clock period

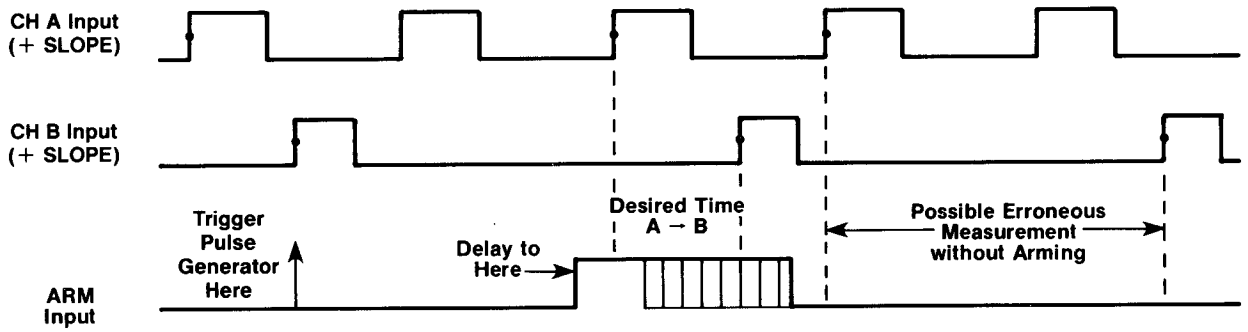
T_p = input period (CH A)

T_B = time from starting A event to stopping A event

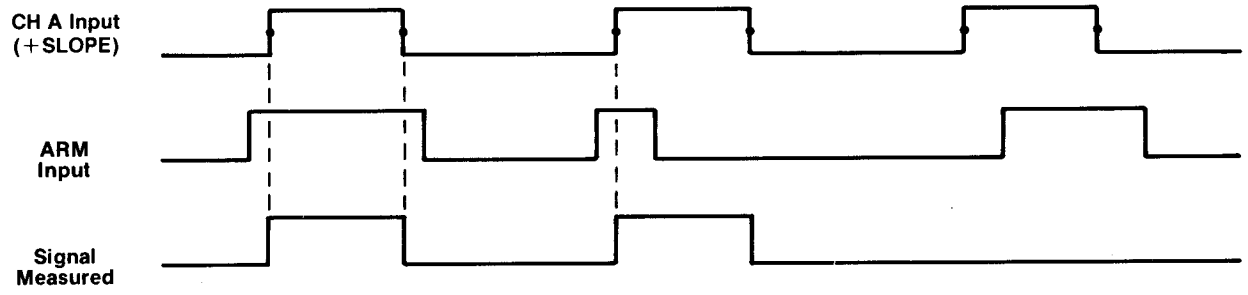
N = number of averages, i.e., 10^6 or 10^9, etc.



a. Use of ARM with FREQ, PERIOD, and RATIO functions.



b. Use of a triggered delay pulse generator to generate a TIME A → B arming signal.



c. Use of ARM with WIDTH A and EVENTS B DUR A functions.

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Fig. 2-9. Examples of arming.

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

THEORY OF OPERATION

BLOCK DIAGRAM DESCRIPTION

Introduction

Refer to the Block Diagram illustration located in the foldout pages at the rear of this manual during the following discussion.

Signal Conditioning and Amplifiers

The functional blocks for the Signal Conditioning and Amplifiers (Channel A and Channel B) are essentially identical. Each channel amplifier circuit contains seven magnetic latching relays which control the input conditioning and routing of the front panel input signals. Six relays control the ac or dc coupling modes, the 1 or 5 attenuation factors, and the termination impedance. The seventh relay provides for a Channel A and Channel B commoning function. The data for these relays are sent from the microprocessor via data shifted through serial-to-parallel shift registers, in these functional blocks.

The Channel A and Channel B amplifiers used matched DMOS FET followers that buffer the input signal and trigger level. The buffered signal and trigger level are combined and amplified in a differential cascode integrated circuit (IC). This IC also provides for switching the output into a low pass filter or straight through at full bandwidth.

Schmitt Triggers

The amplified signal and trigger level are applied to the inputs of the Schmitt Trigge IC. The differential Schmitt output is applied to transistors that select the triggered slope. This circuit also provides the Shaped Out signals.

D/A's, Relay Protect, and Arming

This functional block contains triggering level control and 10-bit digital-to-analog converters (D/A converters) for Channel A and Channel B. The operational amplifiers driven from the D/A converter output, set both the offset and range for the individual channels.

The 50 Ω protect circuitry consists of two "window" comparators (Channel A and Channel B). These comparators receive the protect sense levels from the Channel A or Channel B inputs (relays) and operate within a ±2 volts window sense level. If these voltage levels vary up or down from this window, the comparators will send a protection signal (50 Ω protect) to the microprocessor. The microprocessor automatically changes the input impedance to 1 MΩ and protects the 50 Ω circuitry.

The arming input is applied from the front panel or rear interface. This circuit consists of a 1 TTL input load with appropriate input protection and a Schmitt trigger circuit for noise immunity. The output provides the arming signal ($\overline{\text{ARM}}$).

Main Gating

After the Schmitt trigger, the signals to be measured are routed through the proper logic gates for the operating mode selected. These gates are enabled (or disabled) via latched data in a serial-to-parallel shift register located in this functional block.

The counter has what is sometimes called a "ratio architecture". That is, events are always accumulated in one count chain, called Accumulator A, and a time related or Channel B event count is accumulated in another counter chain, called Accumulator B. The microprocessor actually controls the measurement interval, which is typically asynchronous with the input signals. Thus, two flipflop synchronizers are used to guarantee that the accumulators always see a whole number of pulses of input signals or a whole number of pulses from the internal time base that is being counted.

The arming input ($\overline{\text{ARM}}$), from D/A's, RELAY PROTECT and ARMING functional block, is applied to this block where it is logically ANDed with the measurement GATE generated by the microprocessor.

Time Base, 320 MHz PLL, and Noise Generator

This block contains the 10 MHz crystal-controlled time base, a 320 MHz PLL (phase locked loop) and a pseudo-

random noise generator that is activated for time interval averaging measurements.

The 320 MHz PLL circuit contains a frequency and phase comparator, a filter circuit, a Varactor diode for 320 MHz tuning, and a feedback loop consisting of a fast divide-by-4 section followed by a divide-by-80 section.

CH A and CH B Count Chains

The Channel A signal is divided or counted by four ECL binary stages, five LS TTL binary stages, and then by four binary stages in a single CMOS counter. The Channel A SLOW output from the CMOS counter is then applied to a microprocessor peripheral device on diagram 9, where the signal is counted by another 16 binary stages internal to that device.

The Channel B accumulator is similar to the Channel A accumulator with four ECL binary stages, five LS TTL binary stages, followed by 15 binary stages in two CMOS counters. The Channel B SLOW signal is also applied to the microprocessor peripheral device on diagram 9. Each accumulator circuit has ECL to TTL or ECL to CMOS translator circuits where required.

The outputs of these counters are applied to the parallel inputs of five parallel to serial shift registers (two for Channel A and three for Channel B). To obtain the binary count accumulated in these counters, the microprocessor asserts the Serial Read Latch Line at least once for every measurement interval.

Processor and Display Drivers

The microprocessor control the measurement gate interval, generates the relay strobe signal, and by using address decoding circuits enables the shift registers, display strobe circuits, and the data buffer for the front panel button sensing. This functional block has a microprocessor peripheral device containing a 128 X 18 static RAM, a 2048 X 8 ROM, a programmable counter, an 8-bit serial data channel, bidirectional data lines, and interrupt inputs. Additional program memory space is provided by a 4096 X 8 ROM and a 256 X 8 RAM.

Pushbuttons and LED's/Display

The key element in this functional block is a ten-state decade counter that provides the time slot decoding for scanning the front panel pushbuttons and other controls. The counter also provides the multiplexing functions for the seven-segment LED display and annunciators. Information is presented to the display by latching six bits of data from the microprocessor parallel data bus. Four bits of the latched data are then decoded from binary coded decimal to seven-segment information. The remaining two bits are used to drive the annunciators and decimal points.

The display consists of nine seven-segment LEDs, annunciators, and the LEDs of the lighted pushbuttons. The time slot lines generated by a ten-state decade counter drives the common cathodes of the seven-segment LEDs and scans the buttons and annunciators. The anodes of the seven-segment LEDs are connected to a buffer circuit through current limiting resistors.

Power Supplies

The instrument draws power from both of its power module connectors to derive its four primary supplies: +5 V and +12 V on the Auxiliary board and another +5 V and −12 V supply on the Digital board. Each supply is current limited and individually fused, and all four are referenced to a single precision 2.5 V reference IC. Several secondary supplies include +2.7 V for the ECL terminator, a +18 V three-terminal regulator chip (in Option 01 timebase only), a −15 V supply derived from the −12 V, a 2.5 V supply to drive the reference IC, and several isolated versions of +5 V, separated by L-C filters.

DETAILED CIRCUIT DESCRIPTION

SIGNAL CONDITIONING AND AMPLIFIERS—DIAGRAM 1

NOTE

Since the Channel B Signal Conditioning and Amplifier circuitry is essentially identical to the Channel A circuitry, this description discusses the theory of operation for the Channel A circuits only.

The Channel A input signal is routed to two magnetic latching relays. Relays K1612S (Channel A) and K1632S (Channel B) provide a normal mode operation (separate channels) or common mode operation (both channels). In the common mode operation (Common Separate), Channel B input becomes an open circuit. The common mode operation is used when making risetime and falltime measurements. In this mode, with the input impedance set to 50 Ω, the leadless chip component, R1611, in conjunction with the 50 Ω (TERM) in each channel, becomes an internal power splitter. Relays K1611S and K1510S provide for 50 Ω termination. When in 50 Ω input impedance, relay K1610S selects either ac or dc coupling (COUPL). In the dc coupling position, resistor R1612 discharges the ac coupling capacitor, C1610. Component R1512 is the isolation resistor for the 50 Ω Protect A Sense line, which will be discussed later. Relay K1511 selects either the X1 or X5 attenuation (ATTEN), when in 50 Ω (TERM).

In the 1 MΩ termination, selected by K1611S, relay K1600 selects either ac or dc coupling (COUPL). In the dc coupling position, resistor R1601 discharges the ac coupling capacitor, C1601. If X5 attenuation is selected, the signal enters the hybrid attenuator, AT1505. The component C1504 is a compensation capacitor and R1504 is the 1 MΩ termination resistor. When attenuated, resistors R1506 and R1507 provide damping for optimum ac performance.

Input signal protection is provided by diode network, CR1512, CR1510, CR1511, CR1513, and resistor R1510 and capacitor C1518.

A matched pair of DMOS field effect transistors (FET), Q1410, provide buffering for both the input signal (at pin 8) and the triggering level signal (at pin 4). These matched FET devices cause a matched level shift from 0 volt to approximately −4.5 volts. Diodes CR1411, VR1412 and CR1410, VR1413 will limit large (overdriving) signals and protect integrated circuit (IC) U1311. In common mode operation, differential transformer, T1410 converts a single-ended signal into a differential signal at high frequencies. This helps to provide for better high frequency performance and helps to reject noise. The FET source followers each have a current source. Transistor Q1402 is the current source for the triggering level source follower output. Transistor Q1403 is the current source for the input signal source follower output.

The IC U1311 is a cascode differential amplifier with switched signal output capability. Signals can be either passed straight through at full bandwidth or through a two-pole low pass filter that passes frequencies from dc to approximately 20 MHz. These signals are switched by control voltages generated from the logic signal $\overline{\text{FILTER}}$ at pins 12 and 11 of U1311. Being complementary, through Q1211 (signal inverter) and Q1210 (buffer) they appear in the Channel B circuitry as well. Therefore, the filters may or may not be selected by these inputs.

Resistor R1417 sets the gain for U1311 (pins 2 and 3). This leadless chip component is soldered directly to the IC pins for optimum ac performance. Transistors Q1400 and Q1401 are current sources for the cascode differential input. Low frequency peaking is provided by components R1406, R1405, and C1403.

SCHMITT TRIGGERS—DIAGRAM 2

The buffered and amplified differential signal is applied to pins 2 and 3 of U1310 (Schmitt Trigger circuit). These signals are looped through this IC and appear at pins 12 and 11, with the load resistors R1313 and R1216. Transistor Q1303 is a current source for the Schmitt Trigger latch devices. The Schmitt Trigger differential output (pins 6 and 8 of U1310) is level shifted by transistors Q1204, Q1302, Q1300, and Q1301. Positive slopes are selected by Q1204 and Q1302 and negative slopes are selected by Q1300 and Q1301. These common base stage level shifters are driven by the + SLOPE A and − SLOPE A signals through transistors Q1202, Q1201, and associated circuitry. The shaped output signal from Q1204 or Q1300 enters Q1203 base, inverts and outputs to J1201 (CH A SHAPED OUT). The output signal (CH A ECL) from Q1302 or Q1301 routes to the ECL logic circuitry (Diagram 3). An operational amplifier, U1202B (Diagram 2) sets the mean dc level of the ECL signal to the correct value. A threshold level generated by an ECL signal (Diagram 3) is sensed at pin 5, U1202B and compared to the mean level sensed at pin 6, U1202B. The output (pin 7, U1202B) supplies the current necessary to adjust the level shifted output to the correct mean ECL threshold level.

MAIN GATING—DIAGRAM 3

The microprocessor controls the measurement gate interval through the GATE signal going to pin 4 of U1110B. The IC's U1000C and U1000B operate as synchronizers to ensure that the accumulator gates, U1001C and U1110A open and close at the proper time for the desired measurement. Synchronizing the accumulator gates with the signals to be counted ensures that the accumulators will contain a count corresponding only to a whole number of input and time-base pulses. In the absence of the synchronizers, the gates would sometimes pass fractional pulses, and the count chains might not be able to make a reliable count. The signals to be counted clock the synchronizers at pin 16, U1000C and pin 1, U1000B.

Before each measurement is initiated by the microprocessor, U1000C and U1000B are set by a MR_1 (Master Reset) pulse on connector J1010 pin 1. The IC's U1001C and U1110A are thus disabled by the high level synchronizer outputs at pins 14 (U1000C) and 11 (U1000B) until the measurement begins.

For those modes that use the Channel A Amplifier with positive slope triggering, negative-going edges are generated on pin 6 of U1001B. Pin 7 of shift register U1200 is latched high for all operating modes except the time interval modes (TIME A→B, WIDTH A, RISE/FALL Time, and EVENTS B DUR A). With pin 7 of U1200 high, U1210D pin 12 is low, so Q114 is enabled. The Channel A signal is then inverted by U1001C and clocks U1000A on pin 5. The Channel A complement signal appearing on pin 6 of U1001B, is inverted by U1001E and clocks the synchronizer flipflop U1000C pin 16 after passing through U1001D.

NOTE

Transistors Q1110, Q1114, Q1111, Q1112 and Q1000 operate as switches to route the Channel A, Channel B, and 320 MHz time base signals through the proper logic gates for the selected front panel function. These transistors are either completely "on" or completely "off", depending on whether their base resistors are pulled high or low. Transistor Q1100 is used to disable U1001A. See Table 3-1.

FREQ A and PERIOD A

If the $\overline{\text{GATE}}$ signal from the microprocessor (U1200 pin 4) and the arming signal ($\overline{\text{ARM}}$) on J1102-1 are both low, a low is set on the D input (pin 15) of U1000C after passing through U1110B. This low is transferred to pin 14 on the first Channel A edge that clocks U1000C after the measurement gate started. The low on pin 14 enables the second synchronizer, U1000B, and the Channel A accumulator gate, U1001C. With U1001C enabled, the next negative edge of the Channel A signal is allowed to pass through U1001C, gets inverted, and is counted by the first binary stage of the Channel A accumulator (U1000A, pin 5).

For the FREQ A and PERIOD A functions, pin 14 of shift register U1200 is latched low. This turns on U1110C and turns off Q1112, allowing the 320 MHz time base signal to clock U1000B on pin 1. The first positive time base edge to clock U1000B after U1000C changed state, sets a low on pin 11 of U1000B, enabling the Channel B accumulator gate, U1110A. The next negative edge of the 320 MHz time base signal then passes through U1110A in its inverted form and is counted by the first binary stage of the Channel B accumulator (U1011C).

Table 3-1
SIGNAL ROUTING SWITCHING LOGIC FOR U1200
(X = low, blank = high)

PIN NUMBERS

Function	11	12	13	14	7
FREQ A				X	
PERIOD A				X	
WIDTH A		X	X	X	X
TIME MAN				X	
TIME A→B	X		X	X	X
RISE/FALL A	X		X	X	X
RATIO B/A	X				
TOTAL A, A+B, A−B	X				
PROBE COMP	X				
EVENTS B DUR A		X	X		X

After the synchronizers and accumulator gates have been enabled, all succeeding input pulses are counted by the Channel A accumulator and all succeeding time base pulses are counted by the Channel B accumulator.

The counting process continues until the selected number of averages have been satisfied or the time out period, while in the auto mode, has been satisfied. At this point, the gate signal from the microprocessor goes high, setting the D input (pin 15) of U1000C high. The next positive edge of the Channel A signal then clocks U1000C and pin 14 goes high, disabling U1000B and U1001C. The next 320 MHz time base edge then clocks U1000B, disabling U1110C and sending $\overline{\text{END}}$ low alerting the microprocessor that the measurement cycle has ended.

When the measurement cycle has ended, the microprocessor reads the total counts in both accumulators. The Channel A accumulator contains the number of events or periods and the Channel B accumulator contains the number of time base clock pulses counted over the same interval.; The microprocessor divides the number of events in the Channel A accumulator by the total time in the Channel B accumulator to obtain the frequency (FREQ A) or divides the total time in the Channel B accumulator by the number of events in the the Channel A accumulator to obtain the period, or time per Channel A event (PERIOD A).

RATIO B/A

The RATIO B/A mode is the same as FREQ A and PERIOD A, except that instead of counting 320 MHz time base pulses, U1110C is disabled by a high on pin 14 of shift register U1200, and Q1112 is enabled by a low from inverter U1210E.This allows the Channel B signal to clock U1000B. The counts are accumulated over the time interval determined by the number of averges selected. The RATIO B/A result is then calculated by dividing the number of Channel B events by the number of Channel A events. The AVGS exponent refers to the count in Channel A.

TIME A→B

For the TIME A→B function, Q1110 and Q1112 are disabled; Q1111, Q1114, Q1000, U1001E, U1110C, and U1001D are enabled. The first Channel A pulse slope that is selected, is inverted by U1001B, inverted again by U1001E, and then applied to pin 19 of U1001D. The synchronizers have been set by the MR_1 (Master Reset) pulse and the Channel A pulse clocks on pin 16 of U1000C.

As soon as the gate signal from the microprocessor sets pin 4 of U1110B low, the next Channel A clock edge to U1000C transfers the low on pin 15 to pin 14 and sets pin 13 high. The high on pin 13 passes through Q1000, disables U1001E, and prevents U1001D from being clocked by succeeding Channel A pulses. The Q output of U1000C (pin 14), being low, enables U1001A and allows the first succeeding Channel B pulse edge to clock U1000C via U1001D, setting pin 14 high and pin 13 low again. Pin 13, going low with the Channel B edge, also re-enables U1001E again for the next Channel A edge to clock U1000C.

During the period of time that pin 14 of U1000C is low, U1000B is enabled. The 320 MHz time base clock pulses are synchronized and gated by U1000B and U1110A, and then counted by the binary stages in the Channel B accumulator, beginning with U1011C.

Since Q1114 is disbled, U1001C is enabled with a low on pin 17 and also enabled each TIME A→B interval appears as a negative pulse on pin 10. This negative time interval pulse is converted to a positive time interval pulse by U1001C and then counted by the binary stages in Channel A accumulator. Thus, for each TIME A→B interval, a count is accumulated in the Channel A accumulator; and during each of these intervals, the 320 MHz clock pulses are accumulated in the Channel B accumulator.

The microprocessor is continually reading the counts (accumulated time intervals) in the Channel A accumulator. When it finally reads a count greater than or equal to the selected number of averages (10^N) or when the measurement time in the auto mode ($\approx$0.3 seconds) has been satisfied, the microprocessor sets the gate signal on pin 4 of U1110B to a high level. The next Channel A pulse clocks a high through U1000C to pin 18 of U1001C and disables U1000B. The next 320 MHz clock pulse then toggles U1000B, disabling U1110A and allows the $\overline{\text{END}}$ signal line (J1102-1) to go low. This alerts the microprocessor that the measurement cycle has been completed. The microprocessor then makes a final reading of both accumulators, divides the total time by the number of intervals, and updates the display during the next measurement cycle.

WIDTH A

The WIDTH A function is essentially the same as the TIME A→B except that Q1111 is disabled and Q1110 is enabled. This then allows the leading edge of the Channel A pulse width to be measured, and applied to pin 23 of U1001E and the trailing edge to be applied to pin 2 of U1001A, through the 3.5 ns delay line (DL 500).

The synchronizers (U1000C and U1000B) and the accumulator gates (U1001C and U1110A) function exactly like they did in TIME A→B. The pulse widths are regenerated on pin 14 of U1000C and during each of the negative pulse intervals, U1000B and U1001C are enabled so that the 320 MHz clock pulses (via Q1110C) can be counted by the Channel B accumulator. Also, each regenerated pulse is passed through U1001C and counted by the Channel A accumulator. Again, when the averages conditions have been satisfied, the microprocessor stops the measurement gate, reads both the accumulators, and divides the total time by the number of regenerated time intervals to obtain the averge pulse width.

EVENTS B DUR A

The EVENTS B DUR A function is the same as WIDTH A except that instead of counting 320 MHz clock pulses via U1110C, the instrument is counting Channel B events during the selected Channel A pulse width via Q1112. To do this, Q1110, Q1112, and Q1000 are enabled. The leading and trailing edges of the Channel A pulse are again applied to pin 23 of U1000E and pin 2 of U1001A.

The Channel B signal passes through Q1112 to clock the second synchronizer, U1000B. When the gate signal on pin 15 of U1000C goes low, the synchronizers and accumulator gates function exactly as they did in WIDTH A (and described for TIME A→B). With U1001C enabled on pin 18, the Channel A pulse widths are counted in the Channel A accumulator while the Channel B events are counted in the Channel B accumulator. In EVENTS B DUR A the instrument is counting Channel B events only during Channel A pulse widths and averaging by the selected number of Channel A events.

When the selected or auto averages condition has been satisfied, the microprocessor sends the gate signal on pin 15 of U1000C high. The next Channel A trailing edge disables U1000B (pin 2 high) and the succeeding Channel B edge sets a low on pin 12 of U1000B. This completes the measurement cycle.

TIME MANUAL and TOTALize A

For the TIME MAN and TOTAL A functions, the microprocessor asserts the gate signal on pin 15 of U1000C after the MEASUREMENT START/STOP pushbutton on the front panel is pressed to start the measurement. The gate is unasserted (set high) when the pushbutton is pressed to stop the measurement.

For the TIME MAN function, Q114, Q1100, and U1110C are enabled. Immediately after asserting the gate signal, the microprocessor momentarily changes the Channel A triggering slope from its current setting to the opposite setting and then back again. This change provides an artificial Channel A signal that enables U1000C and allows the 320 MHz clock signal count to be accumulated in the Channel B accumulator. The accumulation continues until the measurement is stopped, at which time the microprocessor unasserts the gate signal and provides another trigger slope change to disable U1000C. This stops the accumulation of time base clock count. Throughout the measurement, the B Channel is continually read and then directly displayed with the proper annunciator illuminated.

While taking this reading, the display will occasionally flicker during the measurement. This is not the result of miscounting by the Channel A or Channel B accumulators; the correct count will be displayed when the measurement is finished.

For the TOTAL A function, Q1114, Q1100, and Q1112 are enabled. When the gate signal is asserted, Channel A events are counted (totalized) in the Channel A accumulator until the measurement is stopped. In this case, the microprocessor does not read the Channel B accumulator; only the Channel A accumulator counts are displayed. Display scaling is accomplished by the microprocessor using the AVGS setting to select the desired scaling factor (power-often). This scaling is independent of the actual counting process and can be changed during or after a measurement without affecting the count. Thus, the full 13 digits of the internal count chain can be examined by changing the AVGS exponent. Time, frequency units, and decimal point are not displayed for this function.

PROBE COMP and TEST

For the PROBE COMP function, the operator applies probe compensating signals to either Channel A or Channel B. For either of these modes, the counter is set up (internally) in RATIO B/A mode. This allows the Channel A or Channel B signals to pass straight through to the accumulators.

For the TEST function, the microprocessor generates artificial signals by programming the digital-to-analog converters (Diagram 6) through their full range. The outputs of the digital-to-analog converters are applied as trigger level changes to the differential amplifier circuits in the Channel A and Channel B Amplifiers (Diagram 2) an end up as counts in the two count chains. If an illegally large signal is present on an input (a signal beyond the range of the digital-to-analog converters), this process does not produce counts, and the TEST may fail. When a failure is indicated, all inputs should be disconnected and the TEST rerun.

A complete description of the self test function is in the Maintenance section. Front panel procedures for the PROBE COMP function are found in the Operating Instructions.

CHANNEL A AND CHANNEL B COUNT CHAINS—DIAGRAM 4

The Channel A and Channel B accumulators are two nearly symmetrical binary ripple counters, each having the capabilities for its contents being "read" serially by the microprocessor. Each accumulator begins with high speed ECL. Then, as the maximum toggle rates decrease, goes to medium speed ECL, then to LS TTL, and eventually CMOS. Wherever possible, a counter IC of a given family is shared: one half is used by Channel A and one half by Channel B.

The Channel A accumulator begins on the Analog board (A12) with signals clocking U1000A, pin 5 (see Diagram 3). The Channel B accumulator signal clocks U1011C, pin 1. The first two binary stages for each accumulator are ECL 100k and consist of U1000A and U1011A (Channel A) and U1011C and U1011B (Channel B).

The counts (CH A FAST and CH B FAST) are routed from the Analog board to the Digital board (A16) through coaxial cables (W520 and W530). The next two binary stages for each count chain are ECL 10k and use IC's U1810A and U1801A (Channel A) and U1810B and U1801B (Channel B). Transistors Q1702, Q1701, Q1704, and Q1703, with associated circuitry, operate as fast ECL to LS TTL converters. These converters provide drive for the following LS TTL stages and must operate reliably up to 25 MHz. The counts in these (and the preceding) ECL stages must also be converted to CMOS levels for eventual readout by the microprocessor. However, since this conversion occurs long after the count chains have stopped counting and are stabilized, these translators need not be fast. The comparators U1710A, B, C, D and U1102A, B, and C have one input set at a voltage half-way between an ECL high and low. This voltage is set by resistors R1712 and R1710. With pull up resistors R1420 (fixed resistor network), R1207, R1208, and R1209 tied to +5 volts, the ECL transition from high to low (on the other input) results in a full CMOS swing on the comparators output. This results in a highly reliable translator that draws little power.

The next bit of each chain is a single LS TTL flip flop, U1120A, Channel A (U1120B, Channel B). Following this IC is an LS TTL 4-bit counter, U1113A, Channel A (U1113B, Channel B). These stages, too, must be read by the microprocessor. The LS TTL outputs are pulled high by the fixed resistor network, R1014, to ensure valid CMOS levels to the serial readout circuitry. At this point, the two accumulator chains lose their symmetry (not for functional reasons but for more economical use of the components). The Channel A accumulator uses the 16-bit counter contained in U1410 (see Diagram 9). The Channel B accumulator (Diagram 4) uses 11 of the 12 bits available in the CMOS counter, U1212. The circuitry described provides a total of 29 hardwired bits for the Channel A accumulator and 24 hardwired bits for the Channel B accumulator. Since each accumulator requires 43 bits, the firmware counters supply 14 bits (Channel A) and 19 bits (Channel B) respectively.

Five CMOS parallel-to-serial shift registers consisting of U1121, U1114, U1122, U1211, and U1312 are used by the microprocessor to read out the contents of the Channel A and B accumulators. When the ILATCH control line (pin 9 of each register) is brought high, data are applied into the registers asynchronously with the clock. When pin 9 is brought low again, data can be shifted into (pin 11 of each register) and out of (pin 3 of each register) the registers synchronously with the positive transition of the SERIAL CLOCK signal (pin 10 of each register).

Before each measurement is initiated by the microprocessor, the MR_1 (Master Reset) signal is asserted via pin 33 of U1410 (see Diagram 9). This reset signal is inverted by U1520D (Diagram 4) applying $\overline{MR}$ to pin 1 of U1120A. The $\overline{MR}$ signal is also inverted and buffered again by U1314D, U1314F, and U1520E to provide an ECL, LS TTL, and CMOS compatible reset signal (MR_1) to the ECL stages on both the Analog and Digital board and to the LS TTL and CMOS stages on the Digital board. The MR_1 signal also guarantees the two synchronizer flip flops (located on Diagram 3), U1000C and U1000B, will begin set.

TIME BASE AND 320 MHz PLL—DIAGRAM 5

The 10 MHz standard time base consists of a 10 MHz crystal, Y1520, and a Colpitts oscillator circuit, Q1420, and associated circuitry. The frequency of the standard time base is adjusted by variable capacitor, C1521 (accessed through the instrument's back plate).

The Option 01 high stability time base consists of a self contained, oven controlled 10 MHz oscillator, Y1530. This time base is adjusted via a hole in the rear of the case (accessed through the instrument back plate). The 18 volts input to the time base is derived from the fused +26 volts in the power module and regulated by a three-terminal regulator circuit, U1430, and associated circuitry.

NOTE

The single-starred schematic diagram 5 components for the standard time base circuit are removed if the Option 01 time base circuit is installed.

The 10 MHz output signal from either the internal time bases or an external source (1, 5, 10 MHz) is applied to the base of Q1500. The buffered signal at the collector of Q1500 can be either 1 MHz, 5 MHz or 10 MHz. This signal is buffered again by U1500F. If the input signal frequency is 1 MHz, jumper plug P1510 (located on the Auxiliary board) connects pins 4 and 5 of J1510. A 5 MHz external input signal requires that IC U1411 divide-by-five (÷5), therefore, P1510 connects J1510 pins 2 and 3 or pins 3 and 4. A 10 MHz time base signal requires U1411 to divide-by-ten (÷10). Component P1510 then connects J15120 pins 1 and 2. The signal to the base of Q1401, in all cases, must be 1 MHz.

Emitter follower Q1401 and associated components operate as a single-pole filter generating a sawtooth type signal at the negative input pin of comparator U1400. For the TIME A→B, WIDTH A, and EVENTS B DUR A functions, the base of Q1300 is set low via pin 7 of shift register U1200 (as shown on Diagram 3). In these functions, the Noise Generator (Diagram 5), U1410, is enabled by applying +5 volts to the V_{ss} input, pin 4. The output from U1410 (pin 3) will be −12 volts to +5 volts signal with a pseudo-random edge

distribution. This signal is then attenuated by resistor, R1410, and applied to pin 2 (+) of U1400. Also, with these functions, U1400 operates as a phase modulator circuit. The output (pin 7) of U1400 is a 1 MHz signal that is phase modulated by the noise signal generated by U1410. For the other remaining functions, transistor Q1300 is turned off, U1410 is disabled, and U1400 operates only as a buffer stage.

The 1 MHz squarewave signal from U1400 (pin 7) is applied to pin 1, U1021 with the negative edge (falling edge) used as a reference edge for the Phase Locked Loop (PLL) U1021. This IC compares the signals negative edge (pin 1) with the positive edge (pin 3) and produces an output proportional to the phase difference between these two input signals. The output at pins 5 and 10 (U1021) is then filtered by a low pass filter with its bandpass providing the proper phase noise bandwidth for time interval measurements. This filter, Q1030A with associated components, is amplified and inverted by operational amplifier U1030B. The amplifier output is a dc level proportional to the phase difference between the 1 MHz reference and the output of the PLL multiplier. The dc level voltage is coupled to a Colpitts oscillator circuit, Q1130 and associated components, and is inductor-tuned by the varactor diode, CR1130, and series capacitor C1032. The PLL adjusts the varactor diode voltage, which adjusts the oscillator frequency producing a precise 320 MHz output signal. The oscillator output is ac coupled to U1022A and a threshold reference voltage is generated by sensing the complementary outputs of U1022C through resistors R1021 and R1036. The voltage, at the junction of these two resistors, establishes this threshold reference at pin 3 of U1022A. The oscillator output rate on pin 3 produces a 320 MHz reference sinewave from pin 8. This sinewave is the clock that is counted for the different measurement modes of the counter. The 320 MHz signal is applied to pin 1 of U1022B (a set/reset latch that resets itself at 320 MHz, and buffers and provides proper ECL drive). This signal is then divided down to 160 MHz at pin 12, Q1022B. Another divide-by-two (÷2) IC, U1022C, results in an 80 MHz output. This output is ac coupled to U1020, pin 7 and divided-by-eighty, (÷80) producing the 1 MHz signal at pin 2. Any error in output at pin 2 of U1020 is sensed by U1021. This sensed voltage, applied to varactor diode CR1130, adjusts the Colpitts oscillator producing the precise 1 MHz signal at pin 3 of U1021.

D/A's, 50 Ω PROTECT, AND ARMING—DIAGRAM 6

The isolation resistors for the 50 Ω Protect A (B) sense lines were discussed earlier (Diagram 1). The sense lines are routed from the Analog board to the Auxiliary board via jacks J1510 and J1520.

The 50 Ω Protect circuit is composed of a quad comparator (U1111) with associated components. Two of these comparators are arranged as "window" comparators (Channel A and B), that receive the protect sense levels from the Channel A or B inputs. These voltage sense levels normally operate within a ±2 V window. If the sense levels go outside this window (high or low), the comparator output changes states (to a low state) and issues a 50 Ω A (B) $\overline{\text{PROTECT}}$ signal to the microprocessor. The microprocessor recognizes this protect line and automatically changes the input relays from the 50 Ω TERM to the 1 MΩ TERM.

Trigger levels (CH A LEVEL and CH B LEVEL) are established, using a 10-bit D/A converter, U1210 and U1310 (Channel A and B). The data (SERIAL DATA lines) are received from the microprocessor through serial-to-parallel converters U1010 and U1020 (Channel A and B—see Diagram 7). These parallel output lines (Diagram 6) form the digital word that is applied to the D/A converter. The digital word corresponds to a unique current that is sinked at pin 3 of the D/A converters (U1210, Channel A; U1310, Channel B). This current, appearing at pin 2 of the operational amplifier circuits, U1200A (Channel A) and U1200B (Channel B), is converted to a voltage. This voltage can be offset by potentiometer R1205, (R1207, Channel B) and the voltage range adjusted by potentiometer R1204 (R1206, Channel B). The output of U1200A (U1200B) at pin 1 is the trigger voltage that is routed to the amplifier circuitry on the Analog board (see Diagram 1).

The arming circuit input load (Diagram 6) is 1 standard TTL load. The input is positive overvoltage protected by diode CR1510 (reverse biases upon receiving an excessive positive overvoltage). Diode CR1511 is the negative overvoltage protection component (clamps the output to a diode below ground) and is current limited by resistor R1500.

Transistors Q1510 and Q1511 form a Schmitt trigger providing noise immunity to the arming inputs (ARM IN and EXT ARM IN). The $\overline{\text{ARM}}$ output signal is routed to the digital circuitry (Diagram 3).

RELAY DRIVE—DIAGRAM 7

The serial-to-parallel converters, U1010 (Channel A) and U1020 (Channel B), are used to change the serial data from the microprocessor to the parallel data. This data will select the particular relay to be activated. The converter output data are applied to U1110 (U1020, Channel B) that consists of seven Darlington NPN transistors (shown as inverters). These devices are used as current sinks to drive the relay coils. With one end of the selected relay coil brought low via one of the inverters (U1110), a voltage pulse is applied to the opposite coil end. This voltage pulse is generated by the microprocessor (see Diagram 9) and then amplified and regulated by the pulse amplifier circuit consisting of transistors Q1031, Q1030, Q1032 and associated circuitry (Diagram 7).

The pulse is approximately 8 V in amplitude with a 25 ms width; therefore, when a relay coil is energized, the inverter output is brought low and the microprocessor pulses the pulse amplifier to direct the current flow to the selected relay coil. This causes the relay to change state and latch.

The Darlington transistors Q1121 and Q1120 (with associated circuitry), are used to drive the relay coils, K1612 (K1632, Channel B), that provide for the Common Separate channel input function (see Diagram 1).

POWER SUPPLIES—DIAGRAM 8

The four main supplies derive power input (through the instrument's two rear interface connectors) from the TM 500 or TM 5000-Series power module. These primary supplies are the +12 V and +5 V, located on the Auxiliary board, and the other +5 V and a −12.2 V, located on the Digital board. They are individually fused and current limited. The four supplies are referenced to the +2.5 V (Master Reference) precision voltage reference supply on the Auxiliary board.

The secondary supplies include the +2.7 V (ECL Termination), +5.7 V (derived from the +12 V supply), −5 V (three-terminal regulator derived from the −12.2 V supply), and the +18 V (three-terminal regulator derived from the +33.5 V/+26 V from the power module) that is used in the Option 01 timebase only (see Diagram 5).

The +12 V supply (located on the Auxiliary board—Diagram 8) is derived from the unregulated +33.5 V/+26 V dc power in the power module. The +12 V regulator circuit consists of U1420 and associated components. Load current for this supply passes through resistor R1425 (current limit sensing component) and the PNP series-pass transistor located in the power module. The +12 V supply is regulated within design limits by varying the voltage on the base of the series-pass transistor via P1600 pin 11A. The Zener diodes, VR1410 and VR1411, reduce the voltages to appropriate levels for U1420. Should the load current exceed 0.4 A, the voltage drop across R1425 becomes great enough to current limit U1420. This voltage is sensed at U1420 (pins 2 and 3) and reduces the base-to-collector voltage of the series-pass transistor. Feedback signals for voltage regulation of the +12 V supply appear on pin 4 (U1420) and are compared with the +2.5 V reference voltage on pin 5. Capacitor C1310 provides for frequency compensation.

Emitter follower Q1330 uses pin 6 (V_{ref}) of U1420 to provide an input voltage for the precision voltage reference, U1223. The +2.5 output voltage is used for all four major supplies and is a master reference source for the D/A's.

The +5 V supply (located on the Auxiliary board) is derived from the unregulated +11.5 V/+8 V dc power in the power module. The +5 V regulator circuit consists of U1320 and associated components. Load current for this supply passes through current limit sensing resistor R1426 and the NPN series-pass transistor (located in the power module). This supply is also regulated by varying the voltage on the series-pass transistor base (P1600 pin 6A). If the load current is exceeded, the voltage drop across R1426 will cause U1320 to limit this current. This voltage (sensed at pins 2 and 3 of U1320) causes the series-pass transistor to turn off. The feedback signal for the voltage regulator occurs on pin 4 (U1320) and is compared to the reference voltage on pin 5. Capacitor C1320 provides for frequency compensation.

The other +5 V supply (located on the Digital board) is identical in operation to the +5 V supply just discussed. It consists of the regulator, U1720 and associated components, and an NPN series-pass transistor (located in the power module). An additional filter network consisting of C1022 and L1020 provides the display power and isolates its noise from the rest of the instrument.

The −5 V supply (located on the Auxiliary board) consists of a three-terminal regulator, U1330, that provides regulated −5 V from the −12. V input.

The +2.7 V supply (located on the Auxiliary board) is the ECL termination supply and is used as a terminating supply for all the pull-down resistors located in the ECL circuits on the Analog board (see Diagrams 3 and 5). The +2.7 V supply is derived from the +5 V supply and consists of an error amplifier, Q1333, an amplifier stage, Q1331, an emitter-follower output stage, Q1332, and associated components.

The −12.2 V supply (located on the Digital board) is derived from the unregulated −33.5 V/−26 V dc power in the power module. This supply consists of error amplifier Q1723 and Q1722, error signal amplifier Q1721, current limit sense amplifier Q1720, and associated components. The reference voltage on the base of Q1723 is approximately 0 V. Diode CR1620 provides temperature compensation for the error amplifier circuit. This supply is regulated within design limits by varying the voltage on the base of the PNP series-pass transistor, located in the power module, via the collector of Q1721. An excessive load current through current limit resistor R1718 causes Q1720 to increase conduction and the bases of Q1723 and Q1721 to go more negative. The PNP series-pass transistor base goes more positive, thereby reducing the load current below the design limit.

PROCESSOR AND DISPLAY DRIVERS—DIAGRAM 9

Introduction

The DC 510 is a digital counter based on a microcomputer system. The microprocessor, U1510 (located on the Digital board—Diagram 9), controls the internal operations of the DC 510. The microprocessor recognizes, accepts, and decodes commands (keypushes and control settings) from the front panel logic circuits (Diagram 10) and sets the operating parameters in response to these commands.

Integrated circuit U1410 contains a random access memory (RAM) space that provides a maximum of 128 locations (addresses) which the microprocessor uses to temporarily store 8-bit data bytes. The data is not permanent and will be lost whenever the instrument power is turned off. When power is first applied, the RAM data occurs as random bits and is therefore meaningless. During instrument operation, the microprocessor writes data into the RAM at various addresses for later recall and use.

The instructions (firmware) concerning manual operation of the DC 510 stored in EPROM U1610 (a 4k byte memory) and in the ROM section of U1410 (a 2k byte memory). The other RAM is located in U1311.

System Clock

The microprocessor, U1510, contains a single phase internal clock generator at pins 27 and 28, in conjunction with inverter U1520F, whose 1 μs period (approximately) is controlled by the rc feedback network consisting or R1601 and C1601. The activity of U1510, when it is reading data from or writing data to a memory device, occurs in machine (U1510) cycles. Since no critical system timing relies on the microprocessor clock, a crystal is not needed.

Power Up Reset Cycle

When the instrument is powered up, comparator U1102D (and associated components) operates as a delay/comparator circuit to provide a pulse to reset the microprocessor to its reset vector address location.

Pin 14 of U1102D is held low for approximately 1.5 seconds (to allow all supplies to come up to operating status in the TM 500 or TM 5000-Series power modules). During this time all of the internal registers of U1410 (except the 16-bit counter and serial shift register) are cleared to logic zero. This action places all of the bidirectional input/output lines of U1410 in the input state and disables the internal shift register, Display Interrupt Clock input (pin 37), and the interrupt output (pin 4). Also, during the low level period of the microprocessor reset signal, the writing of data to or from U1510 is inhibited, and a bright digit may be displayed on the DC 510's front panel.

When the positive edge is detected on pin 1 of U1510, the internal mask interrupt flag will be set and the microprocessor will load its internal program counter from the reset vector address listed in Table 3-2. This is the start location for program control.

Interrupt Vector ($\overline{IRQ}$)

Integrated circuit U1410 has two internal registers for interrupt control, an interrupt enable register and interrupt flag register. Corresponding bits in these registers are logically ANDed to set an interrupt request pending flag. When U1410 detects the pending flag bit, it asserts pin 4 as a low output, generating an interrupt request to the microprocessor.

When a low level is set on pin 4 of U1410, the microprocessor completes the current instruction before recognizing the interrupt request and examining its own interrupt mask flag bit. If the interrupt mask flag bit is not set, the microprocessor starts an interrupt routine. The contents of its program counter and status register are temporarily stored in RAM, the interrupt mask flag bit will be set to prevent further interrupts, and the program counter will then be loaded with the high and low bytes of the interrupt vector address listed in Table 3-2. This is the start location for the interrupt routine for U1410.

Table 3-2
DC 510 INTERRUPT VECTORS

Vector Address[a]	Type of Interrupt
$FFFC - $FFFD	Power-Up Reset
$FFFE - $FFFF	Interrupt Request (U1410)

[a]Dollar sign ($) indicates that address code is in hexadecimal notation.

There are three possible reasons why U1410 sets an interrupt pending flag, two external events and one internal event. The two external events are: a negative edge detected on pin 36 (CH B SLOW) or a negative edge detected on pin 37 (Display Interrupt Clock); the one internal event occurs when the 16-bit counter inside U1410 overflows.

Address Decoding

The microprocessor addresses U1610, U1410, and U1313 when communicating with the instrument functions. Table 3-3 lists the hexadecimal address ranges for these devices.

Table 3-3
DC 510 MEMORY ADDRESS RANGE

Hexadecimal Address Range	Comments
$000 - $007F	U1311 (128 X 8 RAM)
$0080 - 0087	U1313 (Front panel display, Serial Data latches, and GPIB address switches)
$0400 - $04FF	U1311 (256 X 8 RAM)
$0700 - $070F	U1410 I/O[a]
$0800 - $0FFF	U1410 (2k X 8 ROM)
$1000 - $1FFF	U1610 (4k X 8 ROM)

[a]See Table 3-4.

Memory select decoders U1313, U1420, and related components, operate to select the proper memory device during program control.

The input/output sections internal to U1410 are accessed by the microprocessor using address bits A0 through A3 for specific control of the internal functions. See Table 3-4.

Table 3-4
ADDRESS CODE FOR U1410
($0700-$070F)

Address Bits				Internal Functions
A3	A2	A1	A0	
0	0	0	0	Port A
0	0	0	1	Port B
0	1	0	0	Read Lower Counter/Write Lower Latch
0	1	0	1	Read Upper Counter/Write Upper Latch and Download
0	1	1	0	Write Lower Latch
0	1	1	1	Write Upper Latch
1	0	0	0	Serial Data Register
1	0	0	1	Interrupt Flag Register
1	0	1	0	Interrupt Enable Register
1	0	1	1	Auxiliary Control Register
1	1	0	0	Peripheral Control Register
1	1	0	1	Data Direction Register—Port A
1	1	1	0	Data Direction Register—Port B

NOTE

Due to the complexity of the internal functions associated with U1410, a detailed description of this device will not be attempted in this manual. If more detailed information is needed, refer to the manufacturer's data sheets.

Serial Data Path. The serial data path is shown on the block diagram (see Figs. 8-6 and 8-7). Serial data are written, via pins 38 and 40 of U1410, to five serial-to-parallel shift registers located on the Auxiliary circuit board (A18 assembly), and one serial-to-parallel shift register on the Analog board (A12 assembly). This is done when the microprocessor sets the instrument's internal circuits for the desired function. These registers are, in sequence:

A18—U1010 ◇7
A18—U1020 ◇7
A18—U1222 ◇6
A18—U1220 ◇6
A18—U1221 ◇6
A18—U1200 ◇3

The serial data output from A12—U1200 then goes, via P1102-6 (Diagram 3), to five parallel-to-serial shift registers (Channel A and Channel B accumulators) located on the Digital circuit board (A16 assembly). Serial data is shifted through these registers and returned to the microprocessor via the data buffer, U1310B. Serial data is read from the following parallel-to-serial shift registers:

A16—U1122 ◇4
A16—U1211 ◇4
A16—U1312 ◇4
A16—U1121 ◇4
A16—U1114 ◇4

Pin 40 of U1410 serves both as an input and output for serial data. When the microprocessor is in the serial write mode, pin 40 is configured as an output and bytes of information are loaded into the internal serial data registers of U1410. They are then shifted out serially to the shift registers on the A12 assembly (Analog board). During the writing of serial data the three-state data buffer, U1310B, is disabled with a high level on pin 15, preventing the serial data input from contending with the serial data output via U1114-3. The microprocessor addresses U1313, causing a negative pulse on pin 14 ($\overline{\text{OLATCH}}$) to latch the serial data in the serial-to-parallel shift registers.

When the microprocessor is reading the serial data from the Channel A and Channel B accumulators, pin 15 of U1310B is set low at the same time pin 40 of U1410 is configured as an input. The serial data are then read in as five consecutive bytes. The microprocessor addresses U1313 and uses pin 15 ($\overline{\text{ILATCH}}$) to latch data during the serial read process.

Display Interrupt Clock. The front panel keyboard and displays are interrupt driven by the timing circuit consisting of U1520A, U1520B, and associated components. This circuit operates at approximately 1.1 kHz. The negative edges of the signal on pin 37 of U1410 interrupt the microprocessor, telling it to update the display and search for a new keypush or control setting. The microprocessor addresses U1313 and uses pins 7, 9, 10, 11, and 12 during this process.

Power Up Sequence. After the microprocessor and peripheral device U1410 have been reset at power up, the DC 510 microprocessor generates the following sequence of events.

1. Loads a 0 in the most significant bit position of the front panel display.

2. Tests the RAM, starting at address $0000. If a RAM failure is found, error code 340 will be displayed.

3. Tests the two ROMs for byte location and determines the checksum. If a ROM error is found, error code 361, 380, or 381 will be displayed.

4. Checks to see if the Channel A TERM button is held in, and, therefore, if signature analysis (SA) is being requested. If the SA is not requested, the interrupt registers in U1410 are enabled.

5. Initializes peripheral device U1410.

6. Performs a serial input/output test. If an error is found, error code 313 will be displayed.

7. Sets up the hardware to determine the state of the front panel, loads the serial-to-parallel shift registers, and generates the relay strobe signals via pin 26 of U1410.

8. Performs the counter chain (Channel A and Channel B accumulators) integrity test. If this test fails, an error code (320 through 324 and 329 for Channel A or 330 through 334 and 339 for Channel B) will be displayed.

9. Starts the measurement cycle by pulsing the master reset line (pin 33 of U1410).

10. After the master reset pulse, the measurement gate on pin 4 of U1200 (Diagram 3) is started. During the measurement gate interval, the microprocessor is continually reading the contents of the Channel A accumulator for a count that is greater than or equal to the number of averages requested by the user. When that count is reached, the measurement gate is unasserted and the microprocessor waits for the signal on pin 35 of U1410 to go low, indicating the end of the measurement cycle. The accumulators are then read again for their final count and a new measurement cycle is started after the result is calculated and the display is updated.

Rear Interface Signals. The $\overline{\text{PRESCALE}}$ line for U1410 (pin 29) operates as an input that indicates to the microprocessor the presence of an external prescaling counter. When an external prescaler is used, the microprocessor multiplies the Channel A accumulated counts by 16 before the display is updated.

The microprocessor interprets the reset input from U1500A (Diagram 6) to pin 32 of U1410 as the electrical equivalent of the front panel MEASUREMENT START/STOP pushbutton.

NOTE

Complete data for all of the rear interface signals are given in the Maintenance section of this manual.

PUSHBUTTONS AND LEDs—DIAGRAM 10

The microprocessor uses five control lines and the 8-bit data bus to communicate with the Pushbuttons and LEDs and Display circuits. The five control lines are all derived from U1313 located on Diagram 9.

The interrupt signal from the Display Interrupt Clock (Timer) circuit to U1410 (Diagram 9, previously discussed) occurs approximately once every 900 μs. Each interrupt causes the microprocessor to start a software routine for servicing the Pushbuttons and LEDs, and Display circuitry.

Each digit and annunciator in the display, each pushbutton LED, and each control or pushbutton is assigned a time slot period approximately equal to the period between successive interrupts. The time slots are generated by U1121, a decade counter with 10 decode decimal outputs. The counter provides time slot decoding for scanning the front panel controls and multiplexing the seven-segment LEDs and LED annunciators located on Diagrams 10 and 11. The logic high outputs of U1121 are buffered by nine Darlington amplifiers (Q1121, Q1122, etc.).

Each interrupt signal causes the microprocessor to clock U1121 with a negative pulse of approximately 500 ns on pin 14, advancing the count to the next time slot. Immediately after clocking U1121, the microprocessor updates the digit associated with that time slot by sending data to U1112 and U1111, which contain six D-type flip flops each. Data are latched in U1112 and U1111 when pin 9 goes low and transfers to the outputs on the positive edge of the CLOCK signal. The BCD output of U1112 is then decoded to seven-segment information by U1101. Data latches into U1111 and are inverted and buffered by U1110 to drive the decimal point (dp), the pushbuttons, and annunciator LEDs. The display drive power supply filter is a pi-network consisting of C1022, L1020, C1020, and C1021 (Diagram 8). This filter circuit prevents display noise pulses from disturbing the sensitive instrument circuits.

After updating the display and checking the front panel status, the microprocessor returns to the routine of resetting the input circuits (if necessary), monitoring the measurement cycle, or collecting the data for the selected function. This continues until the next front panel interrupt signal occurs, when it again clocks U1121 for the next time slot and repeats the procedure.

DISPLAY—DIAGRAM 11

The nine digits in the display are seven-segment, common anode LEDs; DS1001 is the Most Significant Digit (MSD) and DS1301 is the Least Significant Digit (LSD). The time slot lines (previously discussed) are generated by a nine-state decade counter, U1121 (Diagram10). The microprocessor sends all 1's (D1-D4) for the seven-segment information when leading zero supression is indicated. All 1's are decoded by U1101 (Diagram 9) as a blank.

To illuminate the proper LED or indicator in the display, the microprocessor sets pins 9, 25, 30, 33, and 36 of P1001 low only during the time slot that corresponds to the displayed units of measurement or indicator.

The pushbutton switches are common to one of the four sense lines (MISC, FUNCTION, RELAYS, and MORE). The microprocessor senses the switch closure during an active time slot (logic high) by addressing U1310 (tri-state buffer).

The illumination interval of the GATE light (DS1304) during time slot six, is only approximately equal to the actual measurement gate interval. The GATE light is turned on and then off only to tell the operator that the counter has been triggered and that the microprocessor has completed the functional measurement for the selected number of averages. The gate light is not directly connected to the actual hardware gate.

CALIBRATION

PERFORMANCE CHECK PROCEDURE

Introduction

This procedure checks the electrical performance requirements as listed in the Specification section in this manual. Perform the Adjustment Procedure if the instrument fails to meet these checks. In some cases, recalibration may not correct the discrepancy; circuit troubleshooting is then indicated. Also, use this procedure to determine acceptability of performance in an incoming inspection facility.

Calibration Interval

To ensure instrument accuracy, check the calibration every 2000 hours of operation or at a minimum of every six months if used infrequently.

Service Available

Tektronix, Inc. provides complete instrument repair and adjustment at local field service centers and at the factory service center. Contact your local Tektronix field office or representative for further information.

Test Equipment Required

The test equipment (or equivalent) listed in Table 4-1 is suggested to perform the Performance Check and Adjustment Procedure.

Table 4-1
LIST OF TEST EQUIPMENT REQUIREMENTS

Description	Performance Requirements	Perf. Check	Adj. Proc.	Example
Power Module		X	X	TEKTRONIX TM 5003, TM 5006, or TM 500-Series
Digital Multimeter	4 1/2 digits, 0.5%. Ranges: 2 kΩ–2 MΩ and 2-20 Vdc	X	X	TEKTRONIX DM 501A
1 MHz Frequency Standard	1 MHz $\pm 1 \times 10^{-9}$	X		SPECTRACOM CORP TYPE 8161
Leveled Sinewave Generator	Calibrated amplitude @ 350 mV. Frequency: >200 MHz	X		TEKTRONIX SG 503
Leveled Sinewave Generator	Calibrated amplitude @ 350 mV. Frequency: >350 MHz	X		TEKTRONIX SG 504
Function Generator	Range, sinewave 10 Hz to 1 MHz; offset ±13 Vdc level	X	X	TEKTRONIX FG 501A
Pulse Generator	Risetime <1 ns. Amplitude 0–3 V	X	X	TEKTRONIX PG 502
50 Ω Feedthrough Termination	Bnc connectors	X	X	Tektronix Part No. 011-0049-01
Coaxial Cable, 50 Ω Precision 36 inch	Bnc connectors	X	X	Tektronix Part No. 012-0482-00
Coaxial Cable, 50 Ω Precision 18 inch	Bnc connectors	X		Tektronix Part No. 012-0076-00
Coaxial Cable, 50 Ω Precision 42 inch	Bnc connectors	X		Tektronix Part No. 012-0057-01
Adapter, Bnc Female To Dual Banana		X	X	Tektronix Part No. 103-0090-00
Cable Assembly RF (bnc-to-slide on connector)	50 Ω coaxial cable	X	X	Tektronix Part No. 175-3765-01
Probe, 5x		X		TEKTRONIX P6125
Flexible Extender			X	Tektronix Part No. 067-0645-02
Power Dividier GR		X		Tektronix Part No. 017-0082-00
GR To Bnc Female adapters (3)		X		Tektronix Part No. 017-0063-00
50 Ω, 10X Attenuator	Bnc connectors	X	X	Tektronix Part No. 011-0059-02
50 Ω, 5X Attenuator	Bnc connectors	X		Tektronix Part No. 011-0060-02
50 Ω, 2X Attenuator	Bnc connectors		X	Tektronix Part No. 011-0069-02
Connector, Dual Bnc		X		Tektronix Part No. 103-0029-00

PRELIMINARY CONTROL SETTINGS

DC 510

FREQ A	(lighted)
CHANNEL A and CHANNEL B	
SLOPE	+ (unlighted)
ATTEN	X1 (lighted)
COUPL	DC (unlighted)
TERM	1 MΩ (unlighted)

1. Check Oscillator Frequency (Standard timebase)

NOTE

The timebase accuracy is a function of temperature and time. The temperature stability for the standard time base is ±5 ppm (0° C to 50° C) with an aging rate of ±1 ppm/year.

After one year of operation (since the time base was calibrated), the 1 MHz frequency standard should read 1.0000000, ±6.0 ppm for any temperature between 0° C to 50° C. The ±6.0 ppm are determined by ±5 ppm due to temperature, ±1 ppm due to aging, and ±1 count to synchronization error. After this check is completed, the user should determine if a time base recalibration is required.

a. Connect a coaxial cable from the 1 MHz frequency standard output to the DC 510 CHANNEL A input.

b. Press the DC 510 AUTO TRIG button.

c. CHECK—that the DC 510 readout is within 999.99399 kHz and 1.0000061 MHz (±6.0 ppm, ±1 count).

2. Check Time Base Oscillator Frequency (Option 01)

NOTE

The temperature stability for the Option 01 time-base is 0.2 ppm (0° C to 50° C) with an aging rate of ±1 ppm/year and ±1 count.

a. Connect a coaxial cable from the 1 MHz frequency standard output to the DC 510 CHANNEL A input.

b. Press to light the DC 510 FREQ A button, then press the AUTO TRIG button.

c. CHECK—that the DC 510 readout is within 999.99879 kHz and 1.0000013 MHz.

d. Remove all cable connections from the DC 510.

3. Check the Trigger Level CH A and CH B Accuracy

Refer to Fig. 4-1, performance check setup. Use the following control settings.

Digital Multimeter

Function-Range	2 V

DC 510

CHANNEL A and CHANNEL B	
ATTEN	X1 (lighted)

a. Connect the DC 510 CH A SHAPED OUT to the digital multimeter input using the bnc-to-slide on connector assembly (standard accessory).

b. Press the DC 510 AUTO TRIG button.

c. Press the DC 510 ↑ (increment) button until the digital multimeter display just changes to a low readout. Press the DC 510 ↓ (decrement) button until the digital multimeter display just changes to a high readout.

d. CHECK—that the DC 510 display readout indicates between +0.010 and −0.010.

e. Connect a coaxial cable from the pulse generator output to the digital multimeter input using a bnc-to-banana adapter.

f. Set the pulse generator for Ext Trig and Ext Dur and adjust the output for a displayed readout of approximately +2.000 on the digital multimeter. Note this reading.

g. Disconnect the cable from the digital multimeter bnc-to-banana adapter and connect to the DC 510 CHANNEL A input.

h. Reconnect the accessory cable assembly to the digital multimeter input.

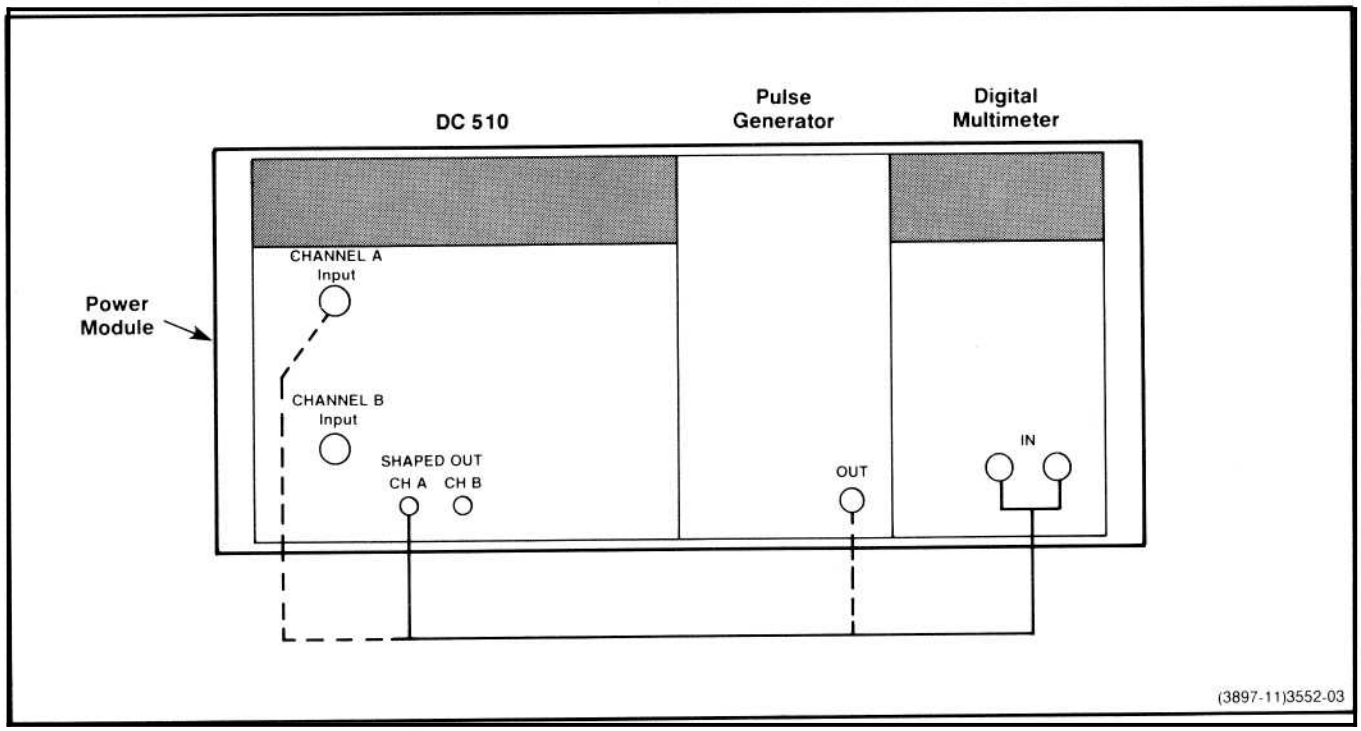

Fig. 4-1. Performance Check setup for step 3.

i. Press the ↑ (increment) button until the digital multimeter display just changes to a low readout. Press the ↓ (decrement) button until the digital multimeter display just changes to a high readout.

j. Press the DC 510 AUTO TRIG button.

k. CHECK—that the DC 510 display readout indicates the same value as was noted on step 3-f, ±40 mV.

4. Check Input Impedance: 50 Ω, ±3%; 1 MΩ, ±1%

Refer to Fig. 4-2 performance check setup. Use the following control settings.

Digital Multimeter

Function-Range	2 MΩ

DC 510

CHANNEL A and CHANNEL B	
ATTEN	X1 (lighted)
TERM	1 mΩ (unlighted)

a. Connect a coaxial cable from the DC 510 CHANNEL A input to the digital multimeter input using a bnc-to-banana adapter.

b. CHECK—that the digital multimeter display readout indicates between .9800 and 1.0200 (MΩ).

c. Press the DC 510 CHANNEL A ATTEN X1 button (lighted).

d. CHECK—that the digital multimeter display readout indicates between .9800 and 1.0200 (MΩ).

e. Change the digital multimeter Function-Range switch to 2 kΩ.

f. Press the DC 510 CHANNEL A TERM 50 Ω button (lighted).

g. CHECK—that the digital multimeter display readout indicates between .0490 and .0510 (kΩ).

h. Press DC 510 CHANNEL A ATTEN X5 button (unlighted).

i. CHECK—that the digital multimeter display readout indicates betwen .0490 and .0510 (kΩ).

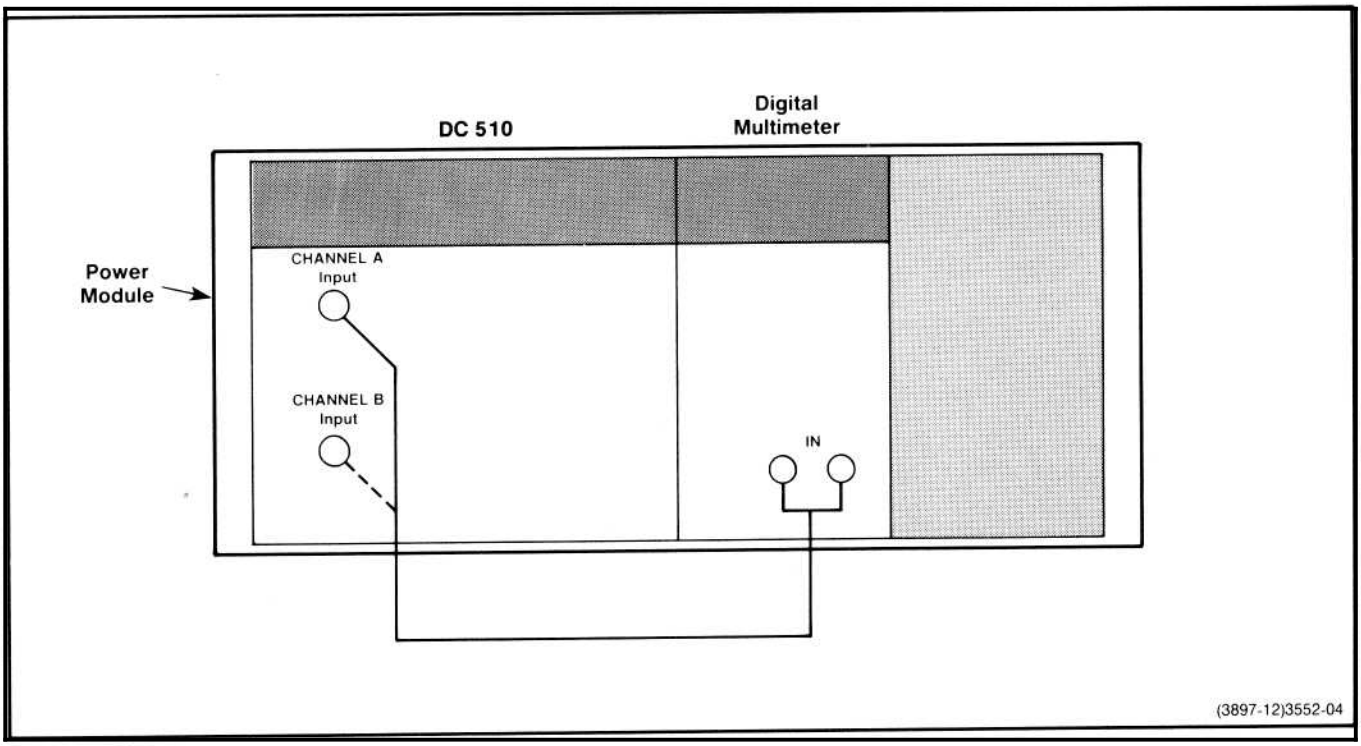

Fig. 4-2. Performance Check setup for steps 4 and 7.

j. Move the cable connection from the DC 510 CHANNEL A input to the CHANNEL B input.

k. Change the digital multimeter Function-Range switch to 2 MΩ.

l. CHECK—that the digital multimeter display readout indicates between .9800 and 1.0200 (MΩ).

m. Press the DC 510 CHANNEL B ATTEN X1 button (lighted).

n. CHECK—that the digital multimeter display readout indicates betwen .9800 and 1.0200 (MΩ).

o. Change the digital multimeter Function-Range switch to 2 kΩ.

p. Press the DC 510 CHANNEL B TERM 50 Ω button (lighted).

q. CHECK—that the digital multimeter display readout indicates between .0490 and .0510 (kΩ).

r. Press the DC 510 CHANNEL B ATTEN X5 button (unlighted).

s. CHECK—that the digital multimeter display readout indicates between .0490 and .0510 (kΩ).

5. Check the Arming Input Pulse Response ≥100 ns (V_H ≥2.4 V, V_L ≤0.4 V)

Refer to Fig. 4-3, performance check setup. Use the following control settings.

Pulse Generator

Pulse Duration	Squarewave
Period	.1 μs
Back Term	(in)

Sinewave Generator

Frequency Range (MHz)	50-100
Output Amplitude	1.25 V

DC 510

CHANNEL A and CHANNEL B	
ATTEN	X1 (lighted)
TERM	50 Ω (lighted)

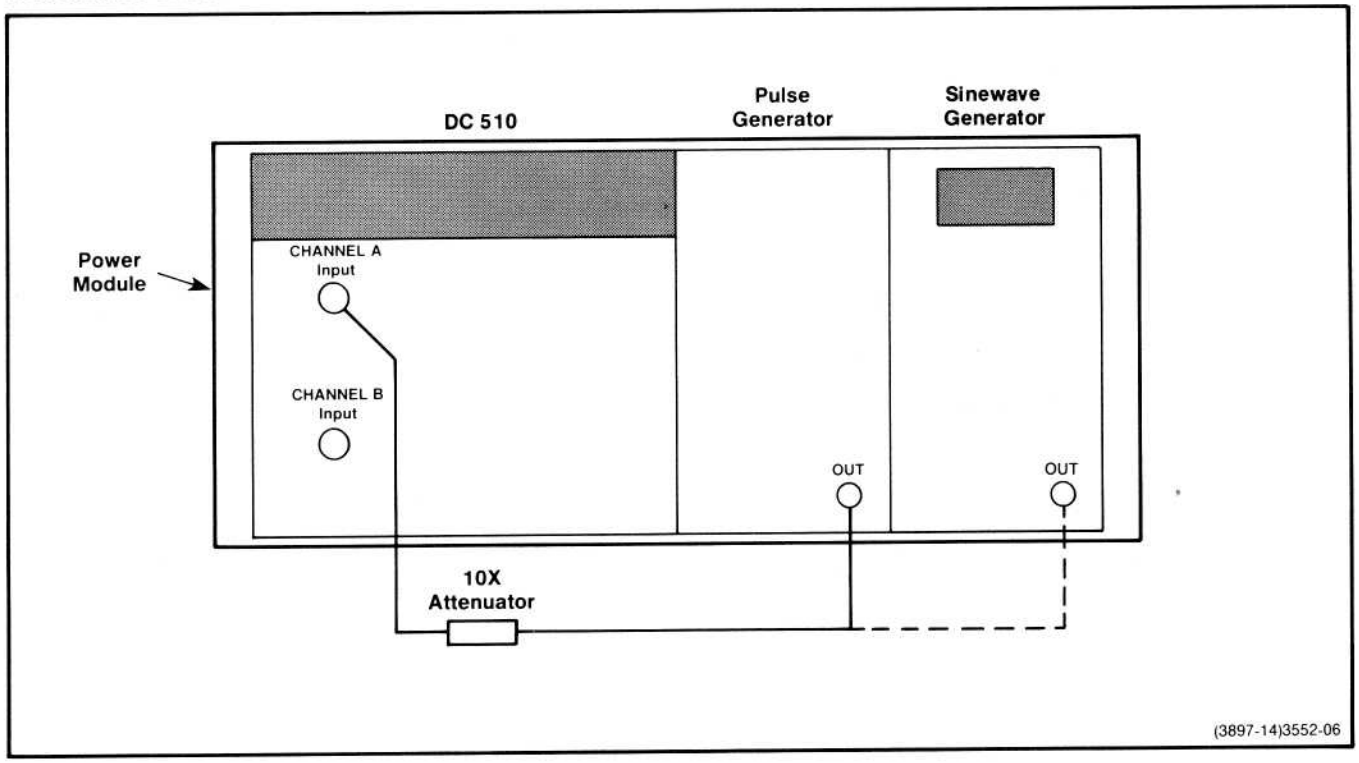

Fig. 4-3. Performance Check setup for steps 5 and 14.

a. Connect a coaxial cable from the pulse generator output to the DC 510 CHANNEL A input.

b. Adjust the pulse generator Period Variable control until the DC 510 display readout indicates 200.0000 (ns).

c. Press the DC 510 ↑ (increment) button to adjust the trigger level for 2.4 V on the display.

d. Adjust the pulse generator High Level control until the DC 510 trigger level is obtained (2.4 V).

e. Press the DC 510 ↓ (decrement) button to adjust the trigger level until the display readout indicates 0.4 V.

f. With the pulse generator High Level control set, adjust the Low Level control until the DC 510 trigger level is obtained (0.4 V).

g. Remove the DC 510 CHANNEL A input connection and connect the sinewave generator output to the CHANNEL A input.

h. Adjust the sinewave generator Frequency Variable control until the DC 510 display readout indicates approximately 75.0XXXX MHz (the last four digits can vary due to source instability).

i. Press the DC 510 AUTO TRIG button, then connect the pulse generator output to the ARM IN.

j. CHECK—that the DC 510 display still indicates approximately 75.0XXXX MHz (the last four digits can vary due to source instability) with the display GATE light blinking.

k. Disconnect the cable from the pulse generator output and attach a 50 Ω terminator (this causes the line to go to a TTL low).

l. CHECK—that the DC 510 readout stops changing values and the display GATE light is not blinking (but may be lighted).

6. Check Input Capacitance: 23 pF, ±10%

Refer to Fig. 4-4, performance check setup. Use the following control settings.

Function Generator

Frequency Hz	2
Multiplier	10^2
Function	(sine)
Offset	(midrange)
Output	(cw)

DC 510

CHANNEL A and CHANNEL B	
TERM	1 MΩ (unlighted)
SLOPE	+ (unlighted)
ATTEN	X1 (lighted)
COUPL	DC (unlighted)
FREQ A	(lighted)
FILTER (20 MHz)	(lighted)

a. Connect the 20 pF normalizer with a 50 Ω terminator and 5X attenuator from the DC 510 CHANNEL A input through a coaxial cable to the function generator output.

b. Press the DC 510 LEVEL CH A button, then the DISPLAY-TEST button.

c. Adjust the DC 510 Channel A triggering level using the ↑ (increment) button until the GATE annunciator light (on the display) just stops blinking.

d. Press the DC 510 DISPLAY-TEST button for the trigger level voltage display readout.

e. Note the DC 510 display readout (peak input voltage).

f. Change the function generator Multiplier switch to 10^5.

g. Press the DC 510 LEVEL CH A button and the DISPLAY-TEST button.

h. Adjust the DC 510 Channel A triggering level using the ↑ (increment) and ↓ (decrement) buttons until the GATE annunciator light (on the display) just starts or stops blinking.

i. Press the DC 510 DISPLAY-TEST button for the trigger level voltage display readout.

j. Note the DC 510 display readout (peak input voltage).

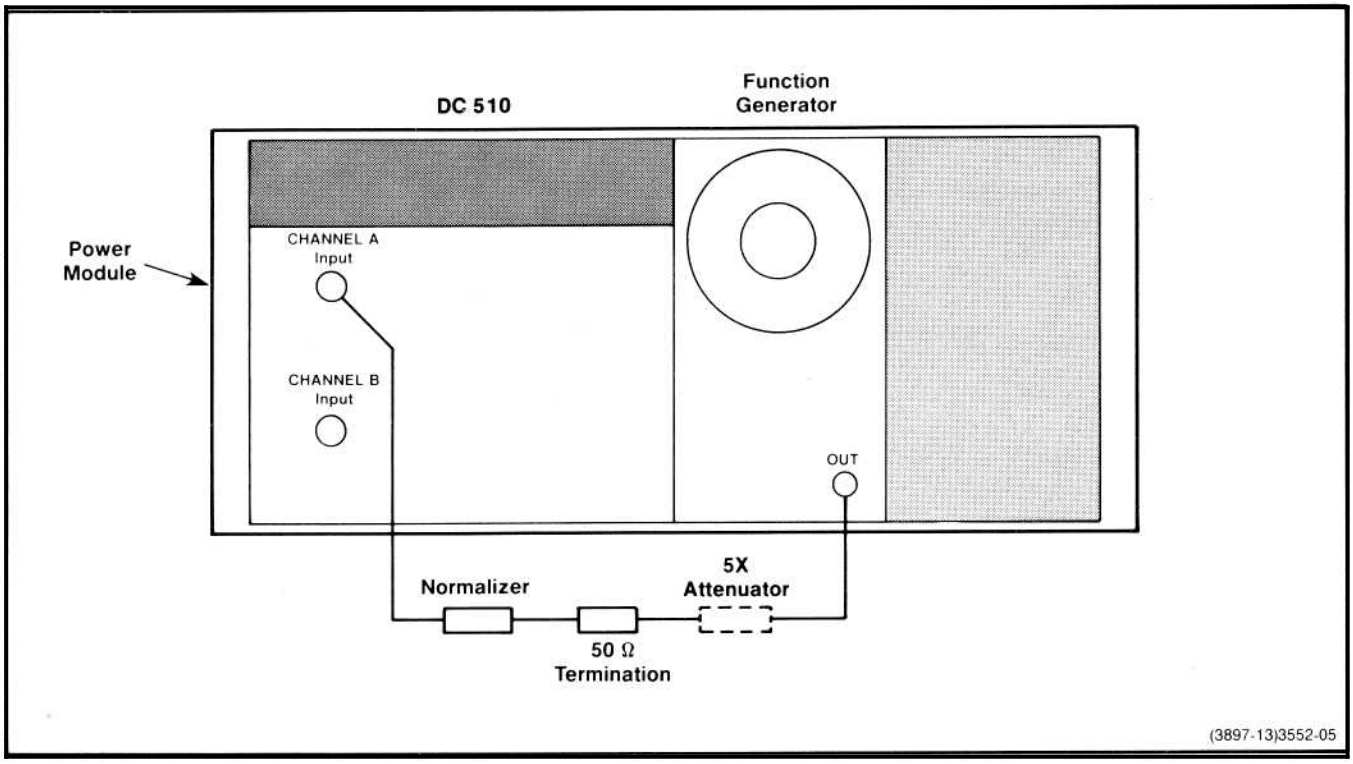

Fig. 4-4. Performance Check setup for step 6.

k. Divide the readout on step 6e by the readout on step 6j.

l. CHECK—that the ratio between the two readings is between 1.03 and 1.13 (ratio of input capacitance value to the 20 pF normalization).

m. Remove the DC 510 CHANNEL A input connection and connect it to the CHANNEL B input. Change the function generator Multiplier switch to 10^2.

n. Press the DC 510 LEVEL CH B button, then press the DISPLAY-TEST button.

o. Adjust the DC 510 Channel B triggering level using the ↑ (increment) button until the GATE light (on the display) just stops blinking.

p. Press the DC 510 DISPLAY-TEST button (trigger level voltage).

q. Note the DC-5010 display readout (peak input voltage).

r. Change the function generator Multiplier switch to 10^5.

s. Press the DC 510 LEVEL CH B button and the DISPLAY-TEST button.

t. Adjust the DC 510 Channel B triggering level using the ↑ (increment) and ↓ (decrement) buttons until the GATE light just starts or stops blinking.

u. Press the DC 510 DISPLAY-TEST button (trigger level voltage).

v. Note the DC 510 display readout (peak input voltage).

w. Divide the readout on step 6q by the readout on step 6v.

x. CHECK—that the ratio between the two readings is between 1.03 and 1.13 (ratio of input capacitance to the 20 pF normalization).

7. Check RISE/FALL Input Impedance: 50 Ω, ±3%, 1 MΩ, 500 kΩ, ±2% (60 MHz sinewave at high level)

Refer to Fig. 4-2, performance check setup.

a. Set the digital multimeter Function Range switch to 2 kΩ.

b. Press the DC 510 CHANNEL B ATTEN X1 button (lighted) and press to light the RISE/FALL A button.

c. CHECK—that the digital multimeter display readout indicates between .0490 and .0510.

d. Press both DC 510 CHANNEL A and B TERM 1 MΩ buttons (unlighted).

e. Change the digital multimeter Function-Range switch to 2000 kΩ.

f. CHECK—that the digital multimeter display readout indicates between .4900 and .5100 (kΩ).

8. Check the Input Sensitivity: X1 Attenuation, DC and AC Coupled; 50 Ω, ≤70 mV p-p

Refer to Fig. 4-5, performance check setup. Use the following control settings.

Sinewave Generator

Frequency MHz	350
Range	LOW
Amplitude	0.70

DC 510

FREQ A	(lighted)
CHANNEL A and B	
COUPL	DC (unlighted)
TERM	50 Ω (lighted)
SLOPE	+ (unlighted)
ATTEN	X1 (lighted)

a. Connect a coaxial cable with a 10X attenuator from the sinewave generator output to the DC 510 CHANNEL A input.

b. Press to light the DC 510 AUTO TRIG button, LEVEL CH A button, and the DISPLAY-TEST button.

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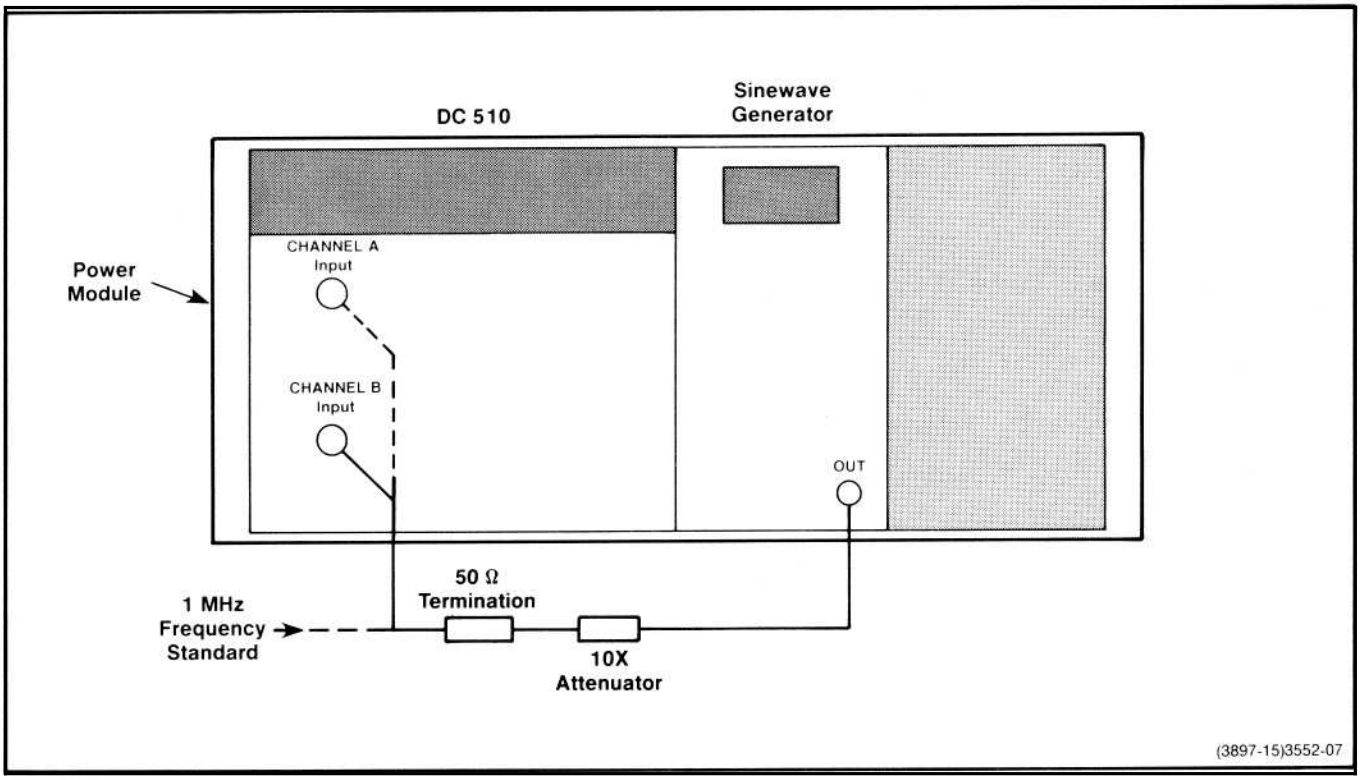


Fig. 4-5. Performance Check setup for steps 8, 9, 10, 11, 12, and 13.

c. Press the DC 510 ↑ (increment) or ↓ (decrement) buttons to adjust the trigger level for a stable display readout.

d. CHECK—that the DC 510 display readout indicates approximately 350.00XXXX (the last four digits can vary due to source instability).

e. Move the DC 510 CHANNEL A input connection to the CHANNEL B input.

f. Connect the 1 MHz frequency standard to the DC 510 CHANNEL A input and press the RATIO B/A button (lighted).

g. Press to light the DC 510 AUTO TRIG button, LEVEL CH B button, and the DISPLAY-TEST button.

h. Press the DC 510 ↑ (increment) or ↓ (decrement) buttons to adjust the trigger level for a stable display readout.

i. CHECK—that the DC 510 display readout indicates approximately 350.00XXX (the last three digits can vary due to source instability).

9. Check the Input Sensitivity: X5 Attenuation, DC and AC Coupled; 50 Ω ≤350 mV p-p

Refer to Fig. 4-5, performance check setup. Use the following control settings.

Sinewave Generator

Frequency MHz	350
Range	Low
Amplitude	3.5

DC 510

FREQ A	(lighted)
CHANNEL A and B	
TERM	50 Ω (lighted)
ATTEN	X5 (unlighted)

a. Connect a coaxial cable with a 10X attenuator from the sinewave generator output to the DC 510 CHANNEL A input.

b. Press to light the DC 510 AUTO TRIG button, LEVEL CH A button, and the DISPLAY-TEST button.

c. Press the DC 510 ↑ (increment) or ↓ (decrement) buttons to adjust the trigger level for a stable display readout.

d. CHECK—that the DC 510 display readout indicates approximately 350.00XXXX (the last four digits can vary due to source instability).

e. Move the DC 510 CHANNEL A input connection to the CHANNEL B input.

f. Connect the 1 MHz frequency standard to the DC 510 CHANNEL A input and press the RATIO B/A button (lighted).

g. Press to light the DC 510 AUTO TRIG button, LEVEL CH B button, and the DISPLAY-TEST button.

h. Press the DC 510 ↑ (increment) or ↓ (decrement) buttons to adjust the trigger level for a stable display readout.

i. CHECK—that the DC 510 display readout indicates approximately 350.00XXX (the last three digits can vary due to source instability).

10. Check Input Sensitivity: X1 Attenuation, DC and AC Coupled; 1 MΩ, ≤42 mV p-p at ≤300 MHz

Refer to Fig. 4-5, performance check setup. Use the following control settings.

Sinewave Generator

Frequency MHz	300
Amplitude	≈120 mV

DC 510

CHANNEL A and B TERM	1 MΩ (unlighted)

a. Remove the DC 510 CHANNEL B input connection and attach a 50 Ω termination to the end of the coaxial cable. Reconnect this cable with the termination and 10× attenuator to the CHANNEL B input.

b. Press to light the DC 510 AUTO TRIG button, LEVEL CH B button, and the DISPLAY-TEST button.

c. Press the DC 510 ↑ (increment) or ↓ (decrement) button to adjust the trigger level for a stable display readout.

d. CHECK—that the DC 510 display readout indicates approximately 300.0XXXX (the last four digits can vary due to source instability).

e. Remove the 1 MHz frequency standard from the DC 510 CHANNEL A input.

f. Move the DC 510 CHANNEL B input connection to the CHANNEL A input.

g. Press to light the DC 510 FREQ A button, AUTO TRIG button, LEVEL CH A button, and the DISPLAY-TEST button.

h. Press the DC 510 ↑ (increment) or ↓ (decrement) button to adjust the trigger level for a stable display readout.

i. CHECK—that the DC 510 display readout indicates approximately 300.00XXXX (the last four digits can vary due to source instability).

j. Remove the cable connections.

11. Check Input Sensitivity: X5 Attenuation, DC and AC coupled; 1 MΩ, ≤350 mV at ≤200 MHz

Refer to Fig. 4-5, performance check setup. Use the following control settings.

Sinewave Generator

Frequency Range	100-250
Frequency Variable	200
Amplitude Multiplier	X.1
Output Amplitude	3.5

DC 510

RATIO B/A	(lighted)
ATTEN	X5

a. Connect the 1 MHz frequency standard to the DC 510 CHANNEL A input.

b. Connect a coaxial cable with a 10X attenuation and 50 Ω termination from the sinewave generator output to the DC 510 CHANNEL B input.

c. Press to light the DC 510 AUTO TRIG button, LEVEL CH B button, and the DISPLAY-TEST button.

d. Press the DC 510 ↑ (increment) or ↓ (decrement) button to adjust the triger level for a stable display readout.

e. CHECK—that the DC 510 display readout indicates approximately 200.00XXX (the last three digits can vary due to source instability).

f. Press to light the DC 510 FREQ A button.

g. Remove the 1 MHz frequency standard from the DC 510 CHANNEL A input.

h. Move the DC 510 CHANNEL B input connection to the CHANNEL A input.

i. Press to light the DC 510 AUTO TRIG button, LEVEL CH A button, and the DISPLAY-TEST button.

j. Press the DC 510 ↑ (increment) or ↓ (decrement) button to adjust the trigger level for a stable display readout.

k. CHECK—that the DC 510 display readout indicates approximately 200.00XXXX (the last four digits can vary due to source instability).

12. Check Input Sensitivity: X1 Attenuation, DC and AC coupled; 1 MΩ, ≤70 mV at ≤200 MHz

Refer to Fig. 4-5, performance check setup. Use the following control settings.

Sinewave Generator

Frequency Range	100-250
Frequency Variable	200
Amplitude Multiplier	X.1
Output Amplitude	0.70

DC 510

RATIO B/A	(lighted)

a. Connect the 1 MHz frequency standard to the DC 510 CHANNEL A input.

b. Connect a coaxial cable with a 10× attenuation and 50 Ω termination from the sinewave generator Output to the DC 510 CHANNEL B input.

c. Press to light the DC 510 AUTO TRIG button, LEVEL CH B button, and the DISPLAY-TEST button.

d. Press the DC 510 ↑ (increment) or ↓ (decrement) button to adjust the trigger level for a stable display readout.

e. CHECK—that the DC 510 display readout indicates approximately 200.00XXX (the last three digits can vary due to source instability).

f. Press to light the DC 510 FREQ A button.

g. Remove the 1 MHz frequency standard from the DC 510 CHANNEL A input.

h. Move the DC 510 CHANNEL B input connection to the CHANNEL A input.

i. Press to light the DC 510 AUTO TRIG button, LEVEL CH A button, and the DISPLAY-TEST button.

j. Press the DC 510 ↑ (increment) or ↓ (decrement) button to adjust the trigger level for a stable display readout.

k. CHECK—that the DC 510 display readout indicates approximately 200.00XXXX (the last four digits can vary due to source instability).

13. Check Input Sensitivity: X5 Attenuation, DC and AC Coupled: 1 MΩ, ≤210 mV p-p at ≤300 MHz

Refer to Fig. 4-5 performance check setup. Use the following control settings.

Sinewave Generator

Frequency MHz	300

DC 510

CHANNEL A and B	
TERM	1 MΩ (unlighted)
ATTEN	X5 (unlighted)

a. Remove the DC 510 CHANNEL B input connection and insert a 50 Ω termination to the coaxial cable. Reconnect this cable to the CHANNEL B input.

b. Press to light the DC 510 AUTO TRIG button, LEVEL CH B button, and the DISPLAY-TEST button.

c. Press the DC 510 ↑ (increment) or ↓ (decrement) button to adjust the trigger level for a stable display readout.

d. CHECK—that the DC 510 display readout indicates approximately 300.00XXX (the last three digits can vary due to source instability).

e. Remove the 1 MHz frequency standard from the DC 510 CHANNEL A input.

f. Move the DC 510 CHANNEL B input connection to the CHANNEL A input.

g. Press to light the DC 510 FREQ A button, AUTO TRIG button, LEVEL CH A button, and the DISPLAY-TEST button.

h. Press the DC 510 ↑ (increment) or ↓ (decrement) button to adjust the trigger level for a stable display readout.

i. CHECK—that the DC 510 display readout indicates approximately 300.00XXXX (the last four digits can vary due to source instability).

j. Remove the cable connections.

14. Check WIDTH A: Range ≤4 ns; minimum Time Stop Edge To Start Edge, ≤8.5 ns

Refer to Fig. 4-3 (using pulse generator only), performance check setup. Use the following control settings.

Pulse Generator

Period	10 ns
Variable	(ccw)
Duration	≤2 ns
Variable	(ccw)
Output	
Back Term	(out)
Low Level	0
High Level	2

DC 510

CHANNEL A and B	
ATTEN	X1 (lighted)
TERM	50 Ω (lighted)
FREQ A	(lighted)

a. Connect a coaxial cable with a 10× attenuator from the pulse generator output to the DC 510 CHANNEL A input.

b. Press to light the DC 510 AUTO TRIG button.

c. Adjust the pulse generator Period Variable control until the DC 510 indicates approximatrely 80.0000 (MHz).

d. Press to light the DC 510 WIDTH A button.

e. CHECK—that the DC 510 display readout indicates between 0.0000 and 4.0000 (ns).

15. Check EVENTS B DUR A Minimum Pulse Width, ≤4.0 ns and ≤8.5 ns

Check Delay Mismatch: Int, ≤2 ns
Check Minimum TIME B → A, ≤12.5 ns

Refer to Fig. 4-6, performance check setup. Use the following control settings.

Pulse Generator

Pulse Period	.1 μs
Pulse Duration	**≥2 ns**
Low Level	0 V
High Level	3 V
Back Term	(out)

DC 510

Time A → B	(lighted)
CHANNEL A and	
CHANNEL B	
ATTEN	X1 (lighted)
TERM	50 Ω (lighted)
SLOPE	+ (unlighted)

EVENTS B DUR A check:

a. Connect a coaxial cable from the pulse generator output to one connector of a 50 Ω power divider (using the GR-to-bnc adapter).

b. Connect an 18-inch coaxial cable from another power divider connector to the DC 510 CHANNEL A input (using the GR-to-bnc adapter).

c. Connect a 42-inch coaxial cable from the other power divider connector to the DC 510 CHANNEL B input (using the GR-to-bnc adapter).

d. Press the DC 510 AUTO TRIG button, then press to light the NULL button.

e. Press the DC 510 CHANNEL B – SLOPE button (unlighted).

f. Adjust the pulse generator Duration Variable control until the DC 510 display readout indicates between 3.95 ns and 4.05 ns.

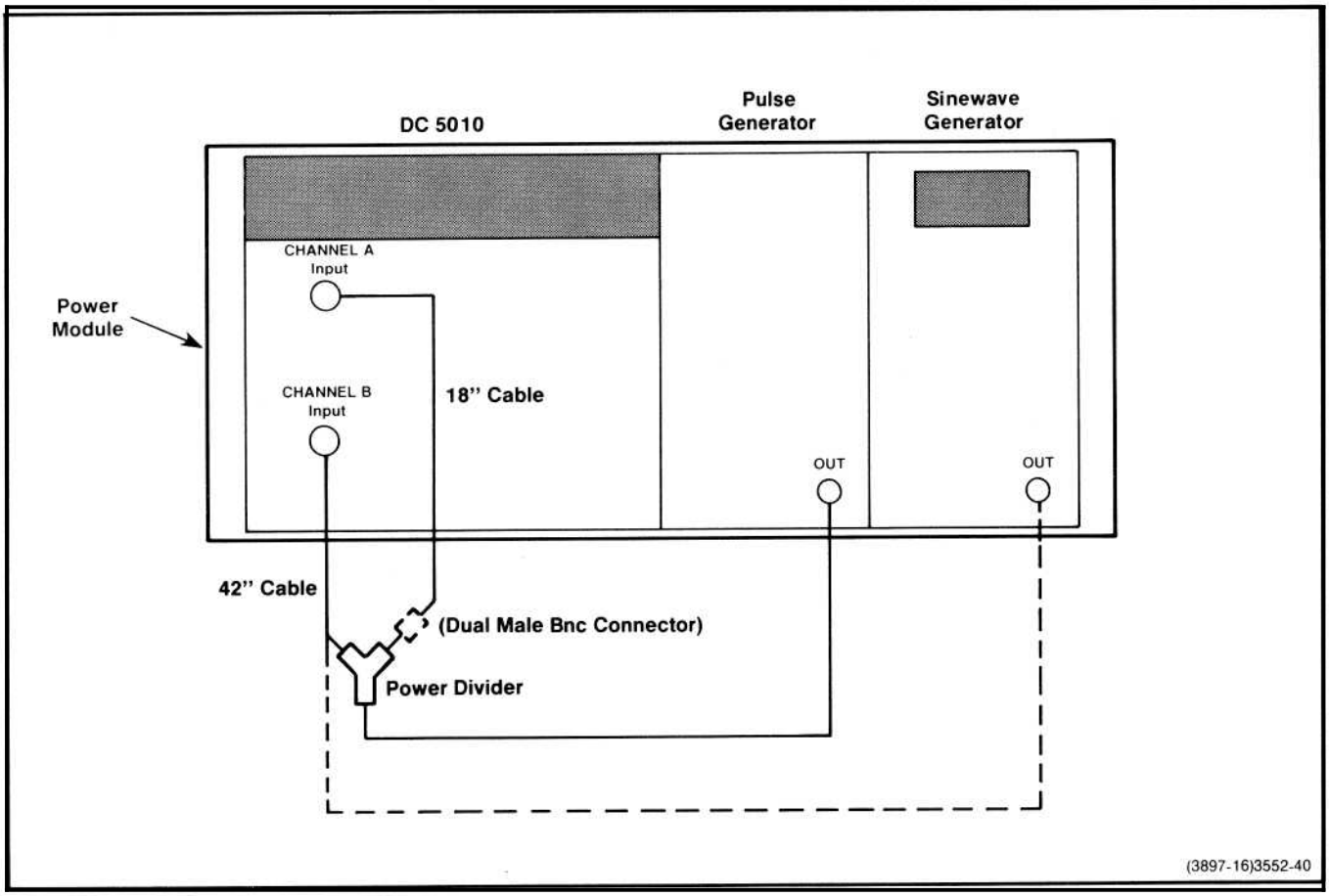


Fig. 4-6. Performance Check setup for step 15.

g. Remove the DC 510 CHANNEL B input cable and terminate this cable end with a 50 Ω terminator.

h. Set the sinewave generator for 350 MHz at approximately 150 mV, and connect the generator output to the DC 510 CHANNEL B input.

i. Change the pulse generator Pulse Period to 10 ns (pulse width is 4.0 ns).

j. Press to light the DC 510 FREQ A button.

k. Adjust the pulse generator Period Variable until the DC 510 display readout indicates 80.XXX MHz (the last three digits can vary due to source instability).

l. Press to light the DC 510 EVENTS B DUR A button, then press the AUTO TRIG button.

m. CHECK—that the DC 510 display readout indicates between 2.45 and 3.85.

Delay Mismatch Check:

n. Press to light the DC 510 TIME A → B button, then press the NULL button (lighted).

o. Replace the 18-inch coaxial cable (from the DC 510 CHANNEL A input to the power divider) with a dual bnc male connector.

p. CHECK—that the DC 510 display readout indicates approximately 2.5 ns. Note this reading.

q. Replace the 42-inch coaxial cable (from the DC 510 CHANNEL B input to the power divider) with the 18-inch cable that was removed in Step 15-o.

r. Press to light the DC 510 TIME A → B button.

s. CHECK—that the DC 510 display indication, minus (−) the readout noted in step 15-p, is 0.

Minimum Time B → A Check:

t. Press to light the DC 510 FREQ A button.

u. Change the pulse generator Pulse Period to 10 ns (pulse width remains 4.0 ns).

v. Adjust the pulse generator Period Variable until the DC 510 display readout indicates 67.XXX MHz (the last three digits can vary due to source instability).

w. Press to light the DC 510 TIME A → B button.

x. CHECK—that the DC 510 display readout indicates between 0 and 6.0 ns.

16. Check Probe Compensation

Use the following control settings.

	DC 510
CHANNEL A and CHANNEL B	
ATTEN	X5
TERM	1 MΩ (unlighted)
FREQ A	(lighted)
TOTAL A	(lighted)

a. Connect a bnc-to-slide on cable asembly from the DC 510 PROBE COMP output to the CHANNEL A input.

b. Press the DC 510 AUTO TRIG button.

c. CHECK—that the DC 510 display readout indicates between 70.0000 and 170.0000 Hz.

d. Press the DC 510 WIDTH A function button.

e. CHECK—that the DC 510 display readout indicates greater than 600.000 μs and less than 1.3 ms.

f. Press the DC 510 LEVEL CH A button.

g. CHECK—that the DC 510 display readout indicates between 2.000 and 3.250 V (50% voltage point; peak voltage equals 4 V to 6.5 V).

This completes the Performance Check.

@

ADJUSTMENT PROCEDURE

Introduction

Use this Adjustment Procedure to restore the DC 510 to original performance requirements. This Adjustment Procedure need not be performed unless the instrument fails to meet the Performance Requirements of the Electrical Characteristics listed in the Specification section. If the instrument has undergone repairs, the Adjustment Procedure is recommended. Allow thirty minutes warmup time for operation to specified accuracy (sixty minutes after storage in a high humidity environment).

Satisfactory completion of all adjustment steps in this procedure assures that the instrument will meet the Performance Requirements, providing the instrument is functioning properly.

Test Equipment Required

The test equipment (or equivalent) listed in Table 4-1 is required for adjustment of the DC 510. Specifications given for the test equipment are the minimum necessary for accurate adjustment. All test equipment is assumed to be correctly calibrated and operating within specifications.

If other test equipment is substituted, calibration setup may need to be altered to meet the requirements of the equipment used.

PRELIMINARY CONTROL SETTINGS

DC 510

FREQ A	(lighted)
CHANNEL A and CHANNEL B	
ATTEN	X1 (lighted)
SLOPE	+ (unlighted)
COUPL	DC (unlighted)
TERM	50 Ω (lighted)
AVGS	10^6

Preparation

Access to the internal adjustments is achieved most easily when the DC 510 is connected to the power module with a flexible plug-in extender. Remove the top and side covers of the DC 510 to reach the adjustments and checks on the Auxiliary, Digital, and Analog boards. Refer to the Adjustment Locations and Setups in the pullout pages at the rear of this manual.

NOTE

Make adjustments at an ambient temperature between +20° C and +30° C.

1. Check the Digital Board +12 V Accuracy (±2%)

a. Set the digital multimeter Function-Range switch to 20 Vdc and connect the Low test lead to the DC 510 chassis ground. Connect the Volts/Ω test lead to the Digital board +12 test point.

b. Check that the digital multimeter readout indicates between 11.40 and 12.60 (volts).

2. Check the Digital Board −12.2 V Accuracy (±2%)

a. Remove the Volts/Ω test lead from the +12 test point and connect it to the −12 test point (Digital board).

b. Check that the digital multimeter readout indicates between −11.40 and −12.60 (volts).

3. Check the Digital Board +5 V Accuracy (±2%)

a. Remove the digital multimeter Volts/Ω test lead from the −12 test point and connect it to the +5 test point (Digital board).

b. Check that the digital multimeter redout indicates between +4.90 and +5.10 (volts).

c. Remove the Volts/Ω test lead from the +5 test point.

4. Check the Digital Board +2.5 V (V ref) Accuracy (±1%)

a. Connect the digital multimeter Volts/Ω test lead to the Digital board Vref test point.

b. Check that the digital multimeter readout indicates between 2.475 and 2.525 (volts).

5. Check the Analog Board +5 V Accuracy (±2%)

a. Remove the digital multimeter Volts/Ω test lead from the Vref test point and connect it to the +5 test point (Analog board).

b. Check that the digital multimeter readout indicates between 4.90 and 5.150 (volts).

6. Check the Analog Board +12 V Accuracy (±2%)

a. Remove the digital multimeter Volts/Ω test lead from the +5 test point and connect to the +12 test point (Analog board).

b. Check that the digital multimeter readout indicates between 11.76 and 12.24 (volts).

7. Check the Analog Board −5 V Accuracy (±5%)

a. Remove the digital multimeter Volts/Ω test lead form the +12 test point and connect it to the −5 test point (Analog board).

b. Check that the digital multimeter readout indicates between −4.75 and −5.25 (volts).

c. Remove the test lead connections.

8. Adjust the Standard Timebase Accuracy, C1521, Osc Adj

a. Connect a coaxial cable from the 1 MHz Frequency Standard to the DC 510 CHANNEL A input.

b. Press the DC 510 AUTO TRIG button.

c. ADJUST—C1521 (through a hole in the back plate) until the DC 510 readout indicates between 999.99990 and 1.0000005 MHz.

NOTE

This sets the DC 510 *oscillator within one part in 10^7. It will take approximately one second for the display to update.*

9. Adjust the Optional Timebase Accuracy, Y1530

NOTE

The Option 01 Timebase adjustment is made through an access hole in the back of the oven timebase. Y1530 is located on the back side of the Auxiliary board.

a. Connect a coaxial cable from the 1 MHz Frequency Standard to the DC 510 CHANNEL A input.

b. Set the DC 510 LEVEL CH A for a stable display readout.

c. ADJUST—Y1530 until the DC 510 display readout indicates 1.0000000 MHz.

d. Press to light the PERIOD A button.

e. ADJUST—Y1530 until the DC 510 display readout indicates between 999.99998 and 999.99999.

f. Remove the cable connections from the DC 510.

10. Adjust R1205, A Off, and R1207, B Off

Refer to Fig. 8-3, adjustment setup, in the pullout pages. Use the following control settings.

DC 510

CHANNEL A and CHANNEL B	
TERM	1 MΩ (unlighted)
SLOPE	+ (unlighted)
ATTEN	X1 (lighted)
COUPL	AC (unlighted)
FREQ A	(lighted)

Digital Multimeter

Function-Range	2 V

Pulse Generator

Output low level	(cw)
Output high level	(cw)
Pulse Period	Ext Duration
Pulse Duration	Ext

a. Connect the interconnecting cable from the DC 510 CH A SHAPED OUT to the digital multimeter input using an rf connector-to-banana adapter.

b. Set the DC 510 LEVEL CH A to display 0 V.

c. ADJUST—R1205 counterclockwise to the point where the digital multimeter display readout changes from approximately 0 V to approximately .2 V.

d. Move the DC 510 CH A SHAPED OUT connection to the CH B SHAPED OUT.

e. Set the DC 510 LEVEL CH B to display 0 V.

f. ADJUST—R1207 counterclockwise to the point where the digital multimeter display readout changes from approximately 0 V to approximately .2 V.

g. Disconnect the digital multimeter cable connection.

11. Adjust R1206, B Rng, and R1204, A Rng

Refer to Fig. 8-3, adjustment setup, in the pullout pages.

a. Connect a coaxial cable with 50 Ω termination from the pulse generator output to the digital multimeter input connectors using a bnc-to-banana adapter.

b. Set the DC 510 CHANNEL A and B COUPL for DC.

c. Adjust the pulse generator Low and High level controls until the display readout (digital multimeter) indicates between 1.900 and 2.000 volts. Note this reading.

d. Move the coaxial cable with the 50 Ω termination from the digital multimeter input to the DC 510 CHANNEL B input.

e. Reconnect the cable from the DC 510 CH B SHAPED OUT to the digital multimeter input connectors.

f. Set the DC 510 LEVEL CH B to display the reading obtained in step 11c (within 4 mV).

g. ADJUST—R1206 to the point where the digital multimeter display readout changes from approximately 0 V to approximately .2 V.

h. Move the coaxial cable with 50 Ω termination from the DC 510 CHANNEL B input to the CHANNEL A input.

i. Set the DC 510 LEVEL CH A to display the reading obtained in step 11c (within 4 mV).

j. ADJUST—R1204 to the point where the digital muiltimeter display readout changes from approximately 0 V to approximately .2 V.

12. Adjust AT1505 (Channel A) and AT1533 (Channel B), Attenuator Compensation

Refer to Fig. 8-4, adjustment setup, in the pullout pages. Use the following control setings.

DC 510

CHANNEL A and CHANNEL B	
TERM	1 MΩ (unlighted)
SLOPE	+ (unlighted)
ATTEN	X5 (unlighted)
COUPL	AC (lighted)
PROBE COMP	(lighted)
FILTER	(lighted)

Function Generator

Frequency Hz	1
Multiplier	10^3
Function	Squarewave
Offset	(midrange)
Output	5 V p-to-p (Amplitude)

a. Connect a 50 Ω terminator and 2X attenuator from the function generator output through a coaxial cable to the DC 510 CHANNEL A input.

b. Press the DC 510 PROBE COMP button.

c. ADJUST—the lower adjustment on AT1505 until the digit on the far left side of the DC 510 display just changes from a steady 1 to a 0. The Channel A X5 attenuation is now compensated.

d. Move the DC 510 CHANNEL A input connection to the CHANNEL B input and again press the PROBE COMP button.

e. ADJUST—the lower adjustment on AT1533 until the DC 510 digit on the far right side of the display just changes from a steady 1 to a 0. The Channel B X5 attenuation is now compensated.

f. Remove all cable connections.

13. Adjust AT1505 (Channel A) and AT1533 (Channel B), Attenuator Input Capacitance.

Function Generator

Output	cw (max amplitude)

a. Compensate a X5 test probe to the DC 510 CHANNEL A input and set for X1 attenuation. Refer to Probe Compensation in the Operating Instructions of this manual.

b. After the probe has been properly compensated, connect the probe tip to the function generator output using a probe tip-to-bnc connector.

c. Set the DC 510 CHANNEL A ATTEN to X5 (lighted button) and press to light the PROBE COMP button.

d. ADJUST—the upper adjustment on AT1505, located on the Analog board, until the digit located on the far left side of the DC 510 display just changes from a steady 1 to a 0. The X5 input capacitance is now equal to the X1 input capacitance.

e. Remove the test probe from the CHANNEL A input and the function generator. Then Compensate the probe (see step 13a) to the DC 510 CHANNEL B X1 attenuator.

f. Reconnect the probe tip to the function generator output.

g. Set the DC 510 CHANNEL B ATTEN to ×5 (lighted) and press the PROBE COMP button.

h. ADJUST—the upper adjustment on AT1533, located on the Analog board until the digit on the far right side of the display just changes from a steady 1 to a 0. The Channel B ×5 attenuation is now compensated.

This completes the Adjustment Procedure.

MAINTENANCE

Static-Sensitive Components

CAUTION

Static discharge may damage semiconductor components in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. See Table 5-1 for relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

Observe the following precautions to avoid damage:

1. Minimize handling of static-sensitive components.

2. Transport and store static-sensitive components or assemblies in their original containers, on a metal rail, or on conductive foam. Label any package that contains static-sensitive assemblies or components.

3. Discharge the static voltage from your body by wearing a wrist strap while handling these components. Servicing static-sensitive assemblies or components should be performed only at a static-free work station by qualified service personnel.

4. Nothing capable of generating or holding a static charge should be allowed on the work station surface.

5. Keep the component leads shorted together whenever possible.

6. Pick up components by the body, never by the leads.

7. Do not slide the components over any surface.

8. Avoid handling components in areas that have a floor or work surface covering capable of generating a static charge.

9. Use a soldering iron that is connected to earth ground.

10. Use only special antistatic suction type or wick type desoldering tools.

Test Equipment

Before using any test equipment to make measurements on static-sensitive components or assemblies, be certain that any voltage or current supplied by the test equipment does not exceed the limits of the component to be tested.

Table 5-1
RELATIVE SUSCEPTIBILITY TO STATIC DISCHARGE DAMAGE

Semiconductor Classes	Relative Susceptibility Levels[a]
MOS or CMOS microcircuits or discretes, or linear microcircuits with MOS inputs. (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFETs	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

[a] **Voltage equivalent for levels:**

1 = 100 to 500 V 4 = 500 V 7 = 400 to 1000 V(est.)
2 =200 to 500 V 5 = 400 to 600 V 8 = 900 V
3 = 250 V 6 = 600 to 800 V 9 = 1200 V

(Voltage discharged from a 100 pF capacitor through a resistance of 100 Ω.)

Circuit Board Removal and Replacement

Qualified service personnel will find the DC 510 instrument cover and board removal quite simple using the following procedure. Refer to Fig. 5-1 and the Parts Location Grids in the pullout pages.

1. Remove the two side covers (four 1/4 turn fasteners).

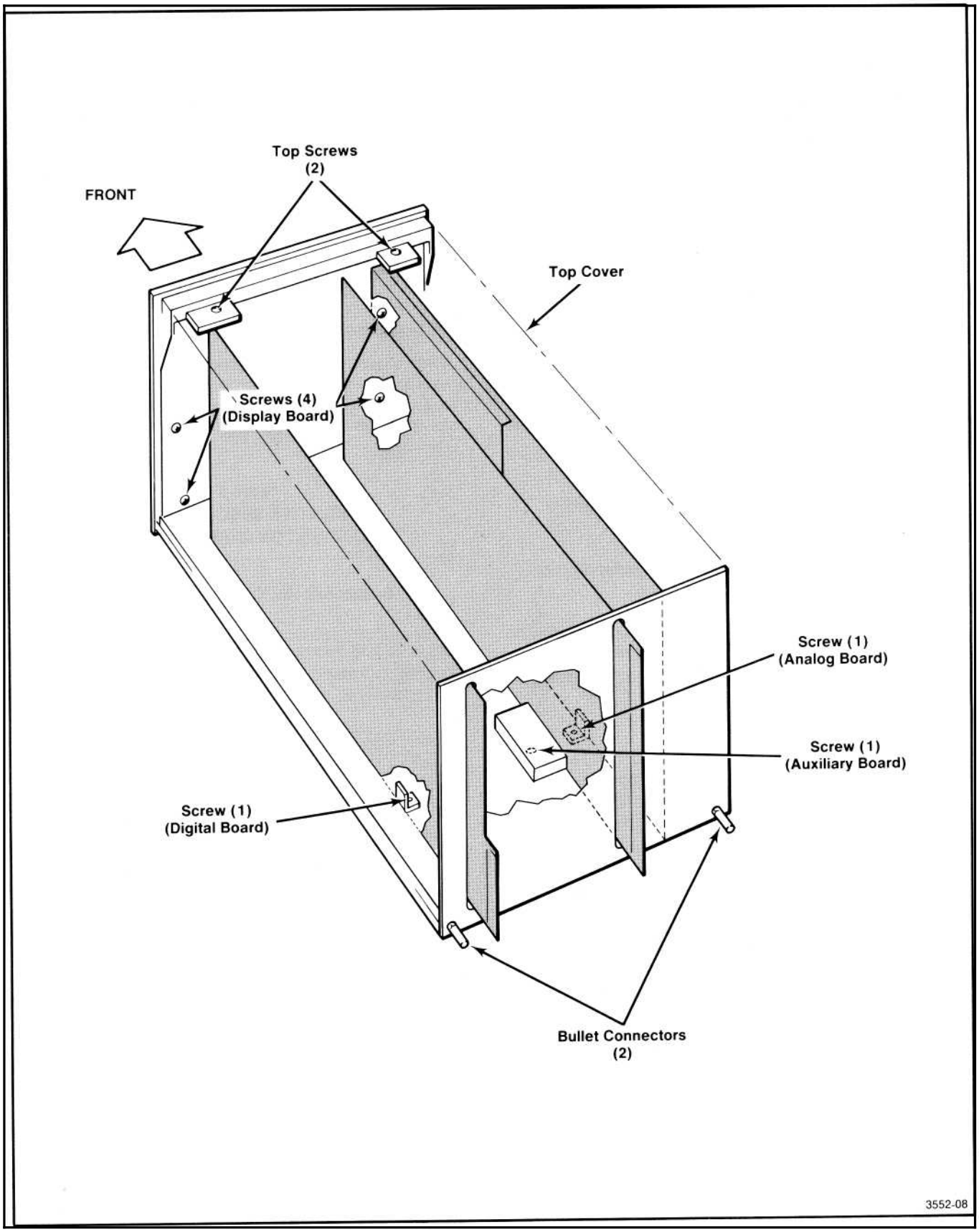


Fig. 5-1. Circuit boards removal and replacement.

2. Remove the top and back covers (may be easily removed as a single unit).

a. Remove the top cover screws (2).

b. Remove the back cover 3/16" hex bullet connectors (2).

c. Carefuly pull the covers up and back to remove.

3. To remove the Digital board.

a. Repeat steps 1 and 2 above.

b. Remove the bottom cover screw that secures the Digital board.

c. Disconnect the connector, P1611 (J1611), from the Auxiliary board.

d. Carefully remove the Digital board.

4. To remove the Analog board or the Auxiliary board (these boards are interconnected and must be removed together).

a. Repeat steps 1 and 2 above.

b. Remove the 9/16" nuts (2) from the front panel Channel A and B bnc input connectors.

c. Remove the bottom cover screws (2) securing both the Analog and Auxiliary boards.

d. Disconnect the two connectors, P1201 (J1201) and P1130 (J1130), from the Analog board.

e. Disconnect the connectors, P1500 (J1500) and P1611 (J1611), from the Auxiliary board.

f. Carefully pull the interconnected boards away from the connector (front panel back) using a gentle up and down rocking motion. Allow sufficient clearance for the input connectors through the front panel.

g. Gently pull the two boards apart, taking care not to damage the interface connector pins. Often it is easier to begin at one end of the board and separate the connectors one at a time.

NOTE

With the Analog board out of the instrument, the Channel A and B bnc connectors are subject to damage. Care should be taken to prevent breaking the bnc solder connections.

5. To remove the Display board (use following to access the seven-segment LEDs and annunciator LEDs).

a. Repeat steps 1 through 5 above.

b. Disconnect the single-pin harmonica connector, P1321.

c. Remove the screws (4) that secure the Display board to the front panel (back).

d. Carefully remove the Display board, pulling up and away from the bottom and lifting out.

6. To replace the circuit boards, reverse the above procedure.

Magnetic Latch Relays

To prevent damage to these relays, do not remove them from the Analog circuit board unless absolutely necessary. If the relay contacts become noisy or the relay fails to operate, remove the relay from the circuit board. Remove the two relay hold down screws located on the rear of the Analog board and carefully remove the relay.

Clean the circuit board contacts with a small brush and isopropyl alcohol. Do not use any solvent that may attack polycarbonates such as hydrocarbon chlorides, ketones, esters, etc. Do not use a cotton swab as small cotton filaments may remain on the contact area.

Clean the contact fingers on the relay armature by lightly brushing the contacts with a brush dipped in isopropyl alcohol.

To remove the relay armature from the relay, obtain a wire or tool with a diameter less than 0.040 inch, such as a paper clip. Before removing the armature, mark the orientation of the armature to the housing. Orientation is important for proper operation. Place the tool in the slot on the side of the housing and gently lift the relay armature. (See Fig.5-2.)

Clean the interior of the relay, around the pole pieces, with isopropyl alcohol. The interior of the relay must be completely dry before reinstalling the armature. Use air to dry excess alcohol from the housing.

NOTE

Do not spray contact cleaners of any type on the relays or the board contacts. Any foreign material, including lubricants, can cause faulty operation.

Cleaning Instructions

This instrument should be cleaned only as often as operating conditions require. Accumulation of dirt on components acts as an insulating blanket and prevents efficient heat dissipation that can cause overheating and component breakdown.

CAUTION

Avoid the use of chemical cleaning agents that might leave a film or damage the plastic material used in this instrument. Use a nonresidue type of cleaner; preferably, isopropyl alcohol or totally denatured ethyl alcohol. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

Exterior. Loose dust accumulated on the front panel can be removed with a soft cloth or a small brush. Dirt that remains can be removed with a soft cloth dampened with a mild detergent and water solution. Abrasive cleaners should not be used.

Interior. Dust in the interior of the instrument should be removed occasionally, due to its electrical conductivity under high humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low pressure air then use a soft brush. If further cleaning is required, use a mild detergent and water solution, flushing well with clean water.

CAUTION

Do not clean the circuit board with water, air, or any solvent, unless the relays are removed first. Any dirt forced or carried under the contacts can cause intermittent operation. Circuit boards and components must be dry before applying power to prevent damage from electrical arcing.

Drying can be accomplished with dry, low-pressure air or by placing in an oven at 40°C to 60°C for approximately four hours.

After making minor board repairs, cleaning is best accomplished by carefully flaking or chipping the solder flux from the repaired area.

Isopropyl alcohol can be used to clean major repairs to the circuit board; however, flush the board well with clean, isopropyl alcohol. Make certain that resin or dirt is carefully removed from the board.

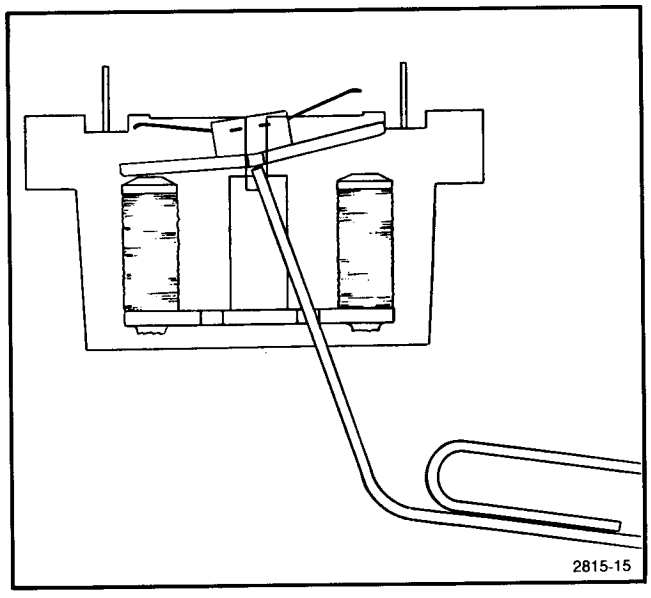


Fig. 5-2. Method of removing magnetic latch relay armature.

Obtaining Replacement Parts

Electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained from a local commercial source. Before purchasing or ordering parts from a source other than Tektronix, Inc., check the Replaceable Electrical Parts list for the proper value, rating, tolerance, and description.

Ordering Parts

When ordering replacement parts from Tektronix, Inc., it is important to include all of the following information.

1. Instrument type (include modification or option numbers).

2. Instrument serial number.

3. A description of the part (if electrical, include the component number).

4. Tektronix part number.

Soldering Techniques

WARNING

To avoid electric shock hazard, disconnect the instrument from the power source before soldering.

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 rosin-core, electronic grade solder. The choice of soldering iron is determined by the repair to be made.

CAUTION

The Analog board in the DC 510 is a multilayer type board with a conductive path laminated between the top and bottom board layers. All soldering on this board should be done with extreme care to prevent breaking the connections to this conductive path. Only experienced maintenance personnel should attempt to repair this board. Do not allow solder or solder flux to flow under printed circuit board relays. The printed circuit board is part of the relay contacts; intermittent relay operation can occur if the contacts are contaminated.

When soldering on circuit boards or small wiring, use only a 15 watt, pencil type soldering iron. A higher wattage soldering iron can cause the etched circuit wiring to separate from the board base material and melt the insulation from small wiring. Always keep the soldering iron tip properly tinned to ensure the best heat transfer to the solder joint. Apply only enough heat to remove the component or to make a good solder joint. To protect heat sensitive components, hold the component lead with a pair of long-nose pliers between the component body and the solder joint. Use a solder removing wick to remove excess solder from connections or to clean circuit board pads.

To remove in-line integrated circuits use an extracting tool. This tool is available from Tektronix, Inc.; order Tektronix Part Number 003-0619-00. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the integrated circuit. Try to avoid disengaging one end before the other end.

Interconnecting Pins

Several methods of interconnection, including square pin, are used to electrically connect the circuit boards with the other boards and components.

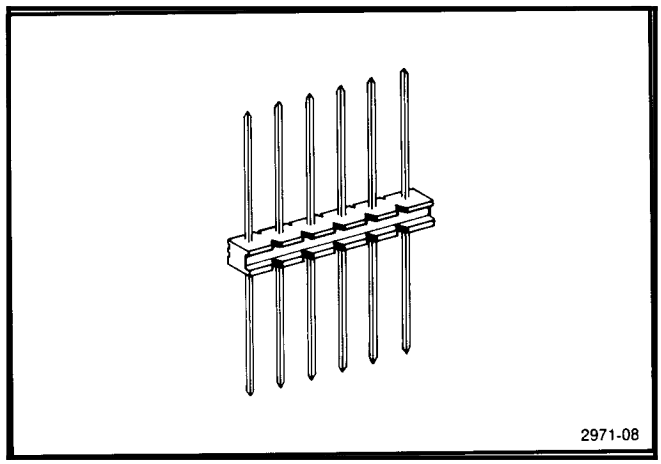
Several types of mating connectors are used for these interconnecting pins. The following information provides the removal and replacement procedure for the various interconnecting methods.

Square Pin Assemblies

See Fig. 5-3. These pins are of various lengths. They are attached to each other with a plastic strip. To remove them simply unsolder from the circuit board.

Bottom Entry and Side Entry Circuit Board Pin Sockets

To remove or replace these sockets unsolder the pins from the circuit board. Use a vacuum or other type desoldering tool to remove excess solder. Use caution to prevent circuit board damage. See Fig. 5-4 for bottom entry socket example.



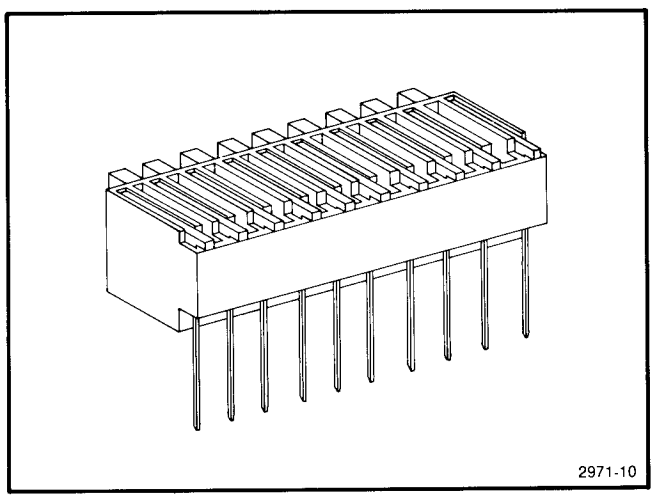


Fig. 5-4. Bottom entry circuit board pin socket.

Multipin Connectors

The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the wires.

To replace damaged multipin connectors, remove the old pin connector from the holder. Do this by inserting a scribe between the connector and the holder and prying the connector from the holder. Clamp the replacement connector to the wire. Reinstall the connector in the holder.

If the individual end lead pin connectors are removed from the plastic holder, note the order of the individual wires for correct replacement in the holder. For proper replacement see Fig. 5-5.

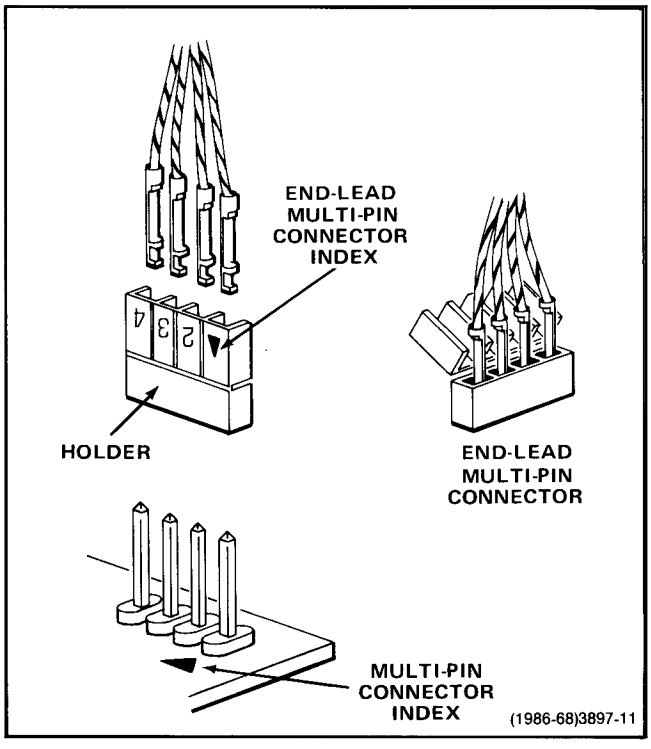


Fig. 5-5. Orientation and disassembly of multipin connectors.

REAR INTERFACE CONNECTORS

Introduction

Refer to Fig. 5-6 for the following.

A slot between pins 21 and 22 on the rear connector identifies this instrument as a member of the TM 5000 counter family. Insert a barrier in the corresponding position of the power module jack to prevent noncompatible plug-ins from being used in that compartment. Consult the power module manual for further information.

Functions Available at Right Rear Interface Connector (P1600)

Pin 14A. External Clock Input—This input allows an external 1, 5, or 10 MHz frequency standard to be used in place of the internal timebase. The input is ac coupled and has a 1 kΩ input resistance. The peak-to-peak input voltage required is ≥0.5 V.

Pin 14B. $\overline{\text{Prescale}}$—When this available line is held low, the counter automatically adjusts the displayed answer for use with a divide-by-16 prescaler in FREQ A, PERIOD A, RATIO B/A, and TOTALIZE A modes (≤1 TTL load).

Pin 15A. 10 MHz Clock Out Ground—This terminal is the ground return for the clock input-output signals.

Pin 15B. 10 MHz Clock Out—This available output line will drive one TTL load. This line is not intended to drive large capacitance loads and cable length should be kept to a minimum.

Pin 26A. $\overline{\text{Reset}}$ Input—When this line is set low, the current measurement process is aborted for all selected functions and causes all digits in the display to read 8.8.8.8.8.8.8.8.8. All eight annunciators (and push buttons) are also illuminated. When this line is set high, a new measurement process is initiated for the selected FUNCTION and operating conditions. (CMOS ^{V}IL ≤1.5 V and ^{V}IH ≥3.5 V with a minimum pulse width of approximately 10 ms.) When not used, the line is in the high state.

OUTPUT OR INPUT	PIN B		PIN A	OUTPUT OR INPUT
	28		28	ARMING INPUT GROUND
	27		27	ARMING INPUT
	26		26	$\overline{\text{RESET}}$ INPUT
	25		25	
	24		24	
	23		23	
	22	BARRIER SLOT	22	
	21		21	
	20		20	
	19		19	
	18		18	
	17		17	
	16		16	
10MHz CLOCK OUT	15		15	10MHz CLOCK OUT GROUND
$\overline{\text{PRESCALE}}$	14		14	EXTERNAL CLOCK INPUT
	13		13	
+33.5V DC	12		12	+33.5V DC
COLLECTOR LEAD OF PNP SERIES PASS	11		11	BASE LEAD OF PNP SERIES PASS
	10		10	EMITTER LEAD OF PNP SERIES PASS
±33.5V COMMON	9		9	±33.5V COMMON
-33.5V DC	8		8	-33.5V DC
COLLECTOR LEAD OF NPN SERIES PASS	7	TM 500 BARRIER SLOT	7	EMITTER LEAD OF NPN SERIES PASS
	6		6	BASE LEAD OF NPN SERIES PASS
	5		5	
+11.5V COMMON	4		4	+11.5V COMMON
+11.5V COMMON	3		3	+11.5V COMMON
+11.5V DC	2	REAR VIEW OF PLUG-IN	2	+11.5V DC
	1		1	

3552-09

Fig. 5-6. Right rear interface connector assignments.

Pin 27A. Arming Input—This terminal is normally at a TTL high level. When pulled to a TTL low state with a TTL signal or transistor collector, the counter is prevented from making a measurement until the input goes to a TTL high state. When this input is routed to the rear interface it is dc coupled to the front panel arm signal. ($^{V}H \geq 2.4$ V, $^{V}L \leq 0.4$ V approximately 2 TTL loads).

Pin 28A. Arming Input Ground—This terminal is the ground return for the rear interface arming input signal.

Functions Available at Left Rear Interface Connector (P1820)

Refer to Fig. 5-7 for connector assignments.

OUTPUT OR INPUT	PIN B		PIN A	OUTPUT OR INPUT
+33.5V DC	12		12	+33.5V DC
COLLECTOR LEAD OF PNP SERIES PASS	11		11	BASE LEAD OF PNP SERIES PASS
	10		10	EMITTER LEAD OF PNP SERIES PASS
±33.5V COMMON	9		9	±33.5V COMMON
-33.5V DC	8	TM 500 BARRIER SLOT	8	-33.5V DC
COLLECTOR LEAD OF NPN SERIES PASS	7		7	EMITTER LEAD OF NPN SERIES PASS
	6		6	BASE LEAD OF NPN SERIES PASS
	5		5	
+11.5V COMMON	4		4	+11.5V COMMON
+11.5V COMMON	3		3	+11.5V COMMON
+11.5V DC	2	REAR VIEW OF PLUG-IN	2	+11.5V DC
	1		1	

3552-10

Fig. 5-7. Left rear interface connector assignments.

DIAGNOSTICS

Introduction

The following information is intended to aid in the diagnosis and repair of a malfunctioning instrument. With power-on Self Test, signature analysis checks, and other troubleshooting data, the qualified service personnel will be able to verify proper operation or detect malfunction in this instrument.

Not all of the instrument faults may be isolated by this information or indicated by the instrument's built-in self test features. The service personnel should then refer to the Theory of Operation section, in this manual for a better understanding of the circuit details.

Equipment Required

The recommended diagnostic tests require the following equipment or equivalent.

Data analyzer. TEKTRONIX type SA 501 or type 308 Data Analyzer (for signature analysis)

Digital counter. TEKTRONIX type DC 503A (for time-base frequency checks)

Digital multimeter. TEKTRONIX type DM 501A (for checking power supplies)

Also refer to the equipment list in the Calibration section of this manual for suggestions on oscilloscope systems, probes, adapters, terminations and other equipment that may be useful for troubleshooting purposes.

Adjustment and Test Point Locations

When locating adjustable components and test points, refer to the Adjustment and Setups Location in the pullout pages of this manual.

Self Test

The DC 510 has two modes of self test. The automatic test sequence at power on and the TEST function selected by the front panel TEST button.

The automatic test sequence at power-on (Power On Self Test) is initiated each time the power is applied to the instrument. The microprocessor sequences through special data patterns to test the operation of the circuits in the in-

@

strument. At power-on, after the microprocessor reset line has been released, the following tests are performed:

1. The display (time slot generator, diagram 10) is reset to the most significant digit (digit to extreme left) and a 0 readout is displayed.

2. The RAM is tested by writing a known bit pattern into the RAM and reading it back. Each byte in the RAM is verified. If any byte does not verify, the RAM test error code is displayed on the front panel and the test sequence stops. The patterns written are FF, AA, 55, 00 (hexidecimal) in succession leaving the RAM cleared when the test is finished. If this test is not successfully completed, the proper error code is displayed and the self test sequence stops.

3. The ROM's are checked for proper checksums. If any of these tests fail, the power on self test sequence is stopped and the proper error code is displayed. The order of the RAM and ROM test is given in Table 5-2.

Table 5-2
RAM & ROM Test Sequence
(DC 510 Placement and Checksum)

RAM	$0000 - $007F
	$0400 - $04FF
ROM	$0800 - $0FFF
	$1000 - $1FFF

4. Next, the automatic test sequence sets the instrument gating to the RATIO B/A function.

5. The serial I/O data loop is checked next, by writing out a data pattern to the serial-to-parallel shift registers. The data pattern is read back through the parallel-to-serial shift registers. If the data are correct, the power-on sequence continues. If the data are not correct, the error code for this test is displayed and the test sequence stops. This test checks the shift registers and the data path, including the serial clock but does not check the input or output stages of the shift registers or the latch control lines. Troubleshooting of the serial I/O loop is best accomplished using signature analysis.

6. The next test is the counter integrity test. This test first resets the instrument's Channel A and Channel B accumulators by pulsing the MR (master reset) line. It then checks each of the tested counter stages to verify that all bits are reset. If any bits are not reset, the proper error code is displayed and the test sequence stops. Next, the $\overline{\text{GATE}}$ signal, (diagram 3) is asserted. The instrument then inputs counts to the accumulators. These counts are generated by changing the trigger levels for both Channel A and Channel B using the D/A converters. The D/A converter level changes (cycles) from its current setting to +2.0 V then to −2.0 V and back to +2.0 V. This cycle represents one count if the Channel A and Channel B input voltages are within this voltage range and the ARM signal, (diagram 6) is in the high state.

After each cycle or set of cycles, the accumulators are read and checked to see if the proper count has been reached. If a count greater than or equal to the proper count has not been accumulated, the error code for that accumulator stage is displayed and the self test sequence stops.

An improper count might occur because of a bad counter chip, a bad readout chip, or a disconnected cable.

NOTE

The signal path starts at the D/A converters and the cycle must pass through the amplifiers, gating, and the accumulators. A first bit error (320, 330) may indicate an amplifier, FET or Schmitt error.

7. If the counter integrity test fails for any of the described reasons, the D/A converters will be set to −2 V. The gating (diagram 3), remains in the RATIO B/A function and by applying a signal, that crosses the −2 V Trigger level settings, to the appropriate channel input, the service personnel can trace this signal through the amplifier, gating, and accumulator circuits. Also refer to Table 8-2 in the pullout pages.

TEST Function

The TEST function from the front panel is similar to the Power On Self Test sequence with one exception. The RAM test is not executed, thereby preventing the instrument's settings from being lost while in the TEST function.

TROUBLESHOOTING

The following is a general troubleshooting procedure to use when the instrument malfunctions.

First, verify that the instrument is properly connected to the appropriate power module and that this power module is operable. Then refer to Fig. 8-5, General Troubleshooting Flowchart, in the pullout pages. This flowchart is a guide for qualified service personnel to locate various areas of circuitry, depending on the instrument symptoms. It may also refer the service personnel to the following signature analysis procedure.

SIGNATURE ANALYSIS

Introduction

The DC 510 was designed to be compatible with two signature analysis methods.

Internal signature analysis—this is a microprocessor driven pattern generator contained in the ROM. This method will only work when the kernel microprocessor and its associated ROM, RAM, and connections are functional.

Kernel signature analysis—this requires the use of an external kernel test service kit (Tektronix part number 067-1007-00). This method allows qualified service personnel to test and isolate problems in the kernel of the instrument.

Internal Signature Analysis

The internal signature analysis mode is entered at power-on by pressing the CHANNEL A TERM button (50 Ω) as power is applied. This mode will not operate if the instrument fails the power on RAM test. Refer to Figs. 8-6, 8-7, 8-8, and 8-9 in the pullout pages, for the internal signatures setup information for each circuit board.

In the internal signature analysis mode, the serial loop is most easily diagnosed. The START, STOP, and CLOCK edge polarities must be properly set as shown on the appropriate signature diagram. When the instrument is in this mode, all segments and annunciators in the display are lighted, with the extreme left digit brighter than the other digits. The pushbuttons are also lighted.

To exit the Internal Signature Analysis mode, the instrument must be powered down and then powered up.

Kernel Signature Analysis

CAUTION

The Digital board microprocessor, U1301, is removed (observing proper static handling procedures) before making the kernel test.

The kernel signature analysis mode is used to diagnose problems that prevent the microprocessor kernel circuitry from functioning properly. It is used with a signature analyzer to verify signatures in the kernel circuitry.

Refer to Fig. 5-8 for the following.

Make certain the power module power is off when connecting this service kit to the instrument. Then, connect J1002 and J1003 of the Kernel Test board to J1210 and J1211 on the instrument Digital board (A16), respectively, using the cables and square pin adapters provided with the kit. Make sure that the cables do not get twisted. Connect the START, STOP, CLOCK, and GROUND connections of the analyzer to the test points as indicated on the appropriate Kernel Signature (Fig. 8-10) in the pullout pages. Also make sure that the START, STOP, and CLOCK polarities have been properly selected on the analyzer.

In troubleshooting the kernel, the following information may be helpful.

Two physically adjacent points having the same signature, whether one or both are incorrect, may indicate they are shorted together.

A point with 0000 signature is grounded, or in a low state. A point with the +5 V signature (noted on each signature diagram) may be opened or the driving node may be stuck in the high state. The point might also be shorted to +5 V.

Selected Components (R1307 and R1326)

Refer to diagram 2 (board A12) in the pullout pages for the following.

If IC's U1310 and U1330 (M234 Type) are replaced and the input sensitivity (50 Ω) is found to exceed 57 mV peak-to-peak at 100 MHz (25°C ambient temperature), the following procedure is recommended.

NOTE

If IC's U1310 and U1330 (M234) should have to be replaced, the input sensitivity is unlikely to vary.

The values of selected resistors, R1307 and R1326 (nominal value of 1.4 kΩ each) may be changed to alter the input sensitivity for channels A and B respectively.

If the instrument requires more than a 57 mV peak-to-peak signal to trigger it, the resistance values of R1307 and R1326 will need to increase. The sensitivity will change approximately 10 mV peak-to-peak for each 500 Ω of resistance change. See the Specification section of this manual for the input sensitivity limits.

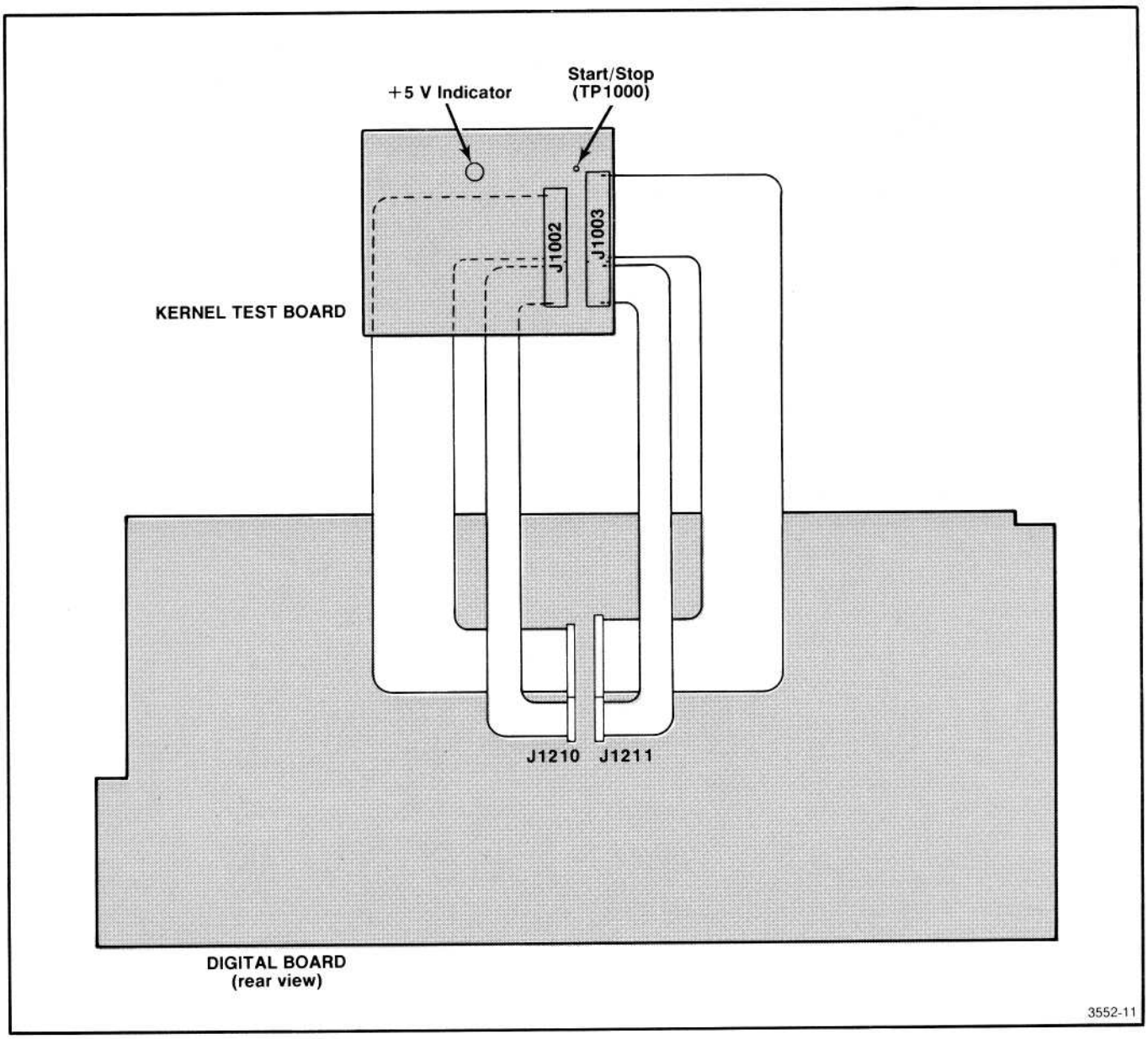


Fig. 5-8. Kernel signature analysis connections.

OPTIONS

Your instrument may be equipped with one or more instrument options or optional accessories. A brief description of each instrument option is given below. For further information on instrument options or optional accessories, see your Tektronix Catalog or contact your Tektronix Field Office. If additional options are made available for this instrument, they may be described in a Change Information insert at the back of this manual or in this section.

OPTION 01

Replaces the standard 10 MHz oscillator with a self contained, proportional temperature controlled oven oscillator for increased accuracy and stability. Information relative to Option 01 can be found on schematic ◇5◇ , and in the Specification, Calibration, and Theory of Operation sections.

REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

LIST OF ASSEMBLIES

A list of assemblies can be found at the beginning of the Electrical Parts List. The assemblies are listed in numerical order. When the complete component number of a part is known, this list will identify the assembly in which the part is located.

CROSS INDEX-MFR. CODE NUMBER TO MANUFACTURER

The Mfr. Code Number to Manufacturer index for the Electrical Parts List is located immediately after this page. The Cross Index provides codes, names and addresses of manufacturers of components listed in the Electrical Parts List.

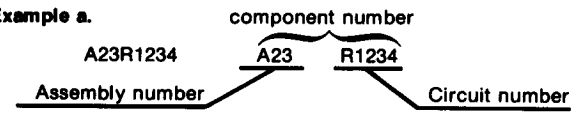
ABBREVIATIONS

Abbreviations conform to American National Standard Y1.1.

COMPONENT NUMBER (column one of the Electrical Parts List)

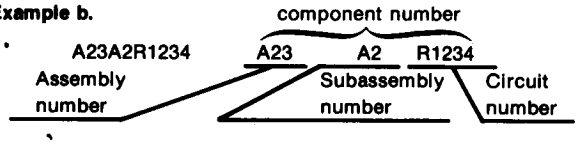
A numbering method has been used to identify assemblies, subassemblies and parts. Examples of this numbering method and typical expansions are illustrated by the following:

Example a.



Read: Resistor 1234 of Assembly 23

Example b.



Read: Resistor 1234 of Subassembly 2 of Assembly 23

Only the circuit number will appear on the diagrams and circuit board illustrations. Each diagram and circuit board illustration is clearly marked with the assembly number. Assembly numbers are also marked on the mechanical exploded views located in the Mechanical Parts List. The component number is obtained by adding the assembly number prefix to the circuit number.

The Electrical Parts List is divided and arranged by assemblies in numerical sequence (e.g., assembly A1 with its subassemblies and parts, precedes assembly A2 with its subassemblies and parts).

Chassis-mounted parts have no assembly number prefix and are located at the end of the Electrical Parts List.

TEKTRONIX PART NO. (column two of the Electrical Parts List)

Indicates part number to be used when ordering replacement part from Tektronix.

SERIAL/MODEL NO. (columns three and four of the Electrical Parts List)

Column three (3) indicates the serial number at which the part was first used. Column four (4) indicates the serial number at which the part was removed. No serial number entered indicates part is good for all serial numbers.

NAME & DESCRIPTION (column five of the Electrical Parts List)

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

MFR. CODE (column six of the Electrical Parts List)

Indicates the code number of the actual manufacturer of the part. (Code to name and address cross reference can be found immediately after this page.)

MFR. PART NUMBER (column seven of the Electrical Parts List)

Indicates actual manufacturers part number.

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
000ID	G & E MICROCIRCUITS	2000 W 14TH STREET	TEMPE, AZ 85281
00779	AMP, INC.	P O BOX 3608	HARRISBURG, PA 17105
01121	ALLEN-BRADLEY COMPANY	1201 2ND STREET SOUTH	MILWAUKEE, WI 53204
01295	TEXAS INSTRUMENTS, INC., SEMICONDUCTOR GROUP	P O BOX 5012, 13500 N CENTRAL EXPRESSWAY	DALLAS, TX 75222
03508	GENERAL ELECTRIC COMPANY, SEMI-CONDUCTOR PRODUCTS DEPARTMENT	ELECTRONICS PARK	SYRACUSE, NY 13201
03888	KDI PYROFILM CORPORATION	60 S JEFFERSON ROAD	WHIPPANY, NJ 07981
04222	AVX CERAMICS, DIVISION OF AVX CORP.	P O BOX 867, 19TH AVE. SOUTH	MYRTLE BEACH, SC 29577
04713	MOTOROLA, INC., SEMICONDUCTOR PROD. DIV.	5005 E MCDOWELL RD,PO BOX 20923	PHOENIX, AZ 85036
07263	FAIRCHILD SEMICONDUCTOR, A DIV. OF FAIRCHILD CAMERA AND INSTRUMENT CORP.	464 ELLIS STREET	MOUNTAIN VIEW, CA 94042
11532	TELEDYNE RELAYS	3155 W EL SEGUNDO BLVD.	HAWTHORNE, CA 90250
14433	ITT SEMICONDUCTORS	3301 ELECTRONICS WAY P O BOX 3049	WEST PALM BEACH, FL 33402
18324	SIGNETICS CORP.	811 E. ARQUES	SUNNYVALE, CA 94086
22526	BERG ELECTRONICS, INC.	YOUK EXPRESSWAY	NEW CUMBERLAND, PA 17070
24546	CORNING GLASS WORKS, ELECTRONIC COMPONENTS DIVISION	550 HIGH STREET	BRADFORD, PA 16701
24931	SPECIALITY CONNECTOR CO., INC.	2620 ENDRESS PLACE	GREENWOOD, IN 46142
27014	NATIONAL SEMICONDUCTOR CORP.	2900 SEMICONDUCTOR DR.	SANTA CLARA, CA 95051
32997	BOURNS, INC., TRIMPOT PRODUCTS DIV.	1200 COLUMBIA AVE.	RIVERSIDE, CA 92507
33096	COLORADO CRYSTAL CORPORATION	2303 W 8TH STREET	LOVELAND, CO 80537
34576	ROCKWELL INTERNATIONAL CORP. ELECTRONIC DEVICES DIVISION	3310 MIRALBMA AVE.	ANAHEIM, CA 92803
50434	HEWLETT-PACKARD COMPANY	640 PAGE MILL ROAD	PALO ALTO, CA 94304
50522	MONSANTO CO., ELECTRONIC SPECIAL PRODUCTS	3400 HILLVIEW AVENUE	PALO ALTO, CA 94304
51642	CENTRE ENGINEERING INC.	2820 E COLLEGE AVENUE	STATE COLLEGE, PA 16801
51984	NEC AMERICA INC. RADIO AND TRANSMISSION DIV.	2990 TELESTAR CT. SUITE 212	FALLS CHURCH, VA 22042
52262	B AND H ELECTRONICS, INC., DBA MICRO COMPONENTS ASSOCIATES	202 E STEVENS ST., SUITE 6	SANTA ANA, CA 92707
52648	PLESSEY SEMICONDUCTORS	1641 KAISER	IRVINE, CA 92714
53184	XCITON CORPORATION	5 HEMLOCK STREET	LATHAM, NY 12110
55210	GETTIG ENG. AND MFG. COMPANY	PO BOX 85, OFF ROUTE 45	SPRING MILLS, PA 16875
55576	SYNERTEX	3050 CORONADO DR	SANTA CLARA, CA 95051
55680	NICHICON/AMERICA/CORP.	6435 N PROESEL AVENUE	CHICAGO, IL 60645
56289	SPRAGUE ELECTRIC CO.	87 MARSHALL ST.	NORTH ADAMS, MA 01247
71400	BUSSMAN MFG., DIVISION OF MCGRAW-EDISON CO.	2536 W. UNIVERSITY ST.	ST. LOUIS, MO 63107
72982	ERIE TECHNOLOGICAL PRODUCTS, INC.	644 W. 12TH ST.	ERIE, PA 16512
73138	BECKMAN INSTRUMENTS, INC., HELIPOT DIV.	2500 HARBOR BLVD.	FULLERTON, CA 92634
74970	JOHNSON, E. F., CO.	299 10TH AVE. S. W.	WASECA, MN 56093
75042	TRW ELECTRONIC COMPONENTS, IRC FIXED RESISTORS, PHILADELPHIA DIVISION	401 N. BROAD ST.	PHILADELPHIA, PA 19108
76493	BELL INDUSTRIES, INC., MILLER, J. W., DIV.	19070 REYES AVE., P O BOX 5825	COMPTON, CA 90224
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
91293	JOHANSON MFG. COMPANY	P O BOX 329	BOONTON, NJ 07005
91637	DALE ELECTRONICS, INC.	P. O. BOX 609	COLUMBUS, NE 68601

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A10	670-6993-00			CKT BOARD ASSY:DISPLAY	80009	670-6993-00
A12	670-6994-00			CKT BOARD ASSY:ANALOG	80009	670-6994-00
A16	670-6995-00			CKT BOARD ASSY:DIGITAL	80009	670-6995-00
A18	670-6996-00			CKT BOARD ASSY:AUXILIARY	80009	670-6996-00
	----- -----			(STANDARD ONLY)		
A18	670-6997-00			CKT BOARD ASSY:AUXILIARY W/OVEN	80009	670-6997-00
	----- -----			(OPTION 01 ONLY)		
A10	----- -----			CKT BOARD ASSY:DISPLAY		
A10C1321	281-0765-00			CAP.,FXD,CER DI:100PF,5%,100V	51642	G1710100X5P101J
A10DS1001	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1002	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1003	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1004	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1005	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1101	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1102	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1103	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1104	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1111	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1112	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1113	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1114	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1131	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1132	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1133	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1134	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1201	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1202	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1203	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1211	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1213	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1214	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1221	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1222	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1223	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1224	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1231	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1232	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1233	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1234	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1301	150-1053-00			LAMP,LED RDOUT:ORANGE,7 SEG,0.4 DIGIT	50522	MAN 4610A
A10DS1302	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1303	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1304	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1306	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1311	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1313	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1314	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1321	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1323	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1325	150-1031-00			LT EMITTING DIO:RED,650NM,40MA MAX	53184	XC209R
A10DS1331	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1332	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10DS1333	150-1043-00			LT EMITTING DIO:RED,20MA,5V	50522	MV5774C
A10P1001	131-1934-00			TERM. SET,PIN:1 X 36,0.1 CTR,0.9 L	22526	65539-001

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A10P1002	131-1934-00			TERM. SET,PIN:1 X 36,0.1 CTR,0.9 L	22526	65539-001
A10P1321	131-1934-00			TERM. SET,PIN:1 X 36,0.1 CTR,0.9 L	22526	65539-001
A10Q1121	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10Q1122	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10Q1123	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10Q1124	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10Q1125	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10Q1126	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10Q1127	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10Q1221	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10Q1222	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A10R1321	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A10S1111	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1111	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1112	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1112	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1113	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1113	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1114	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1114	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1131	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1131	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1132	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1132	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1133	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A10S1313	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1314	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1314	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1321	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1321	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1322	263-0019-03	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-03
A10S1322	263-0019-38	B010240		SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A10S1323	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1323	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1324	263-0019-03	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-03
A10S1324	263-0019-38	B010240		SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A10S1331	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1331	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1332	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1332	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1333	263-0019-01	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-01
A10S1333	263-0019-35	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-35
A10S1334	263-0019-04	B010100	B010239	ACTR ASSY,PB:MOMENTARY	80009	263-0019-04
A10S1334	263-0019-37	B010240		SWITCH,PB ASSY:MOMENTARY	80009	263-0019-37
A10U1121	156-0799-00			MICROCIRCUIT,DI:DECADE CNTR/DTV	80009	156-0799-00

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A12	----- -----			CKT BOARD ASSY:ANALOG		
A12AT1505	307-1012-00			ATTENUATOR,FXD:5X	80009	307-1012-00
A12AT1533	307-1012-00			ATTENUATOR,FXD:5X	80009	307-1012-00
A12C1003	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1004	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1005	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1010	281-0808-00			CAP.,FXD,CER DI:7PF,20%,100V	72982	8035D9AADC0G709G
A12C1011	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1012	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1013	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1014	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1015	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1020	281-0770-00			CAP.,FXD,CER DI:0.001UF,20%,100V	72982	8035D9AADX5R102M
A12C1021	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1022	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1023	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1024	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1025	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1030	283-0423-00			CAP.,FXD,CER DI:0.22UF,+80-20%,50V	04222	DG015E224Z
A12C1031	283-0423-00			CAP.,FXD,CER DI:0.22UF,+80-20%,50V	04222	DG015E224Z
A12C1032	281-0798-00			CAP.,FXD,CER DI:51PF,1%,100V	04222	MC101A510G
A12C1034	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A12C1107	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1108	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1110	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1113	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1114	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1118	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1120	281-0770-00			CAP.,FXD,CER DI:0.001UF,20%,100V	72982	8035D9AADX5R102M
A12C1121	281-0810-00			CAP.,FXD,CER DI:5.6PF,0.5%,100V	72982	1035D2ADC0G569D
A12C1122	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1123	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1130	281-0810-00			CAP.,FXD,CER DI:5.6PF,0.5%,100V	72982	1035D2ADC0G569D
A12C1131	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A12C1140	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1200	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1201	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1210	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1211	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1212	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A12C1213	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1220	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A12C1221	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A12C1230	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1231	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A12C1233	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1234	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1303	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1304	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1312	283-0094-00			CAP.,FXD,CER DI:27PF,10%,200V	72982	835-583-C0G0270K
A12C1313	281-0814-00			CAP.,FXD,CER DI:100PF,10%,100V	04222	GC70-1-A101K
A12C1317	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1319	283-0260-00			CAP.,FXD,CER DI:5.6PF,5%,200V	72982	8111B200C0G569C
A12C1322	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1323	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1330	283-0094-00			CAP.,FXD,CER DI:27PF,10%,200V	72982	835-583-C0G0270K
A12C1331	281-0814-00			CAP.,FXD,CER DI:100PF,10%,100V	04222	GC70-1-A101K

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A12C1333	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1339	283-0260-00			CAP.,FXD,CER DI:5.6PF,5%,200V	72982	8111B200C0G569C
A12C1401	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1403	283-0107-00			CAP.,FXD,CER DI:51PF,5%,200V	72982	8121B232C0G0510J
A12C1405	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1412	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A12C1413	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1414	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1415	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A12C1425	283-0107-00			CAP.,FXD,CER DI:51PF,5%,200V	72982	8121B232C0G0510J
A12C1432	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A12C1435	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1500	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A12C1501	281-0770-00			CAP.,FXD,CER DI:0.001UF,20%,100V	72982	8035D9AADX5R102M
A12C1502	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1503	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1504	283-0185-00			CAP.,FXD,CER DI:2.5PF,5%,50V	72982	8101B057C0K0295B
A12C1506	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1507	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1509	283-0160-00			CAP.,FXD,CER DI:1.5PF,10%,50V	72982	8101A058C0K159B
A12C1512	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1513	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1514	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1515	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1516	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1517	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1518	283-0252-00			CAP.,FXD,CER DI:1000PF,10%,50V	04222	ULA105C102K2T60
A12C1519	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1520	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A12C1521	281-0770-00			CAP.,FXD,CER DI:0.001UF,20%,100V	72982	8035D9AADX5R102M
A12C1522	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1523	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1524	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1525	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1527	283-0160-00			CAP.,FXD,CER DI:1.5PF,10%,50V	72982	8101A058C0K159B
A12C1530	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1531	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A12C1532	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A12C1533	283-0185-00			CAP.,FXD,CER DI:2.5PF,5%,50V	72982	8101B057C0K0295B
A12C1535	283-0252-00			CAP.,FXD,CER DI:1000PF,10%,50V	04222	ULA105C102K2T60
A12C1536	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1537	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1538	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1539	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1601	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1607	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1610	283-0410-00			CAP.,FXD,CER DI:0 .022UF,10%,500V	91293	501548W223KBS
A12C1611	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1612	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1613	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1614	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1615	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1616	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1617	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1620	283-0410-00			CAP.,FXDK,CER DI:0.022UF,10%,500V	91293	501548W223KBS
A12C1621	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1622	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M

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A12C1623	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1624	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1625	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1626	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1631	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A12C1632	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1633	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1634	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1635	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1636	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1637	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12C1639	283-0220-00			CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A12CR1111	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1130	152-0269-00			SEMICOND DEVICE:SILICON,VAR VCAP.,4V,33PF	80009	152-0269-00
A12CR1200	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1201	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1220	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1300	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A12CR1310	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A12CR1311	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1320	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A12CR1330	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1331	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1332	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A12CR1400	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1401	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1410	152-0536-00			SEMICOND DEVICE:SILICON,HOT CARRIER,4V	80009	152-0536-00
A12CR1411	152-0536-00			SEMICOND DEVICE:SILICON,HOT CARRIER,4V	80009	152-0536-00
A12CR1420	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1430	152-0536-00			SEMICOND DEVICE:SILICON,HOT CARRIER,4V	80009	152-0536-00
A12CR1431	152-0536-00			SEMICOND DEVICE:SILICON,HOT CARRIER,4V	80009	152-0536-00
A12CR1510	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A12CR1511	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A12CR1512	152-0246-00			SEMICOND DEVICE:SW,SI,40V,200MA	03508	DE140
A12CR1513	152-0246-00			SEMICOND DEVICE:SW,SI,40V,200MA	03508	DE140
A12CR1520	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A12CR1530	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A12CR1531	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	50434	5082-2672
A12CR1532	152-0246-00			SEMICOND DEVICE:SW,SI,40V,200MA	03508	DE140
A12CR1533	152-0246-00			SEMICOND DEVICE:SW,SI,40V,200MA	03508	DE140
A12DL500	119-1367-00			DELAY LINE,ELEC:4 NAO SEC,50 OHM	80009	119-1367-00
A12J500	131-1097-00			CONNECTOR,RCPT,:BNC,FEMALE,CKT BOARD MT	24931	28JR220-2
A12J510	131-1097-00			CONNECTOR,RCPT,:BNC,FEMALE,CKT BOARD MT	24931	28JR220-2
A12J1010	131-2651-00			CONN,RCPT,ELEC:HEADER,1 X 36,0.1 CTR	22526	65510-436
A12J1102	131-2651-00			CONN,RCPT,ELEC:HEADER,1 X 36,0.1 CTR	22526	65510-436
A12J1130	131-1003-00			CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A12J1201	131-1003-00			CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A12J1230	131-2132-01			CONN,RCPT,ELEC:HEADER,1 X 36,01 CTR	22526	65506-436
A12J1400	131-2132-01			CONN,RCPT,ELEC:HEADER,1 X 36,01 CTR	22526	65506-436
A12J1420	131-2132-01			CONN,RCPT,ELEC:HEADER,1 X 36,01 CTR	22526	65506-436
A12J1510	131-2651-00			CONN,RCPT,ELEC:HEADER,1 X 36,0.1 CTR	22526	65510-436
A12J1520	131-2651-00			CONN,RCPT,ELEC:HEADER,1 X 36,0.1 CTR	22526	65510-436
A12K1500	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1510	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1511	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1520	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1521	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00

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A12K1530	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1600	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1610	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1611	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1612	148-0108-00			RELAY,ARMATURE:2 FORM C,5VDC COIL,2A	11532	720-5
A12K1620	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1630	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1631	148-0128-00			RELAY,ARMATURE:1 FORM X & 1 FORM Y,8VDC	80009	148-0128-00
A12K1632	148-0108-00			RELAY,ARMATURE:2 FORM C,5VDC COIL,2A	11532	720-5
A12L1009	108-0436-00			COIL,RF:FIXED,240NH	80009	108-0436-00
A12L1120	120-0382-00			XFMR,TOROID:14 TURNS,SINGLE	80009	120-0382-00
A12L1220	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1221	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1230	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1231	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1232	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1233	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1302	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1310	108-0262-00			COIL,RF:FIXED,510MH	80009	108-0262-00
A12L1311	108-0262-00			COIL,RF:FIXED,510MH	80009	108-0262-00
A12L1312	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1322	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1330	108-0262-00			COIL,RF:FIXED,510MH	80009	108-0262-00
A12L1331	108-0262-00			COIL,RF:FIXED,510MH	80009	108-0262-00
A12L1332	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1410	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12L1430	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A12Q1000	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A12Q1100	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A12Q1110	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A12Q1111	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A12Q1112	151-0220-00			TRANSISTOR:SILICON,PNP	07263	S036228
A12Q1114	151-0220-00			TRANSISTOR:SILICON,PNP	07263	S036228
A12Q1122	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1130	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1200	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A12Q1201	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A12Q1202	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A12Q1203	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1204	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1210	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A12Q1211	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A12Q1220	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A12Q1221	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A12Q1222	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1300	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1301	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1302	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1303	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1320	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1321	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1322	151-0369-00			TRANSISTOR:SILICON,PNP	01295	SKA6664
A12Q1323	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1400	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1401	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1402	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1403	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00

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A12Q1410	151-1117-00			TRANSISTOR:FE,DUAL,N-CHANNEL,SI	80009	151-1117-00
A12Q1420	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1421	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1422	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1423	151-0427-00			TRANSISTOR:SILICON,NPN	80009	151-0427-00
A12Q1430	151-1117-00			TRANSISTOR:FE,DUAL,N-CHANNEL,SI	80009	151-1117-00
A12R1000	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1001	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A12R1002	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1003	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A12R1004	307-0546-00			RES NTWK,FXD FI:5,75 OHM,5%,0.15W	91637	MSP06A01750J
A12R1005	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1006	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1007	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1008	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1009	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1010	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1013	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A12R1014	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
A12R1015	315-0430-00			RES.,FXD,CMPSN:43 OHM,5%,0.25W	01121	CB4305
A12R1016	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A12R1017	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
A12R1018	315-0430-00			RES.,FXD,CMPSN:43 OHM,5%,0.25W	01121	CB4305
A12R1019	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
A12R1020	315-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
A12R1021	315-0361-00			RES.,FXD,CMPSN:360 OHM,5%,0.25W	01121	CB3615
A12R1022	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
A12R1023	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
A12R1030	315-0393-00			RES.,FXD,CMPSN:39K OHM,5%,0.25W	01121	CB3935
A12R1031	315-0912-00			RES.,FXD,CMPSN:9.1K OHM,5%,0.25W	01121	CB9125
A12R1032	315-0113-00			RES.,FXD,CMPSN:11K OHM,5%,0.25W	01121	CB1135
A12R1033	315-0113-00			RES.,FXD,CMPSN:11K OHM,5%,0.25W	01121	CB1135
A12R1034	315-0361-00			RES.,FXD,CMPSN:360 OHM,5%,0.25W	01121	CB3615
A12R1035	315-0333-00			RES.,FXD,CMPSN:33K OHM,5%,0.25W	01121	CB3335
A12R1036	315-0361-00			RES.,FXD,CMPSN:360 OHM,5%,0.25W	01121	CB3615
A12R1037	315-0113-00			RES.,FXD,CMPSN:11K OHM,5%,0.25W	01121	CB1135
A12R1101	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
A12R1102	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A12R1103	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1104	307-0546-00			RES NTWK,FXD FI:5,75 OHM,5%,0.15W	91637	MSP06A01750J
A12R1105	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1106	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A12R1107	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
A12R1108	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
A12R1109	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1110	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1112	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
A12R1113	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1116	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
A12R1117	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1118	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1119	315-0750-00			RES.,FXD,CMPSN:75 OHM,5%,0.25W	01121	CB7505
A12R1120	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
A12R1121	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1122	307-0489-00			RES,NTWK,FXD,FI:100 OHM,20%,1W	32997	4308R-101-101
A12R1123	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1124	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015

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Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A12R1125	321-0236-00			RES.,FXD,FILM:2.8K OHM,1%,0.125W	91637	MFF1816G28000F
A12R1126	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	91637	MFF1816G40200F
A12R1127	315-0751-00			RES.,FXD,CMPSN:750 OHM,5%,0.25W	01121	CB7515
A12R1128	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1130	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
A12R1131	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
A12R1132	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
A12R1133	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
A12R1140	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1200	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A12R1201	321-0236-00			RES.,FXD,FILM:2.8K OHM,1%,0.125W	91637	MFF1816G28000F
A12R1202	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A12R1203	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1204	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1205	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	91637	MFF1816G40200F
A12R1206	321-0235-00			RES.,FXD,FILM:2.74K OHM,1%,0.125W	91637	MFF1816G27400F
A12R1207	321-0173-00			RES.,FXD,FILM:619 OHM,1%,0.125W	91637	MFF1816G619R0F
A12R1208	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1209	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1211	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
A12R1212	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
A12R1213	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	91637	MFF1816G45300F
A12R1214	321-0203-00			RES.,FXD,FILM:1.27K OHM,1%,0.125W	91637	MFF1816G12700F
A12R1215	321-0010-00			RES.,FXD,FILM:12.4 OHM,1%,0.125W	91637	MFF1816G12R40F
A12R1216	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
A12R1217	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
A12R1218	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
A12R1220	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
A12R1221	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
A12R1222	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A12R1223	321-0235-00			RES.,FXD,FILM:2.74K OHM,1%,0.125W	91637	MFF1816G27400F
A12R1224	321-0173-00			RES.,FXD,FILM:619 OHM,1%,0.125W	91637	MFF1816G619R0F
A12R1225	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1226	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1230	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	91637	MFF1816G45300F
A12R1231	321-0203-00			RES.,FXD,FILM:1.27K OHM,1%,0.125W	91637	MFF1816G12700F
A12R1233	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
A12R1234	321-0010-00			RES.,FXD,FILM:12.4 OHM,1%,0.125W	91637	MFF1816G12R40F
A12R1300	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1301	321-0097-00			RES.,FXD,FILM:100 OHM,1%,0.125W	91637	MFF1816G100R0F
A12R1302	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1303	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1304	321-0097-00			RES.,FXD,FILM:100 OHM,1%,0.125W	91637	MFF1816G100R0F
A12R1305	321-0173-00			RES.,FXD,FILM:619 OHM,1%,0.125W	91637	MFF1816G619R0F
A12R1306	321-0235-00			RES.,FXD,FILM:2.74K OHM,1%,0.125W	91637	MFF1816G27400F
A12R1307	321-0207-00			RES.,FXD,FILM:1.4K OHM,1%,0.125W	91637	MFF1816G14000F
A12R1308	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
A12R1309	321-0138-00			RES.,FXD,FILM:267 OHM,1%,0.125W	91637	MFF1816G267R0F
A12R1313	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
A12R1314	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A12R1315	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A12R1316	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
A12R1317	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
A12R1318	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1319	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1320	321-0097-00			RES.,FXD,FILM:100 OHM,1%,0.125W	91637	MFF1816G100R0F
A12R1321	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705

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A12R1322	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1323	321-0097-00			RES.,FXD,FILM:100 OHM,1%,0.125W	91637	MFF1816G100R0F
A12R1324	321-0173-00			RES.,FXD,FILM:619 OHM,1%,0.125W	91637	MFF1816G619R0F
A12R1325	321-0235-00			RES.,FXD,FILM:2.74K OHM,1%,0.125W	91637	MFF1816G27400F
A12R1326	321-0207-00			RES.,FXD,FILM:1.4K OHM,1%,0.125W	91637	MFF1816G14000F
A12R1327	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
A12R1328	321-0138-00			RES.,FXD,FILM:267 OHM,1%,0.125W	91637	MFF1816G267R0F
A12R1329	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1331	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
A12R1332	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
A12R1333	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A12R1334	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A12R1335	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
A12R1336	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
A12R1337	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1339	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1400	321-0259-00			RES.,FXD,FILM:4.87K OHM,1%,0.125W	91637	MFF1816G48700F
A12R1401	321-0186-00			RES.,FXD,FILM:845 OHM,1%,0.125W	91637	MFF1816G845R0F
A12R1402	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1403	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1404	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A12R1405	317-0150-00			RES.,FXD,CMPSN:15 OHM,5%,0.125W	01121	BB1505
A12R1406	317-0150-00			RES.,FXD,CMPSN:15 OHM,5%,0.125W	01121	BB1505
A12R1407	307-0488-00			RES,NTWK,FXD,FI:100 OHM,20%,0.75W	01121	206A101
A12R1408	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1409	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1411	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1412	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1413	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1417	307-0514-00			RES.,FXD,FILM:27 OHM,1%,0.075W	52262	MCRA270FYZ
A12R1420	321-0186-00			RES.,FXD,FILM:845 OHM,1%,0.125W	91637	MFF1816G845R0F
A12R1421	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1422	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1423	321-0259-00			RES.,FXD,FILM:4.87K OHM,1%,0.125W	91637	MFF1816G48700F
A12R1424	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A12R1425	317-0150-00			RES.,FXD,CMPSN:15 OHM,5%,0.125W	01121	BB1505
A12R1426	317-0150-00			RES.,FXD,CMPSN:15 OHM,5%,0.125W	01121	BB1505
A12R1427	307-0488-00			RES,NTWK,FXD,FI:100 OHM,20%,0.75W	01121	206A101
A12R1428	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1429	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
A12R1432	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1433	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A12R1434	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A12R1438	307-0514-00			RES.,FXD,FILM:27 OHM,1%,0.075W	52262	MCRA270FYZ
A12R1500	321-0199-00			RES.,FXD,FILM:1.15K OHM,1%,0.125W	91637	MFF1816G11500F
A12R1501	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	91637	MFF1816G45300F
A12R1502	315-0203-00			RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
A12R1503	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1504	321-0481-00			RES.,FXD,FILM:1M OHM,1%,0.125W	24546	NA4D1004F
A12R1506	317-0361-00			RES.,FXD,CMPSN:360 OHM,5%,0.125W	01121	BB3615
A12R1507	317-0111-00			RES.,FXD,CMPSN:110 OHM,5%,0.125W	01121	BB1115
A12R1510	317-0564-00			RES.,FXD,CMPSN:560K OHM,5%,0.125W	01121	BB5645
A12R1511	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
A12R1512	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A12R1514	323-0107-00			RES.,FXD,FILM:127 OHM,1%,0.50W	75042	CECT0-1270F
A12R1515	323-0107-00			RES.,FXD,FILM:127 OHM,1%,0.50W	75042	CECT0-1270F
A12R1516	307-0734-00			RES.,FXD,FILM:200 OHM,1%,0.5W	03888	PCWT200X235

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A12R1520	321-0199-00			RES.,FXD,FILM:1.15K OHM,1%,0.125W	91637	MFF1816G11500F
A12R1521	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	91637	MFF1816G45300F
A12R1522	315-0203-00			RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
A12R1523	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
A12R1524	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
A12R1525	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A12R1526	323-0107-00			RES.,FXD,FILM:127 OHM,1%,0.50W	75042	CECT0-1270F
A12R1527	323-0107-00			RES.,FXD,FILM:127 OHM,1%,0.50W	75042	CECT0-1270F
A12R1528	307-0734-00			RES.,FXD,FILM:200 OHM,1%,0.5W	03888	PCWT200X235
A12R1530	317-0564-00			RES.,FXD,CMPSN:560K OHM,5%,0.125W	01121	BB5645
A12R1531	321-0481-00			RES.,FXD,FILM:1M OHM,1%,0.125W	24546	NA4D1004F
A12R1535	317-0111-00			RES.,FXD,CMPSN:110 OHM,5%,0.125W	01121	BB1115
A12R1536	317-0361-00			RES.,FXD,CMPSN:360 OHM,5%,0.125W	01121	BB3615
A12R1601	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
A12R1610	315-0390-00			RES.,FXD,CMPSN:39 OHM,5%,0.25W	01121	CB3905
A12R1611	307-0733-00			RES.,FXD,FILM:25 OHM,1%,0.5W	03888	PCWT200X235
A12R1612	315-0394-00			RES.,FXD,CMPSN:390K OHM,5%,0.25W	01121	CB3945
A12R1620	315-0394-00			RES.,FXD,CMPSN:390K OHM,5%,0.25W	01121	CB3945
A12R1631	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
A12R1632	315-0390-00			RES.,FXD,CMPSN:39 OHM,5%,0.25W	01121	CB3905
A12T1410	120-0286-00			XFMR,TOROID:2 TURNS,BIFILAR	80009	120-0286-00
A12T1430	120-0286-00			XFMR,TOROID:2 TURNS,BIFILAR	80009	120-0286-00
A12TP1020	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A12TP1310	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A12TP1330	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A12U1000	156-1031-00			MICROCIRCUIT,DI:TRIPLE D FLIPFLOP	07263	F100131FC
A12U1001	156-1032-00			MICROCIRCUIT,DI:QUINT 2 OR/NOR	80009	156-1032-00
A12U1011	156-1031-00			MICROCIRCUIT,DI:TRIPLE D FLIPFLOP	07263	F100131FC
A12U1020	156-1449-00			MICROCIRCUIT,DI:DIVIDE BY 80 150MHZ	52648	SP8627DG
A12U1021	156-0124-00			MICROCIRCUIT,DI:SGL FREQ/PHASE DETECTOR	80009	156-0124-00
A12U1022	156-1031-00			MICROCIRCUIT,DI:TRIPLE D FLIPFLOP	07263	F100131FC
A12U1030	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	MC1458V
A12U1110	156-1032-00			MICROCIRCUIT,DI:QUINT 2 OR/NOR	80009	156-1032-00
A12U1200	156-0796-00			MICROCIRCUIT,DI:8 STG SHF & STORE BUS RGTR	80009	156-0796-00
A12U1202	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	MC1458V
A12U1210	156-0494-00			MICROCIRCUIT,DI:HEX INVERTER/BUFFER	80009	156-0494-00
A12U1310	155-0253-00			MICROCIRCUIT,LI:HIGH SPEED SCHMITT TRIGGER	80009	155-0253-00
A12U1311	155-0078-10			MICROCIRCUIT,LI:ML,VERTICAL AMPLIFIER	80009	155-0078-10
A12U1330	155-0253-00			MICROCIRCUIT,LI:HIGH SPEED SCHMITT TRIGGER	80009	155-0253-00
A12U1331	155-0078-10			MICROCIRCUIT,LI:ML,VERTICAL AMPLIFIER	80009	155-0078-10
A12VR1412	152-0693-00			SEMICOND DEVICE:ZENER,0.4W,4V,5%	80009	152-0693-00
A12VR1413	152-0693-00			SEMICOND DEVICE:ZENER,0.4W,4V,5%	80009	152-0693-00
A12VR1432	152-0693-00			SEMICOND DEVICE:ZENER,0.4W,4V,5%	80009	152-0693-00
A12VR1433	152-0693-00			SEMICOND DEVICE:ZENER,0.4W,4V,5%	80009	152-0693-00

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A16	----- -----			CKT BOARD ASSY:DIGITAL		
A16C1020	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A16C1021	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1022	290-0746-00			CAP.,FXD,ELCTLT:47UF,+50-10%,16V	55680	16U-47V-T
A16C1023	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1101	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1121	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1201	290-0755-00			CAP.,FXD,ELCTLT:100UF,+50-10%,10V	56289	502D223
A16C1211	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1401	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1501	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1520	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A16C1601	281-0811-00			CAP.,FXD,CER DI:10PF,10%,100V	72982	8035D2AADC1G100K
A16C1610	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1621	281-0812-00			CAP.,FXD,CER DI:1000PF,10%,100V	72982	8035D9AADX7R102K
A16C1721	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A16C1722	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A16C1723	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1801	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A16C1810	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	56289	502D225
A16CR1001	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A16CR1010	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A16CR1020	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A16CR1620	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A16CR1720	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
A16CR1721	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
A16F1820	159-0042-00			FUSE,CARTRIDGE:3AG,0.75A,250V,FAST-BLOW	71400	AGC 3/4
A16F1821	159-0015-00			FUSE,CARTRIDGE:3AG,3A,250V,FAST-BLOW	71400	AGC 3
A16J1001	131-1632-00			CONNECTOR,RCPT,:CKT CD MTG,20CONTACT,FEM	22526	65001-025
A16J1210	131-2132-01			CONN,RCPT,ELEC:HEADER,1 X 36,01 CTR	22526	65506-436
A16J1211	131-2132-01			CONN,RCPT,ELEC:HEADER,1 X 36,01 CTR	22526	65506-436
A16L1020	108-0473-00			COIL,RF:150UH	80009	108-0473-00
A16Q1701	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A16Q1702	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A16Q1703	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A16Q1704	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A16Q1720	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A16Q1721	151-0432-00			TRANSISTOR:SILICON,NPN	80009	151-0432-00
A16Q1722	151-0453-00			TRANSISTOR:SILICON,PNP	80009	151-0453-00
A16Q1723	151-0453-00			TRANSISTOR:SILICON,PNP	80009	151-0453-00
A16R1001	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
A16R1002	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
A16R1003	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
A16R1004	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
A16R1005	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
A16R1006	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
A16R1007	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
A16R1008	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
A16R1009	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
A16R1010	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A16R1011	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A16R1012	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A16R1013	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
A16R1014	307-0675-00			RES NTWK,FXD,FI:9,1K OHM,2%,1.25W	01121	210A102
A16R1021	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A16R1022	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
A16R1103	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055

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A16R1201	321-0311-00			RES.,FXD,FILM:16.9K OHM,1%,0.125W	91637	MFF1816G16901F
A16R1202	321-0318-00			RES.,FXD,FILM:20K OHM,1%,0.125W	91637	MFF1816G20001F
A16R1203	321-0275-00			RES.,FXD,FILM:7.15K OHM,1%,0.125W	91637	MFF1816G71500F
A16R1204	321-0275-00			RES.,FXD,FILM:7.15K OHM,1%,0.125W	91637	MFF1816G71500F
A16R1205	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A16R1206	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A16R1207	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A16R1208	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A16R1209	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A16R1210	307-0446-00			RES,NTWK,FXD FI:10K OHM,20%,(9) RES	91637	MSP10A01-103M
A16R1220	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A16R1301	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A16R1420	307-0446-00			RES,NTWK,FXD FI:10K OHM,20%,(9) RES	91637	MSP10A01-103M
A16R1520	315-0393-00			RES.,FXD,CMPSN:39K OHM,5%,0.25W	01121	CB3935
A16R1521	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
A16R1601	315-0303-00			RES.,FXD,CMPSN:30K OHM,5%,0.25W	01121	CB3035
A16R1620	315-0362-00			RES.,FXD,CMPSN:3.6K OHM,5%,0.25W	01121	CB3625
A16R1621	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
A16R1622	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
A16R1701	315-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.25W	01121	CB5605
A16R1702	315-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.25W	01121	CB5605
A16R1703	307-0541-00			RES,NTWK,THK FI:(7)1K OHM,10%,1W	91637	MSP08A01-102G
A16R1710	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A16R1711	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A16R1712	315-0362-00			RES.,FXD,CMPSN:3.6K OHM,5%,0.25W	01121	CB3625
A16R1713	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A16R1714	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A16R1715	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A16R1716	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A16R1717	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A16R1718	308-0677-00			RES.,FXD,WW:1 OHM,5%,2W	75042	BWH-1R000J
A16R1719	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A16R1720	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A16R1721	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
A16R1722	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
A16R1724	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
A16R1725	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
A16R1726	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A16R1727	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
A16R1728	308-0244-00			RES.,FXD,WW:0.3 OHM,10%,2W	91637	RS2B162ER3000K
A16R1820	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A16R1821	321-0297-00			RES.,FXD,FILM:12.1K OHM,1%,0.125W	91637	MFF1816G12101F
A16S1210	260-1589-00			SWITCH,PUSH:(6)SPST,0.1A,5V	00779	435166-4
A16TP1410	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A16TP1411	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A16TP1420	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A16U1101	156-1243-00			MICROCIRCUIT,DI:BCD-TO-7 SEGMENT DECODER	80009	156-1243-00
A16U1102	156-0411-00			MICROCIRCUIT,LI:QUAD-COMP,SGL SUPPLY	27014	LM339N
A16U1110	156-1245-00			MICROCIRCUIT,LI:7 XSTR,HV/HIGH CUR	04713	MC1413PDS
A16U1111	156-0391-00			MICROCIRCUIT,DI:HEX LATCH WITH CLEAR	04713	74LS174(N OR J)
A16U1112	156-0391-00			MICROCIRCUIT,DI:HEX LATCH WITH CLEAR	04713	74LS174(N OR J)
A16U1113	156-1172-00			MICROCIRCUIT,DI:DUAL 4 BIT BIN CNTR	80009	156-1172-00
A16U1114	156-0576-00			MICROCIRCUIT,DI:8 BIT PRL INP-SERIAL OUTPT	04713	MC14021BCL
A16U1115	156-0579-00			MICROCIRCUIT,DI:DUAL 4-BIT BIN COUNTER	04713	MC14520BCL
A16U1120	156-0388-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	80009	156-0388-00
A16U1121	156-0576-00			MICROCIRCUIT,DI:8 BIT PRL INP-SERIAL OUTPT	04713	MC14021BCL
A16U1122	156-0576-00			MICROCIRCUIT,DI:8 BIT PRL INP-SERIAL OUTPT	04713	MC14021BCL

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A16U1210	156-0649-00			MICROCIRCUIT,DI:3 STATE HEX. NON INVT BFR	80009	156-0649-00
A16U1211	156-0576-00			MICROCIRCUIT,DI:8 BIT PRL INP-SERIAL OUTPT	04713	MC14021BCL
A16U1212	156-0545-00			MICROCIRCUIT,DI:12-BIT BINARY COUNTER	80009	156-0545-00
A16U1310	156-0649-00			MICROCIRCUIT,DI:3 STATE HEX. NON INVT BFR	80009	156-0649-00
A16U1311	156-1484-00			MICROCIRCUIT,DI:256 X 8 SCRM	000ID	35392C
A16U1312	156-0576-00			MICROCIRCUIT,DI:8 BIT PRL INP-SERIAL OUTPT	04713	MC14021BCL
A16U1313	156-0469-00			MICROCIRCUIT,DI:3-LINE TO 8-LINE DECODER	01295	SN74LS138N
A16U1314	156-0494-00			MICROCIRCUIT,DI:HEX INVERTER/BUFFER	80009	156-0494-00
A16U1410	160-1183-00			MICROCIRCUIT,DI:I/O TIMER,ROM,RAM	34576	R6531P
A16U1420	156-0541-00			MICROCIRCUIT,DI:DECODER/DEMULTIPLEXER	27014	DM74LS139N
A16U1421	156-0382-00			MICROCIRCUIT,DI:QUAD 2-INPUT NAND GATE	01295	SN74LS00(N OR J)
A16U1510	156-1482-00			MICROCIRCUIT,DI:8-BIT MICROPRC,8K ADDRESS	55576	SYP6504
A16U1520	156-0494-00			MICROCIRCUIT,DI:HEX INVERTER/BUFFER	80009	156-0494-00
A16U1610	160-1111-00			MICROCIRCUIT,DI:4096 X 8 MROM,PRGM	55576	SYP2333
A16U1710	156-0411-00			MICROCIRCUIT,LI:QUAD-COMP,SGL SUPPLY	27014	LM339N
A16U1720	156-0071-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	04713	MC1723CL
A16U1801	156-0230-00			MICROCIRCUIT,DI:DUAL D MA-SLAVE FLIP-FLOP	80009	156-0230-00
A16U1810	156-0880-00			MICROCIRCUIT,DI:DUAL D MASTER SLAVE FF	80009	156-0880-00
A16W1303	131-0566-00			BUS CONDUCTOR:DUMMY RES,2.375,22 AWG	55210	L-2007-1

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A18	----- -----			CKT BOARD ASSY:AUXILIARY		
A18C1030	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	56289	502D225
A18C1031	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A18C1230	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A18C1231	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A18C1232	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A18C1300	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A18C1301	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A18C1310	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A18C1320	281-0770-00			CAP.,FXD,CER DI:0.001UF,20%,100V	72982	8035D9AADX5R102M
A18C1321	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A18C1322	290-0776-00			CAP.,FXD,ELCTLT:22UF,+50-10%,10V	55680	10ULA22V-T
A18C1324	290-0782-00			CAP.,FXD,ELCTLT:4.7UF,+75-10%,35V	55680	35ULA4R7V-T
A18C1330	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A18C1331	283-0220-00	B010100	B010469	CAP.,FXD,CER DI:0.01UF,20%,50V	72982	8121N075X7R0103M
A18C1331	281-0773-00	B010470		CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A18C1332	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A18C1410	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A18C1411	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	04222	GC70-1C103K
A18C1413	281-0814-00			CAP.,FXD,CER DI:100PF,10%,100V	04222	GC70-1-A101K
A18C1420	281-0630-00			CAP.,FXD,CER DI:390PF,5%,500V	72982	630000Y5D391J
	----- -----			(STANDARD ONLY)		
A18C1421	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
	----- -----			(STANDARD ONLY)		
A18C1430	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
	----- -----			(OPTION 01 ONLY)		
A18C1431	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
	----- -----			(OPTION 01 ONLY)		
A18C1510	281-0775-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8005D9AABZ5U104M
A18C1521	281-0198-00			CAP.,VAR,AIR DI:1.7-11PF,250V	74970	187-0306-105
	----- -----			(STANDARD ONLY)		
A18C1522	281-0564-00			CAP.,FXD,CER DI:24PF,5%,500V	72982	301-000C0G0240J
	----- -----			(STANDARD ONLY)		
A18C1523	281-0630-00			CAP.,FXD,CER DI:390PF,5%,500V	72982	630000Y5D391J
	----- -----			(STANDARD ONLY)		
A18CR1120	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
A18CR1121	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
A18CR1122	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
A18CR1123	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
A18CR1124	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
A18CR1232	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	14433	LG4016
A18CR1500	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A18CR1510	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A18CR1511	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	01295	1N4152R
A18F1510	159-0042-00			FUSE,CARTRIDGE:3AG,0.75A,250V,FAST-BLOW	71400	AGC 3/4
A18F1511	159-0015-00			FUSE,CARTRIDGE:3AG,3A,250V,FAST-BLOW	71400	AGC 3
A18J1500	131-1003-00			CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
A18J1510	131-1857-00			TERM. SET,PIN:36/0.025 SQ PIN,ON 0.1 CTRS	22526	65500136
A18J1511	131-1857-00			TERM. SET,PIN:36/0.025 SQ PIN,ON 0.1 CTRS	22526	65500136
A18J1611	131-1857-00			TERM. SET,PIN:36/0.025 SQ PIN,ON 0.1 CTRS	22526	65500136
A18L1420	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A18L1421	108-0245-00			COIL,RF:3.9UH	76493	B6310-1
A18Q1030	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A18Q1031	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A18Q1032	151-0335-00			TRANSISTOR:SILICON,PNP	04713	SJE917
A18Q1120	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A18Q1121	151-0254-00			TRANSISTOR:SILICON,NPN	03508	X38L3118
A18Q1300	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K

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A18Q1330	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A18Q1331	151-0342-00			TRANSISTOR:SILICON,PNP	07263	S035928
A18Q1332	151-0462-00			TRANSISTOR:SILICON,PNP	04713	TIP30C
A18Q1333	151-0341-00			TRANSISTOR:SILICON,NPN	07263	S040065
A18Q1401	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A18Q1420	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
	----- -----			(STANDARD ONLY)		
A18Q1500	151-0188-00			TRANSISTOR:SILICON,PNP	04713	SPS6868K
A18Q1510	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A18Q1511	151-0190-00			TRANSISTOR:SILICON,NPN	07263	S032677
A18R1000	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A18R1030	315-0301-00			RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
A18R1031	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
A18R1032	315-0121-00			RES.,FXD,CMPSN:120 OHM,5%,0.25W	01121	CB1215
A18R1033	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
A18R1100	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A18R1101	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A18R1110	321-0229-00			RES.,FXD,FILM:2.37K OHM,1%,0.125W	91637	MFF1816G23700F
A18R1111	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
A18R1112	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A18R1113	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
A18R1114	321-0229-00			RES.,FXD,FILM:2.37K OHM,1%,0.125W	91637	MFF1816G23700F
A18R1115	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
A18R1120	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A18R1121	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A18R1200	321-0197-00			RES.,FXD,FILM:1.1K OHM,1%,0.125W	91637	MFF1816G11000F
A18R1201	321-0202-00			RES.,FXD,FILM:1.24K OHM,1%,0.125W	91637	MFF1816G12400F
A18R1202	321-0197-00			RES.,FXD,FILM:1.1K OHM,1%,0.125W	91637	MFF1816G11000F
A18R1203	321-0202-00			RES.,FXD,FILM:1.24K OHM,1%,0.125W	91637	MFF1816G12400F
A18R1204	311-1236-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	73138	72-22-0
A18R1205	311-1236-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	73138	72-22-0
A18R1206	311-1236-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	73138	72-22-0
A18R1207	311-1236-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	73138	72-22-0
A18R1210	321-0202-00			RES.,FXD,FILM:1.24K OHM,1%,0.125W	91637	MFF1816G12400F
A18R1211	321-0189-00			RES.,FXD,FILM:909 OHM,1%,0.125W	91637	MFF1816G909R0F
A18R1212	321-0173-00			RES.,FXD,FILM:619 OHM,1%,0.125W	91637	MFF1816G619R0F
A18R1213	321-0173-00			RES.,FXD,FILM:619 OHM,1%,0.125W	91637	MFF1816G619R0F
A18R1214	321-0189-00			RES.,FXD,FILM:909 OHM,1%,0.125W	91637	MFF1816G909R0F
A18R1215	321-0202-00			RES.,FXD,FILM:1.24K OHM,1%,0.125W	91637	MFF1816G12400F
A18R1310	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
A18R1311	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A18R1312	315-0393-00			RES.,FXD,CMPSN:39K OHM,5%,0.25W	01121	CB3935
A18R1313	321-0287-00			RES.,FXD,FILM:9.53K OHM,1%,0.125W	91637	MFF1816G95300F
A18R1314	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
A18R1315	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
A18R1321	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
A18R1322	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
A18R1323	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
A18R1324	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
A18R1331	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
A18R1332	315-0361-00			RES.,FXD,CMPSN:360 OHM,5%,0.25W	01121	CB3615
A18R1333	315-0751-00			RES.,FXD,CMPSN:750 OHM,5%,0.25W	01121	CB7515
A18R1334	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A18R1335	315-0681-00			RES.,FXD,CMPSN:680 OHM,5%,0.25W	01121	CB6815
A18R1400	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
A18R1401	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A18R1402	315-0121-00			RES.,FXD,CMPSN:120 OHM,5%,0.25W	01121	CB1215

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A18R1403	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
A18R1410	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
A18R1411	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A18R1412	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
A18R1413	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
A18R1414	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
A18R1420	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W (STANDARD ONLY)	01121	CB1525
A18R1421	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W (STANDARD ONLY)	01121	CB1025
A18R1424	315-0562-00			RES.,FXD,CMPSN:5.6K OHM,5%,0.25W (STANDARD ONLY)	01121	CB5625
A18R1425	308-0058-00			RES.,FXD,WW:1.5 OHM,10%,1W	75042	BW20-1R500K
A18R1426	308-0742-00			RES.,FXD,WW:0.24 OHM,5%,2W	75042	BWH-R2400J
A18R1430	321-0213-00			RES.,FXD,FILM:1.62K OHM,1%,0.125W (OPTION 01 ONLY)	91637	MFF1816G16200F
A18R1431	321-0105-00			RES.,FXD,FILM:121 OHM,1%,0.125W (OPTION 01 ONLY)	91637	MFF1816G121R0F
A18R1500	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
A18R1501	315-0181-00			RES.,FXD,CMPSN:180 OHM,5%,0.25W	01121	CB1815
A18R1502	315-0112-00			RES.,FXD,CMPSN:1.1K OHM,5%,0.25W	01121	CB1125
A18R1503	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
A18R1504	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A18R1510	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
A18R1511	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
A18R1512	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
A18R1513	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
A18R1514	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
A18R1515	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
A18R1516	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
A18R1520	315-0183-00			RES.,FXD,CMPSN:18K OHM,5%,0.25W (STANDARD ONLY)	01121	CB1835
A18TP1400	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A18U1010	156-0796-00			MICROCIRCUIT,DI:8 STG SHF & STORE BUS RGTR	80009	156-0796-00
A18U1020	156-0796-00			MICROCIRCUIT,DI:8 STG SHF & STORE BUS RGTR	80009	156-0796-00
A18U1021	156-1245-00			MICROCIRCUIT,LI:7 XSTR,HV/HIGH CUR	04713	MC1413PDS
A18U1110	156-1245-00			MICROCIRCUIT,LI:7 XSTR,HV/HIGH CUR	04713	MC1413PDS
A18U1111	156-0411-00			MICROCIRCUIT,LI:QUAD-COMP,SGL SUPPLY	27014	LM339N
A18U1200	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	18324	MC1458V
A18U1210	156-0927-00			MICROCIRCUIT,LI:DIGITAL TO ANALOG CONVERTER	80009	156-0927-00
A18U1220	156-0796-00			MICROCIRCUIT,DI:8 STG SHF & STORE BUS RGTR	80009	156-0796-00
A18U1221	156-0796-00			MICROCIRCUIT,DI:8 STG SHF & STORE BUS RGTR	80009	156-0796-00
A18U1222	156-0796-00			MICROCIRCUIT,DI:8 STG SHF & STORE BUS RGTR	80009	156-0796-00
A18U1223	156-1173-00			MICROCIRCUIT,LI:VOLTAGE REFERENCE	04713	MC1403UDS
A18U1310	156-0927-00			MICROCIRCUIT,LI:DIGITAL TO ANALOG CONVERTER	80009	156-0927-00
A18U1320	156-0071-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	04713	MC1723CL
A18U1330	156-1150-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR,NEGATIVE	04713	MC79L05ACP
A18U1400	156-1126-00			MICROCIRCUIT,LI:VOLTAGE COMPARATOR	51984	UPC311C
A18U1410	156-1433-00			MICROCIRCUIT,DI:NOISE SOURCE	27014	MM5837N
A18U1411	156-0656-00			MICROCIRCUIT,DI:DECADE COUNTER	01295	SN74LS90N OR J
A18U1420	156-0071-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR	04713	MC1723CL
A18U1430	156-1161-00			MICROCIRCUIT,LI:VOLTAGE REGULATOR (OPTION 01 ONLY)	27014	LM317T
A18U1500	156-0385-00			MICROCIRCUIT,DI:HEX.INVERTER	80009	156-0385-00
A18VR1001	152-0195-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	04713	SZ11755
A18VR1410	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	SZ11738
A18VR1411	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	SZ11738

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A18Y1520	158-0129-00 ----- -----			XTAL UNIT,QTZ:10MHZ,0.001%,PARALLEL (STANDARD ONLY)	33096	PB1109
A18Y1530	119-0894-01 ----- -----			OSCILLATOR,RF:10MHZ,18V (OPTION 01 ONLY)	80009	119-0894-01

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DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The overline on a signal name indicates that the signal performs its intended function when it is in the low state.

Abbreviations are based on ANSI Y1.1-1972.

Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

Y14.15, 1966 Drafting Practices.
Y14.2, 1973 Line Conventions and Lettering.
Y10.5, 1968 Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

American National Standard Institute
1430 Broadway
New York, New York 10018

Component Values

Electrical components shown on the diagrams are in the following units unless noted otherwise:

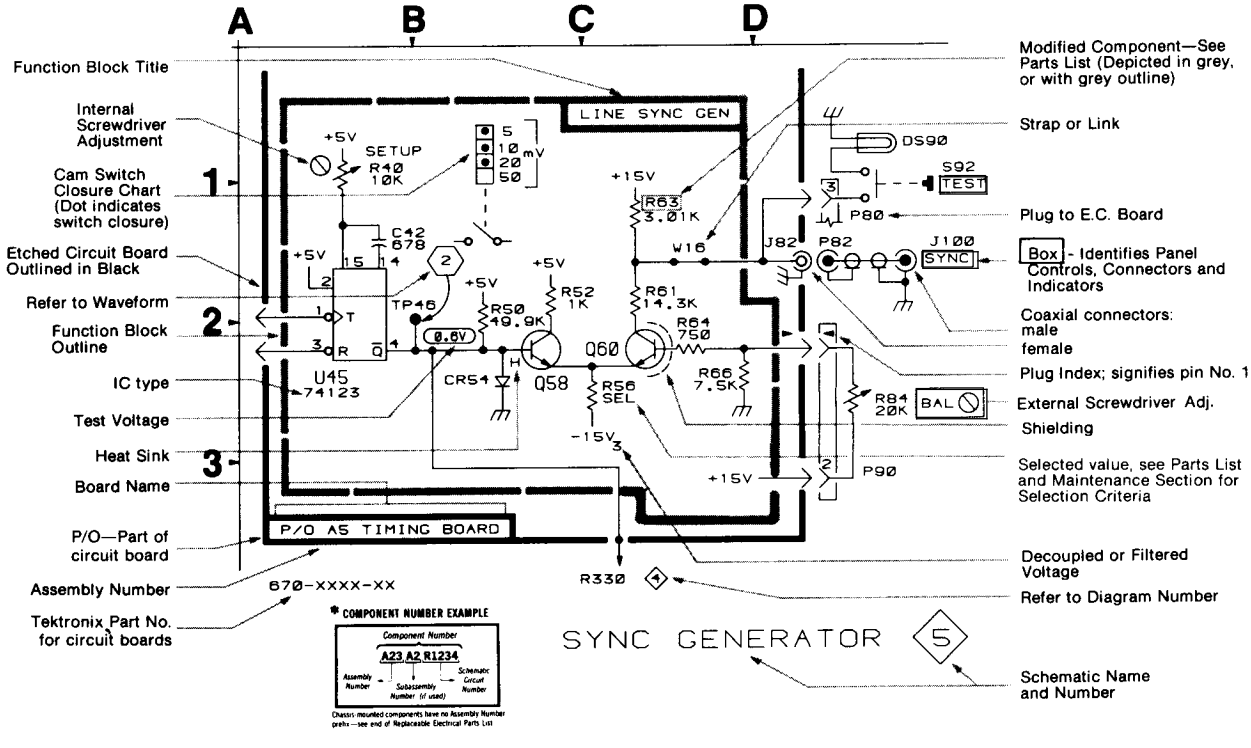
Capacitors = Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).
Resistors = Ohms (Ω).

The information and special symbols below may appear in this manual.

Assembly Numbers and Grid Coordinates

Each assembly in the instrument is assigned an assembly number (e.g., A20). The assembly number appears on the circuit board outline on the diagram, in the title for the circuit board component location illustration, and in the lookup table for the schematic diagram and corresponding component locator illustration. The Replaceable Electrical Parts list is arranged by assemblies in numerical sequence; the components are listed by component number *(see following illustration for constructing a component number).

The schematic diagram and circuit board component location illustration have grids. A lookup table with the grid coordinates is provided for ease of locating the component. Only the components illustrated on the facing diagram are listed in the lookup table. When more than one schematic diagram is used to illustrate the circuitry on a circuit board, the circuit board illustration may only appear opposite the first diagram on which it was illustrated; the lookup table will list the diagram number of other diagrams that the circuitry of the circuit board appears on.



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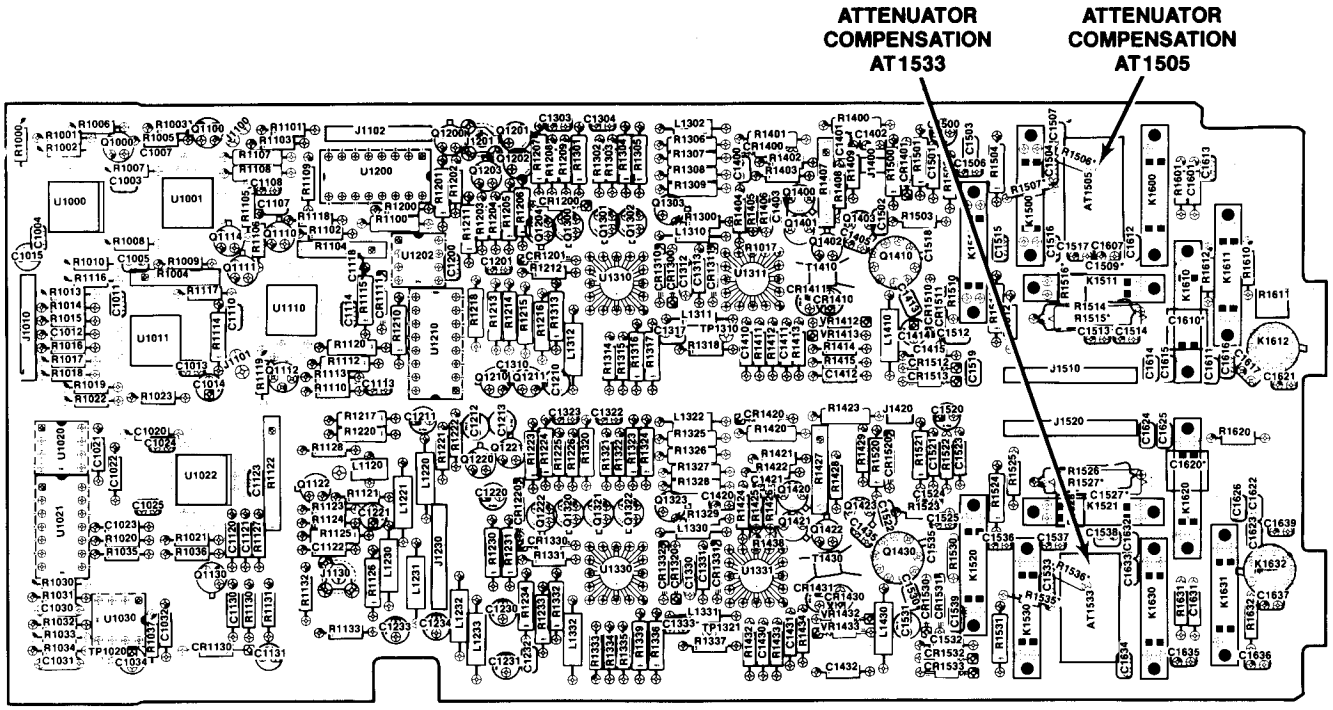


Fig. 8-1. Analog Board (A12).

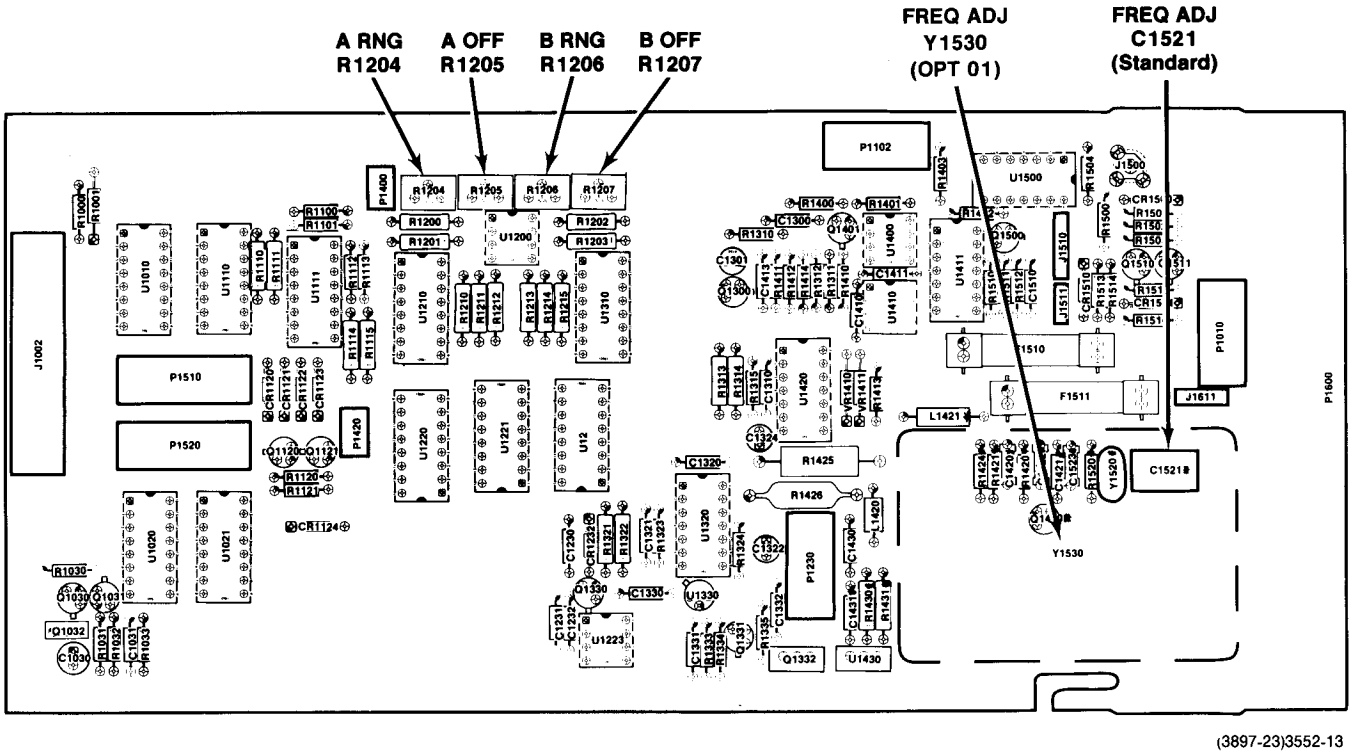


Fig. 8-2. Auxiliary Board (A18).

LOCATIONS AND SETUPS

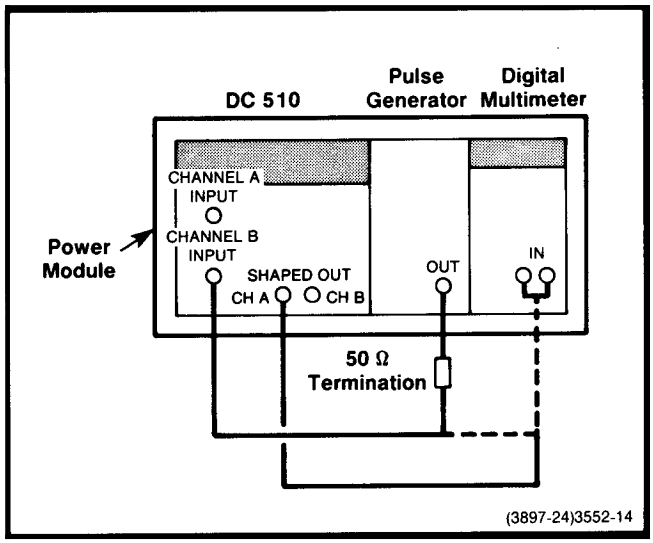


Fig. 8-3. Adjustment setup for steps 10 and 11.

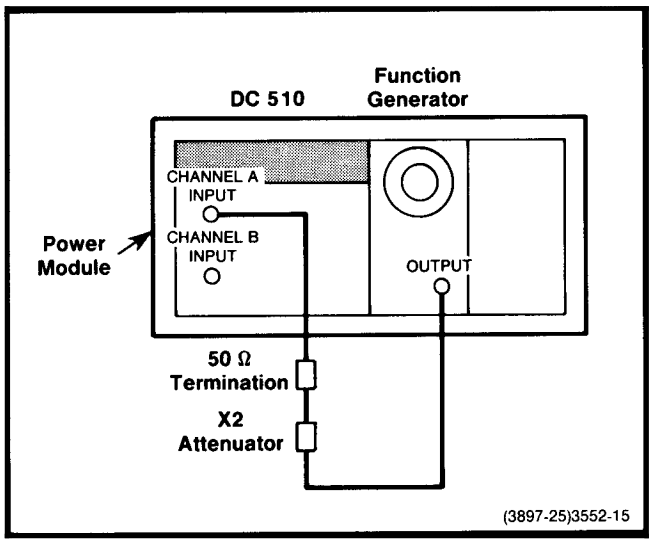


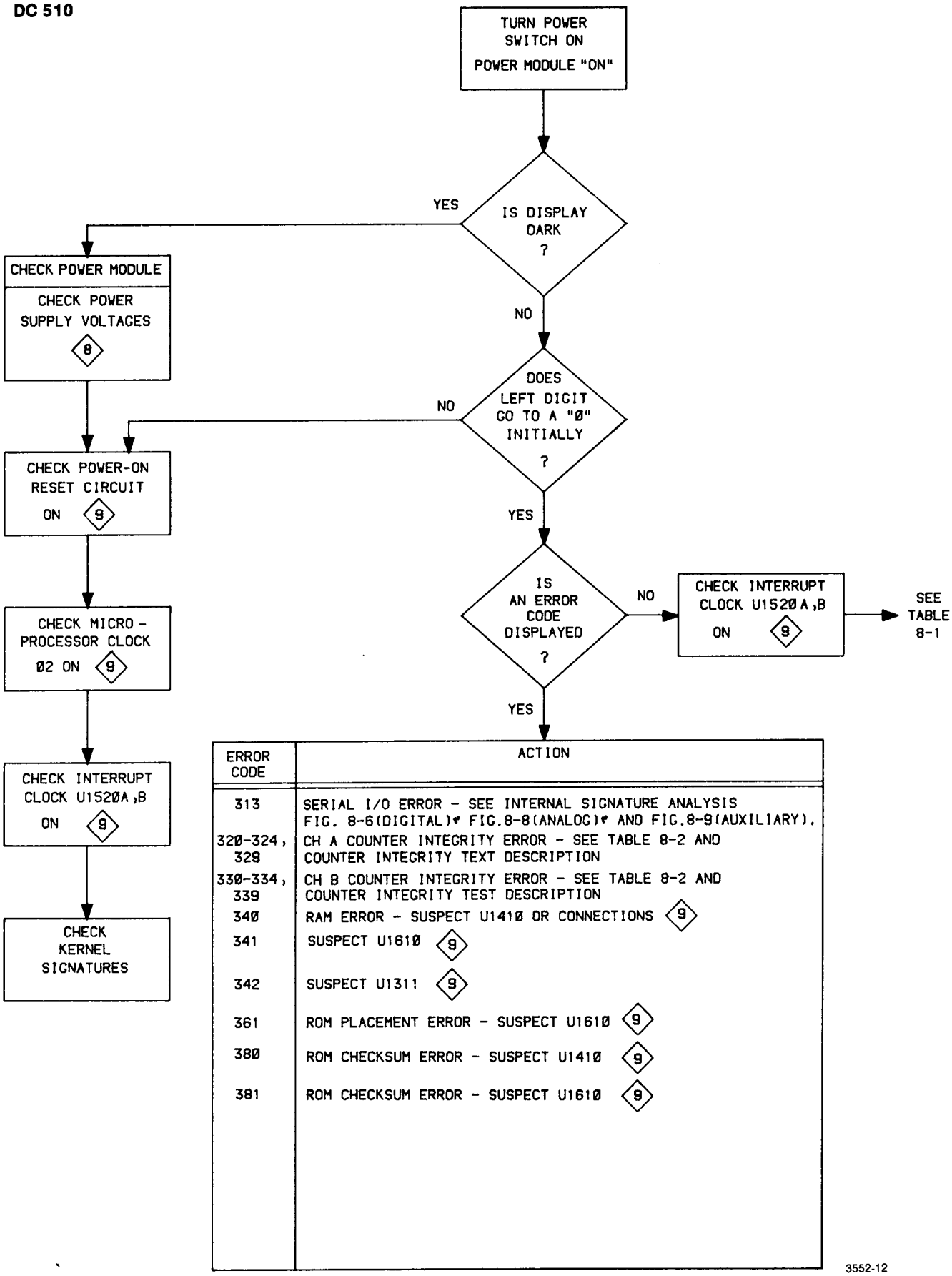
Fig. 8-4. Adjustment setup for steps 12 and 13.

Table 8-2
COUNTER INTEGRITY ERRORS

ERROR CODE	SUSPECT CIRCUITRY
320	1. CHECK THAT INPUT SIGNAL IS WITHIN TRIGGER LEVEL RANGE, OR NO INPUT. 2. MAKE SURE ARM INPUT IS HIGH. ◇6◇ 3. CHECK +12V, -12V,-5V. 4. SUSPECT FET Q1410, CHECK FOR SIGNAL ON T1418 5. CHECK MR AND $\overline{MR}$ LINES. ◇4◇ 6. CHECK CH A DAC. ◇6◇ 7. CHECK CH A AMP. ◇1◇, ◇2◇ 8. CHECK GATING. ◇3◇ 9. CHECK INPUT TO ACCUMULATOR. ◇4◇ 10. SUSPECT U1000A. ◇3◇ 11. SUSPECT U1102B, U1121. ◇4◇
321	1. SUSPECT U1000A, U1011 ◇3◇ 2. SUSPECT U1710D, U1121 ◇4◇
322	1. SUSPECT U1011A ◇3◇ 2. CHECK CABLE W528 3. SUSPECT U1810A ◇4◇ 4. SUSPECT U1710B, U1121 ◇4◇
323	1. SUSPECT U1801A ◇4◇, LEVEL SHIFTER Q1702, Q1701 ◇4◇ 2. SUSPECT U1121 ◇4◇
324	1. SUSPECT LEVEL SHIFTER Q1702, Q1701 2. SUSPECT U1120A ◇4◇ 3. SUSPECT U1121
329	1. SUSPECT CABLE W528 OR ANY ACCUMULATOR IC
330	1. CHECK CH B DAC ◇6◇ 2. CHECK CH B AMP ◇1◇ ◇2◇ 3. CHECK FET Q1430 4. CHECK FOR SIGNAL ON T1430 5. CHECK GATING ◇3◇ 6. CHECK INPUT TO ACCUMULATOR ◇3◇ 7. SUSPECT U1011C ◇3◇ 8. SUSPECT U1102A OR U1122 ◇4◇
331	1. SUSPECT U1011C, U1011B ◇3◇ 2. SUSPECT U1710C, U1122 ◇4◇
332	1. SUSPECT U1011, OR CABLE W538 ◇3◇ 2. SUSPECT U1810B ◇4◇ 3. SUSPECT U1103 ◇4◇
333	1. SUSPECT U1810B, LEVEL SHIFTER Q1704, Q1703 ◇4◇ 2. SUSPECT U1122 ◇4◇
334	1. SUSPECT LEVEL SHIFTER Q1704, Q1703 ◇4◇ 2. SUSPECT U1120B, U1122 ◇4◇
339	1. SUSPECT CABLE W529 OR ANY ACCUMULATOR IC

Table 8-1
GENERAL PROBLEMS

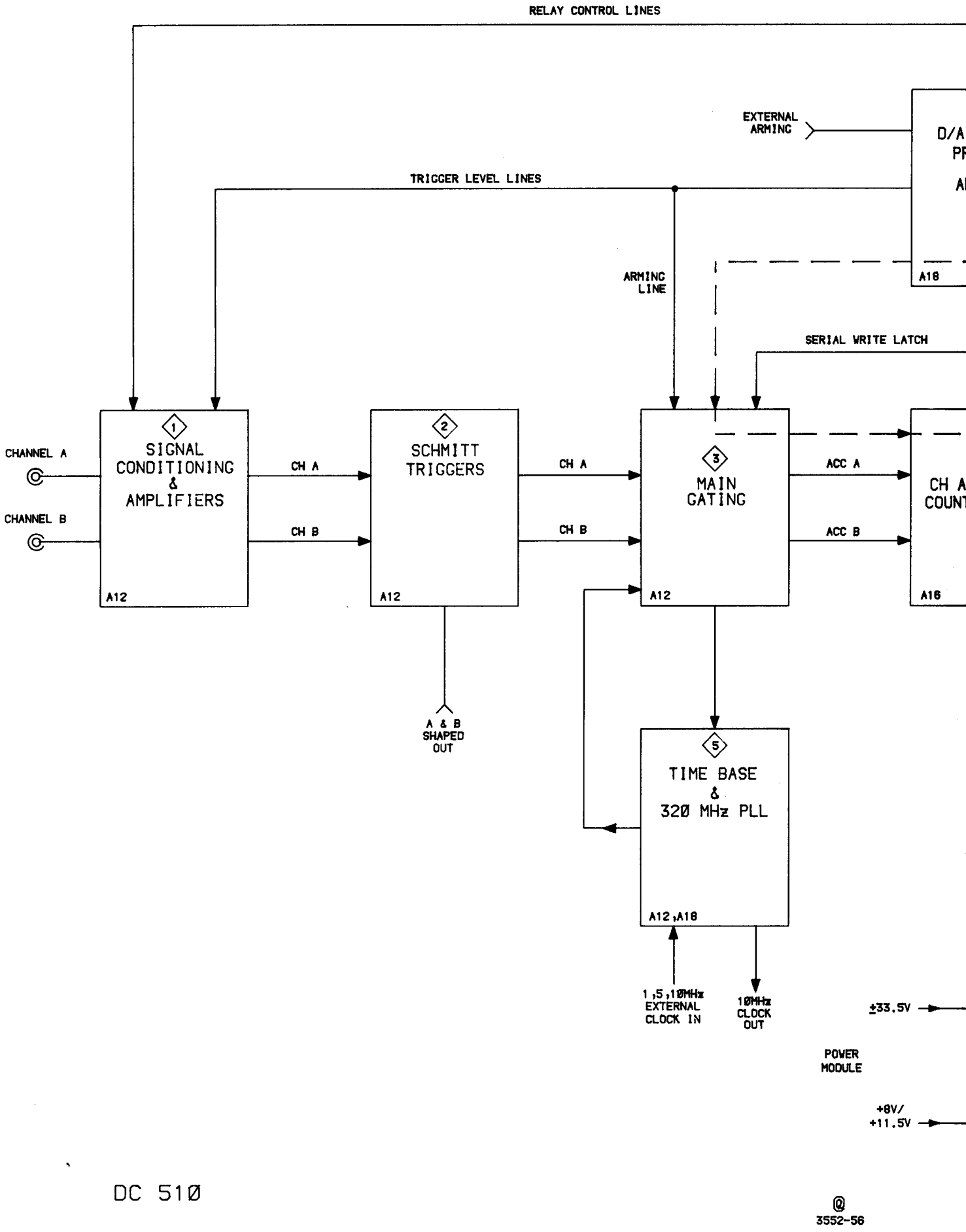
PROBLEM	SUSPECT CIRCUITRY
MEASUREMENTS ARE STABLE BUT NOT ACCURATE.	TIME BASE OSCILLATOR (+18V SUPPLY FOR OPT. 1). BUFFER - Q1500, DIVIDER - U1411, AND PHASE LOCKED LOOP COMPONENTS OR JUMPERS J1511 OR J1515 LOOSE. ⑤
DOES NOT TRIGGER PROPERLY (MAY BE INDICATED BY INCORRECT SHAPED OUTPUTS).	DUAL DMOS IN AMPLIFIER ①, +12V, -12V, -5V, $+5V_2$ SUPPLIES ⑧, AMPLIFIER COMPONENTS ①, ②.
INPUT CONDITIONING DOES NOT FUNCTION PROPERLY.	SWITCH ⑨ ⑩, RELAYS ①, RELAY DRIVERS ⑦, U1520E ⑨
DISPLAY DOES NOT FUNCTION PROPERLY.	DISPLAY CIRCUITRY ⑩ ⑪
AUTO TRIGGER DOES NOT FUNCTION PROPERLY.	+2.5V SUPPLY ⑧, D/A CONVERTERS - U1210, U1310 ⑥, SERIAL-TO-PARALLEL SHIFT REGISTERS - U12222, U1220, U1221 ⑥, INPUT AMPLIFIERS ①, ②, BUFFERS - U1200 ⑥.
MEASUREMENTS WITH LOW FREQUENCY INPUT SIGNAL ARE NOT STABLE. GATE LIGHT ALWAYS ON. NO MEASUREMENT COMPLETED.	$\overline{END}$ SIGNAL ③, ④ SUSPECT U1102C, U1410 ⑨, SCHMITT TRIGGERS, AMPLIFIERS ①, ②. $\overline{END}$ SIGNAL ③, ④ SUSPECT U1102C, U1410 ⑨. ARM STUCK LOW : Q1510, Q1511 ⑥



ERROR CODE	ACTION
313	SERIAL I/O ERROR - SEE INTERNAL SIGNATURE ANALYSIS FIG. 8-6(DIGITAL), FIG.8-8(ANALOG), AND FIG.8-9(AUXILIARY).
320-324, 329	CH A COUNTER INTEGRITY ERROR - SEE TABLE 8-2 AND COUNTER INTEGRITY TEXT DESCRIPTION
330-334, 339	CH B COUNTER INTEGRITY ERROR - SEE TABLE 8-2 AND COUNTER INTEGRITY TEST DESCRIPTION
340	RAM ERROR - SUSPECT U1410 OR CONNECTIONS 9
341	SUSPECT U1610 9
342	SUSPECT U1311 9
361	ROM PLACEMENT ERROR - SUSPECT U1610 9
380	ROM CHECKSUM ERROR - SUSPECT U1410 9
381	ROM CHECKSUM ERROR - SUSPECT U1610 9

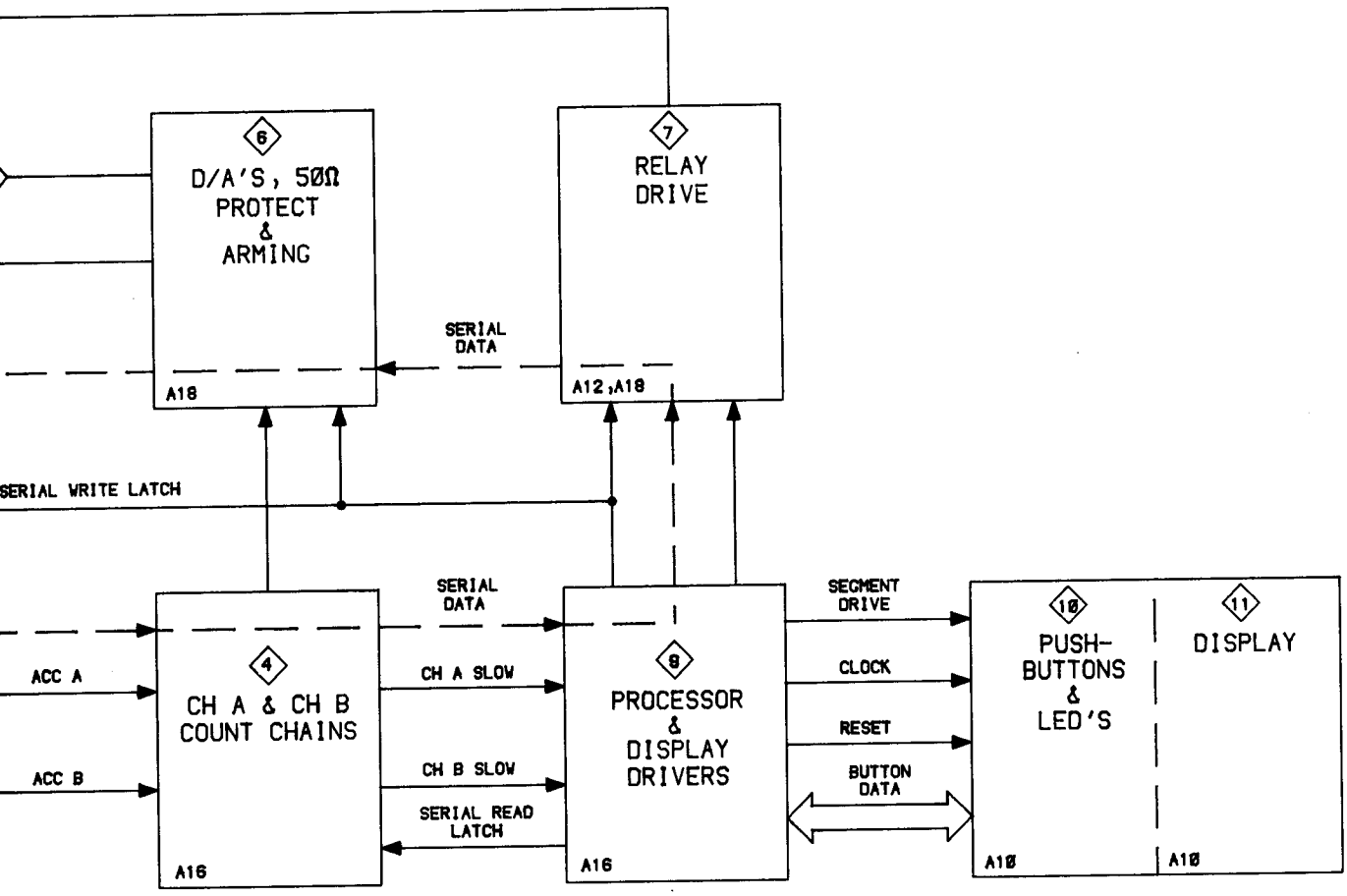
3552-12

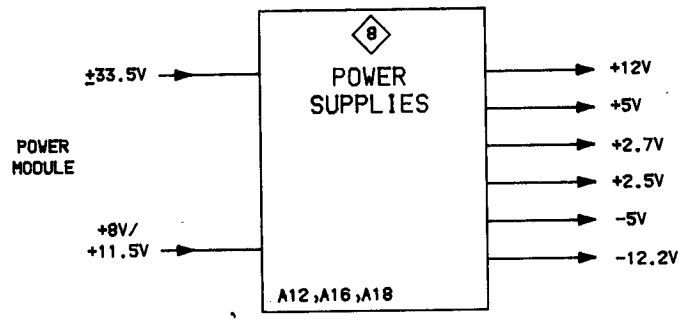
Fig. 8-5. General troubleshooting flow chart.



DC 510

3552-56





BLOCK DIAGRAM JCS

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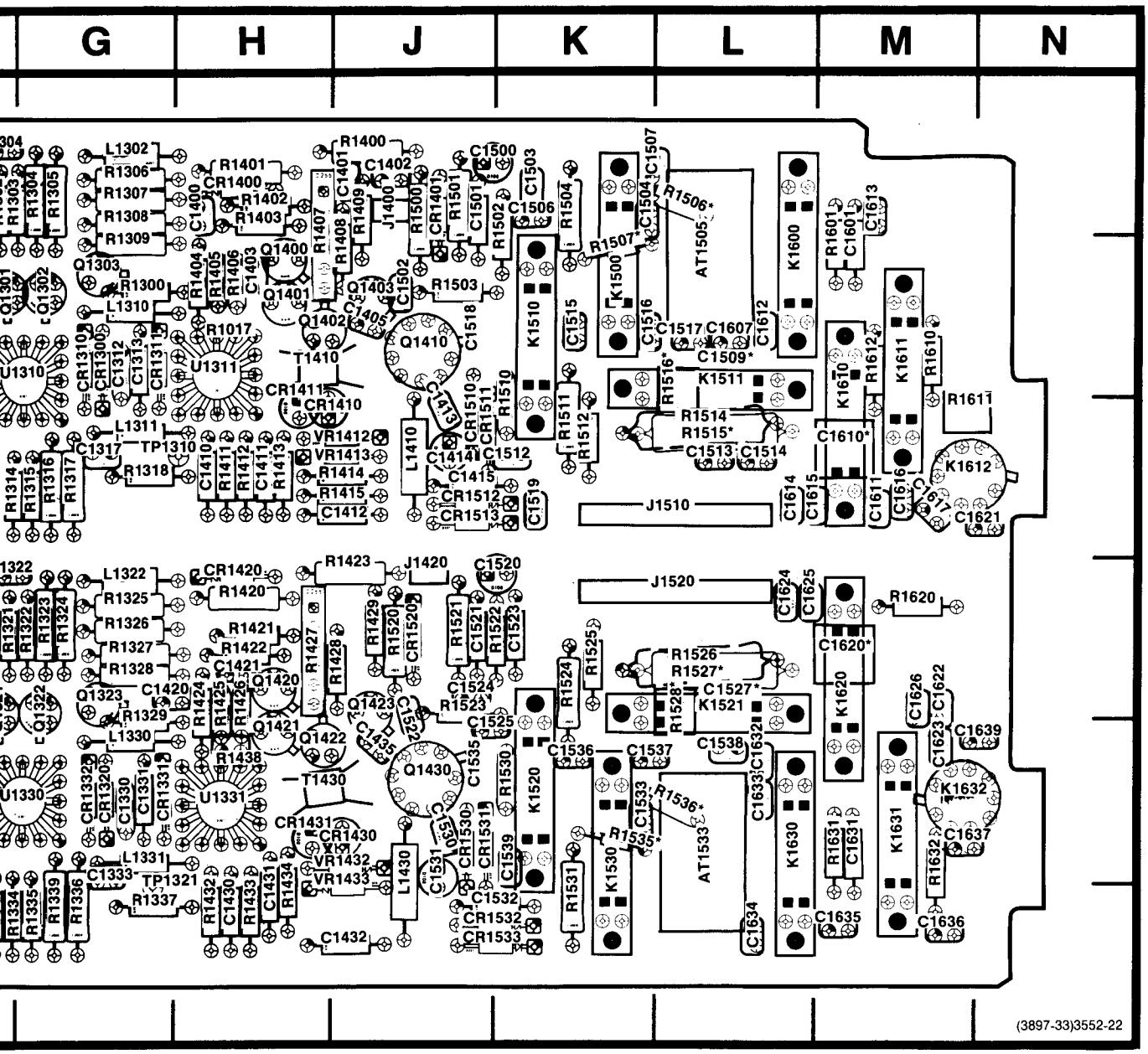
3552-56

OCATION GRID



A12

8-11. Analog board (A12).

*Located on back of board.

PARTS LOCATION GR

ANALOG BOARD (A12)
PARTS LOCATION GRID

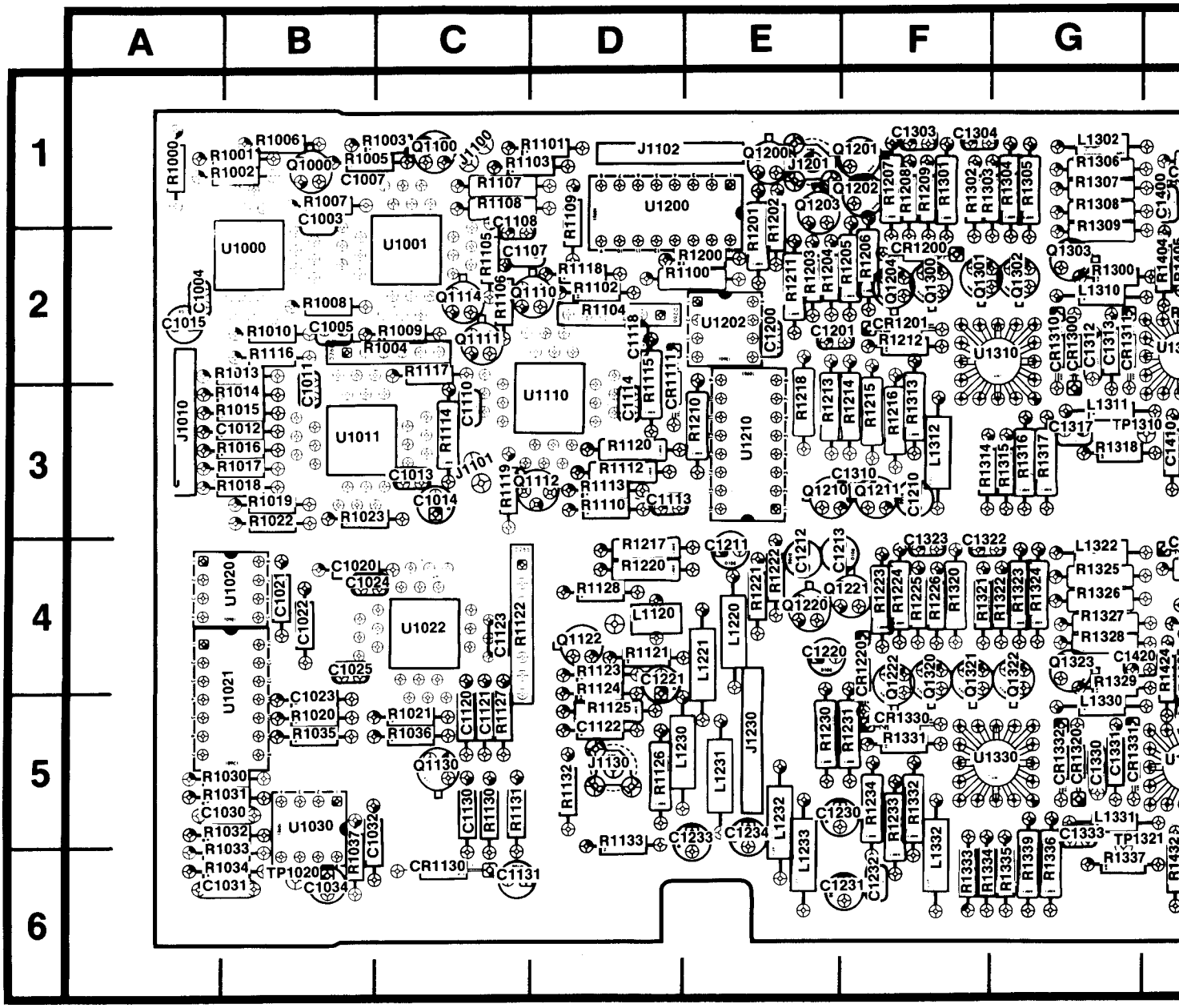
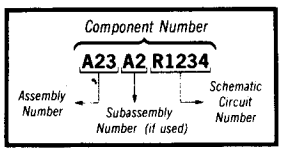


Fig. 8-11. Analog board (A12).

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Table 8-3
COMPONENT REFERENCE CHART
(see Fig. 8-11)

ANALOG BOARD (A12)
PARTS LOCATION GRID

P/O A12 ASSY — SIGNAL CONDITIONING & AMPLIFIERS ◇1

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
AT1505	E3	L2
AT1533	E7	L5
C1312	M3	G2
C1313	L3	G2
C1330	M7	G5
C1331	L7	G5
C1401	I4	J1
C1403	K4	H2
C1405	H3	J2
C1412	I1	J3
C1413	I2	J3
C1414	I2	J3
C1415	F1	J3
C1425	K8	H4
C1432	I5	J6
C1435	H7	J5
C1500	I5	J1
C1501	G4	J1
C1502	H3	J2
C1503	J5	K1
C1504	E3	K1
C1509	E2	L2
C1518	G2	J2
C1520	K9	J4
C1521	G8	J4
C1522	H7	J4
C1523	I9	K4
C1527	E7	L4
C1530	I6	J5
C1531	I6	J5
C1532	F6	K6
C1533	E7	K5
C1535	G6	J5
C1601	C3	M1
C1610	D3	M3
C1620	D7	M4
C1631	C7	M5
CR1300	M3	G2
CR1310	M2	G2
CR1311	L3	G2
CR1320	M7	G5
CR1331	L7	G5
CR1332	M7	G5
CR1400	L5	H1
CR1401	J4	J1
CR1410	J2	H2
CR1411	I2	H2
CR1420	L9	H4
CR1430	J7	J5
CR1431	I7	H5
CR1510	G1	J3
CR1511	H1	J3
CR1512	G1	J3
CR1513	H1	J3
CR1520	J9	J4
CR1530	G5	J5
CR1531	H6	J5
CR1532	G6	K6
CR1533	H5	K6
J1400	B4	J1
J1420	B8	J4
J500	B2	Chassis
J510	B6	Chassis
K1500S	F4	K2
K1510S	G2	K2
K1511S	E1	L2
K1520S	G6	K5
K1521S	E6	L4
K1530S	F8	K5
K1600S	D4	L2
K1610S	D1	M2
K1611S	C2	M2
K1612S	B2	M3
K1620S	D6	M4
K1630S	D8	L5
K1631S	C6	M5
K1632S	C7	M5
L1310	M2	G2
L1311	M3	G3
L1330	M6	G5
L1331	M7	G5
L1410	I2	J3
L1430	I6	J5
Q1210	K1	E3
Q1211	K1	F3
Q1400	J4	H2
Q1401	K4	H2
Q1402	H4	H2
Q1403	I4	J2
Q1410	H2	J2
Q1420	J8	H4
Q1421	K8	H5
Q1422	H8	H5
Q1423	I8	J4
Q1430	H6	J5
R1318	K2	G3
R1337	K6	G6
R1400	M4	J1
R1401	L4	H1
R1402	K4	H1
R1403	K4	H1
R1404	L3	H2
R1405	K4	H2
R1406	J4	H2
R1408	I4	J1
R1409	I4	J1
R1411	K2	H3
R1412	K2	H3
R1413	J2	H3
R1417	K3	H2
R1420	L9	H4
R1421	K8	H4
R1422	K8	H4
R1423	L9	J4
R1424	L8	H4
R1425	K8	H4
R1426	J8	H4
R1427	K9	H4
R1428	I8	J4
R1429	J8	J4
R1432	K6	H6
R1433	K6	H6
R1434	J6	H6
R1438	K8	H5
R1500	J4	J1
R1501	J3	J1
R1502	D4	K1
R1503	G4	J2
R1504	F3	K1
R1506	E4	L1
R1507	E3	K2
R1510	G2	K2
R1511	F2	K3
R1512	F2	K3
R1514	D2	L3
R1515	E2	L3
R1516	E2	L2
R1520	J8	J4
R1521	J8	J4
R1522	D8	K4
R1523	G8	J4
R1524	F6	K4
R1525	F6	K4
R1526	E6	L4
R1527	D6	L4
R1528	E7	L4
R1530	G6	K5
R1531	F7	K6
R1535	E7	K5
R1536	E8	L5
R1601	D4	M1
R1610	C3	M2
R1611	B2	M3
R1612	C2	M2
R1620	C6	M4
R1631	D8	M5
R1632	C7	M5
T1410	J2	H2
T1430	J7	H5
TP1310	M3	G3
TP1321	M7	G5
U1311	J3	H2
U1331	J7	H5
VR1412	I3	J3
VR1413	J3	J3
VR1432	I7	J5
VR1433	J7	J5

P/O A12 ASSY also shown on ◇2 ◇3 ◇5 ◇7 ◇8

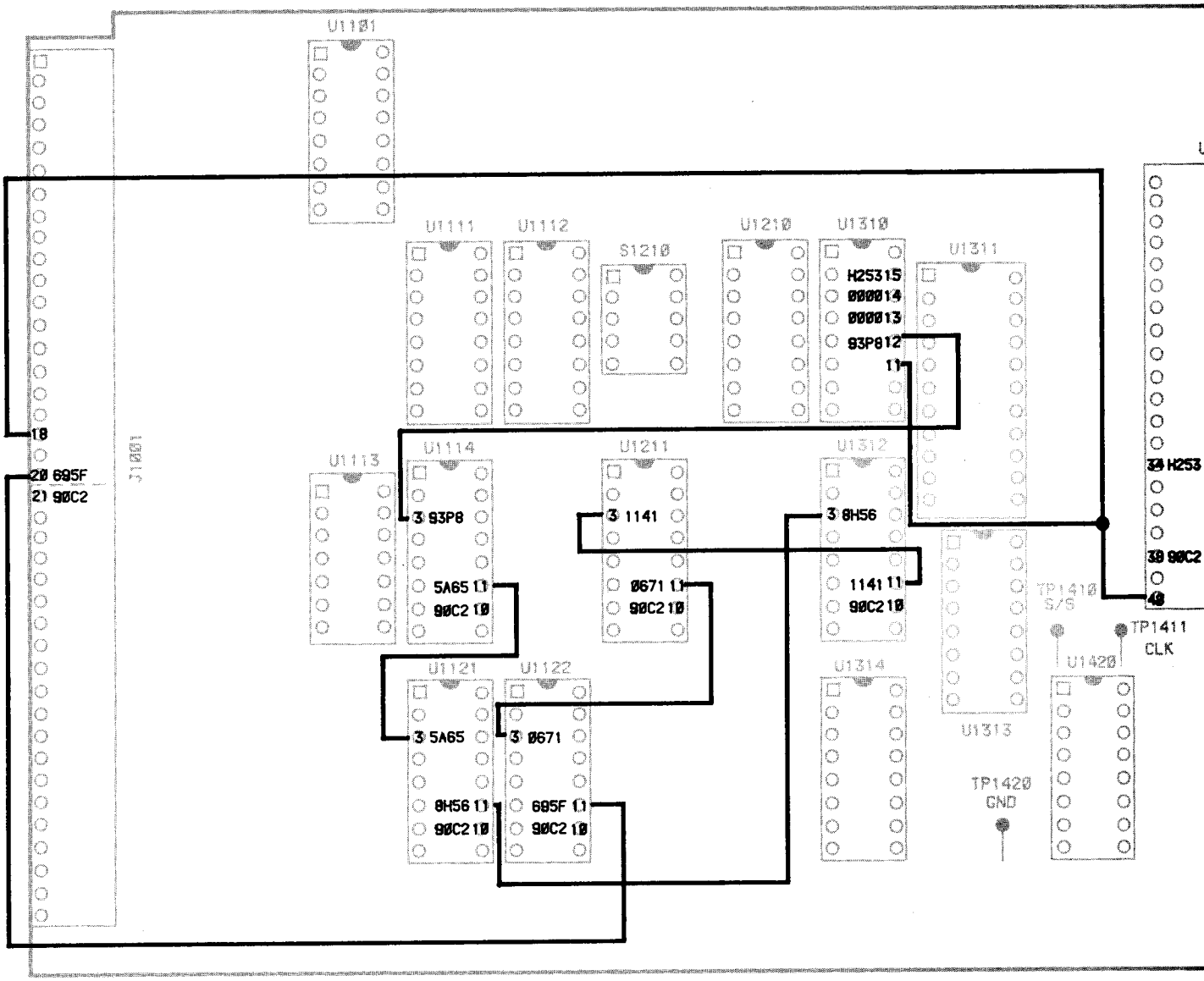
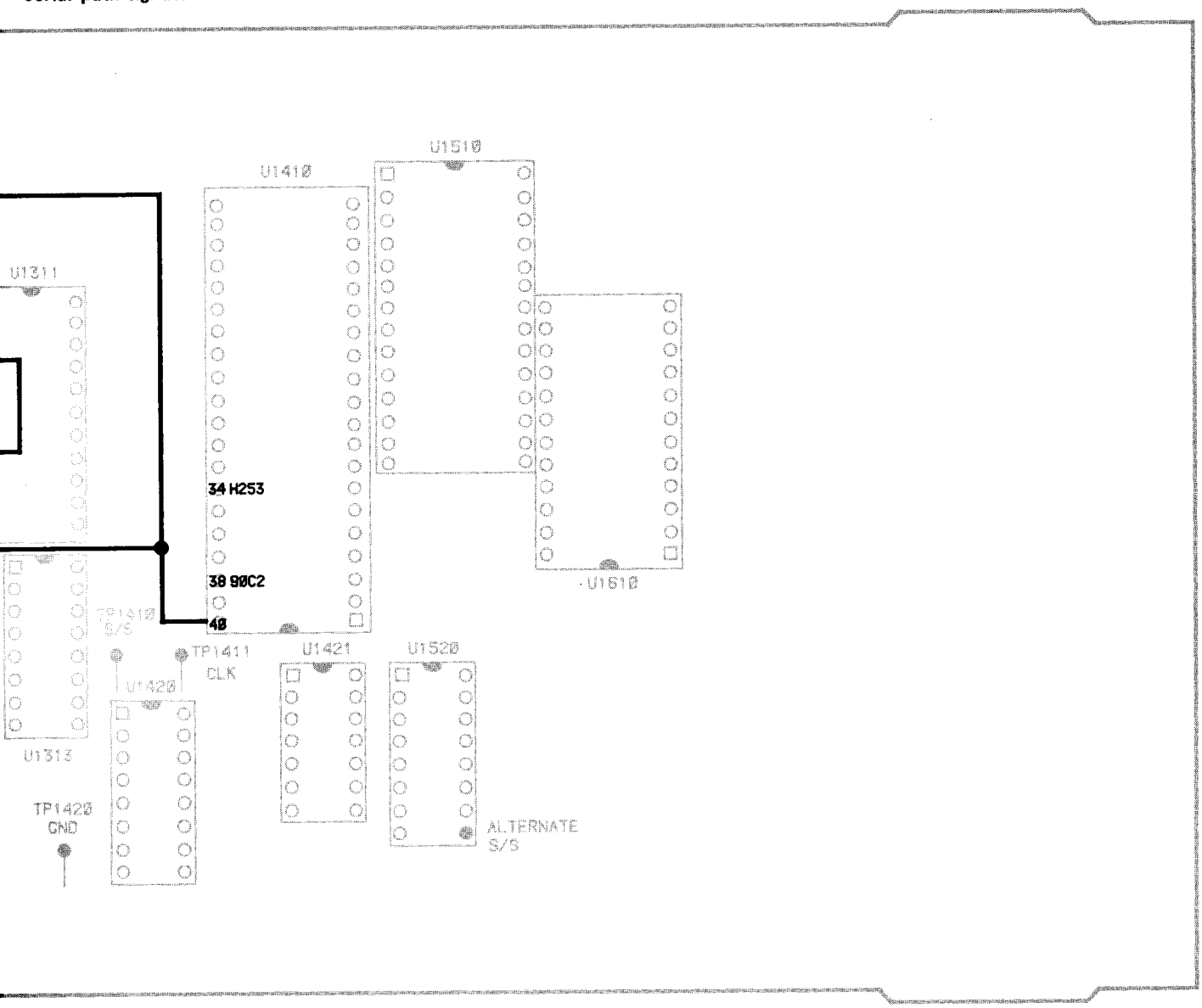


Fig. 8-6. Internal signature analysis "A" (Digital b

Serial path signatures



3552-13

signature analysis "A" (Digital board).

+5V SIGNATURE = 47C6

@

SETUP CONDITIONS

Internal Signatures (Digital Board)

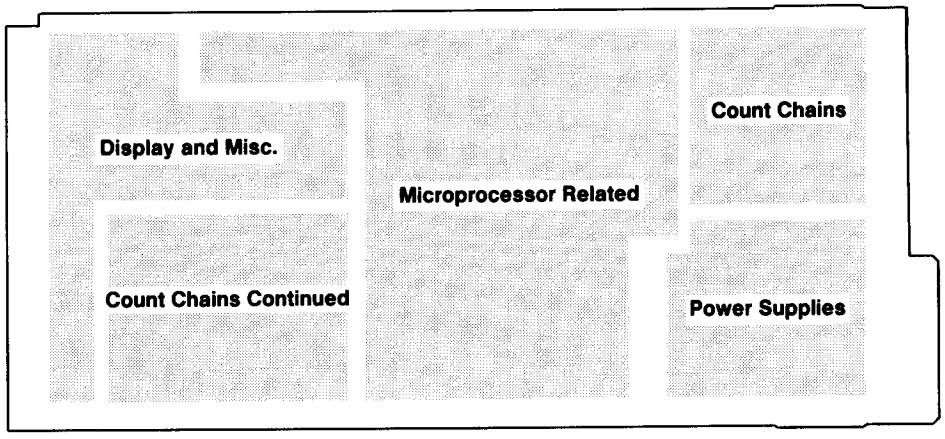
SA CLOCK	TP 1411
SA START	Pin 9 of U1520
SA STOP	Pin 9 of U1520
SA GND	TP 1420

NOTE

Power up DC 510 while holding in CH A ATTEN button to get signatures.

Address switch S1210 set to 20:

S1210



Digital board circuit locations

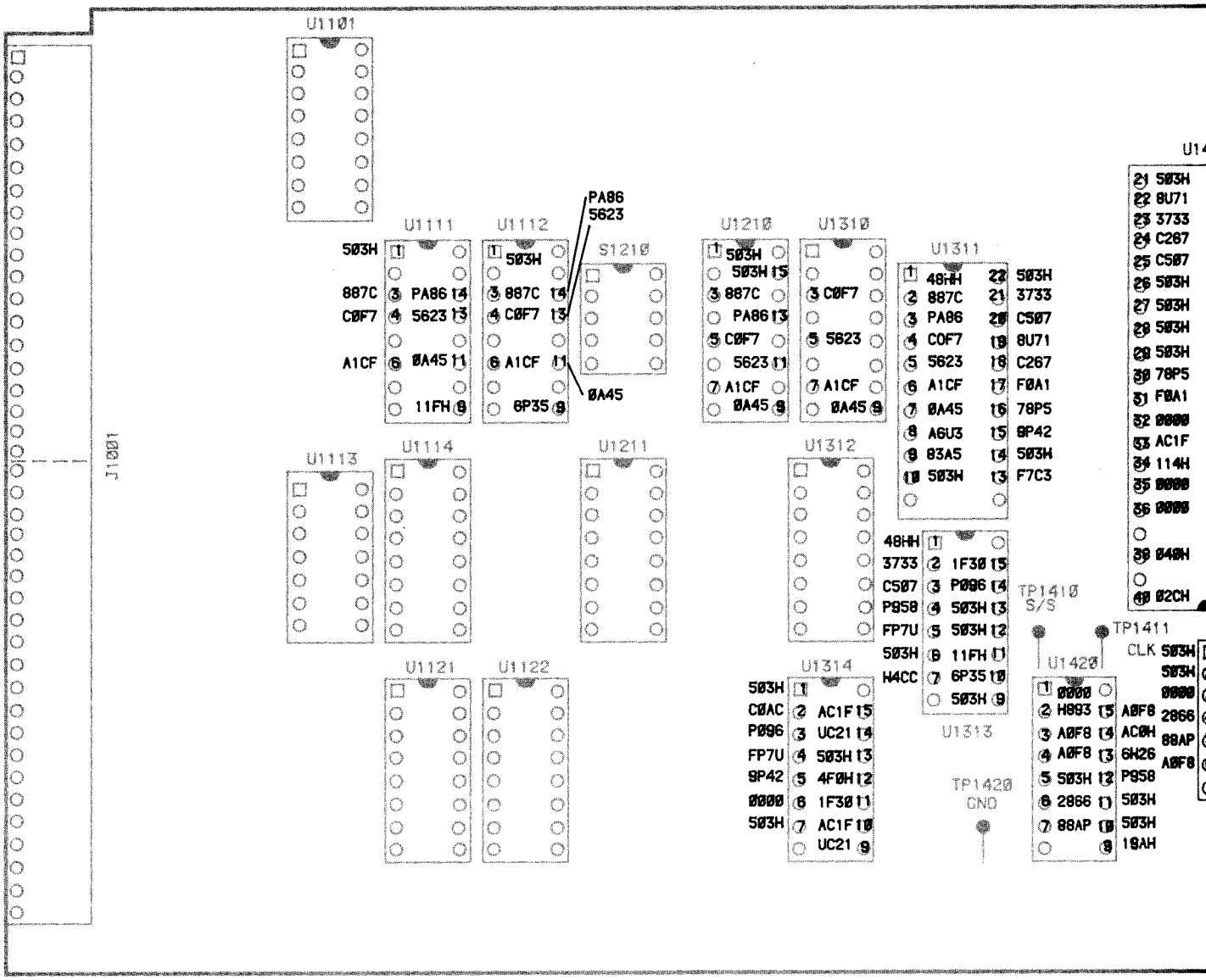
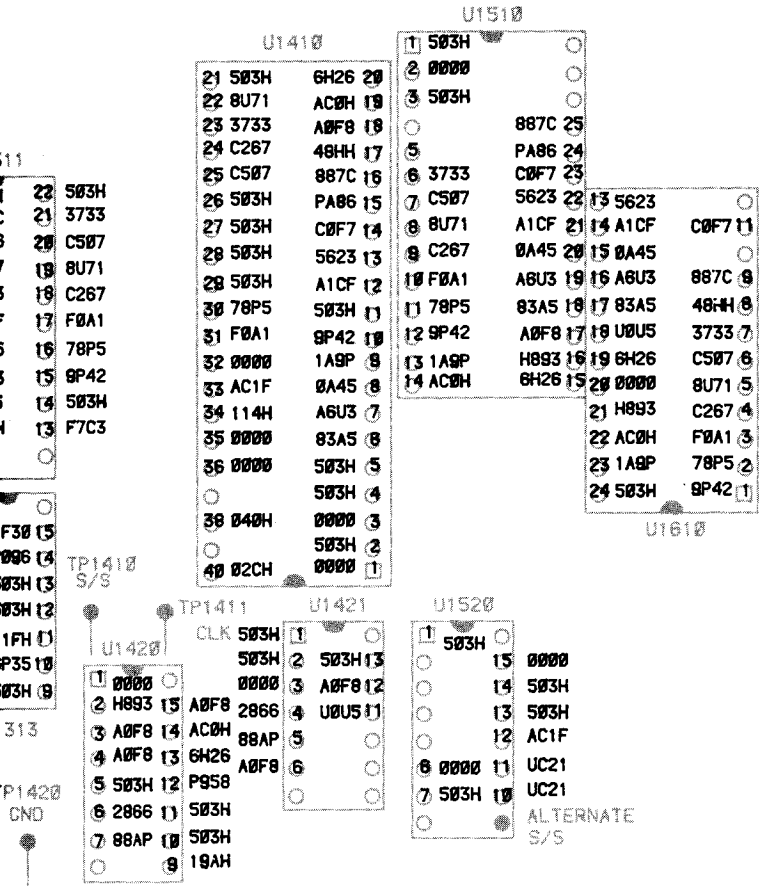


Fig. 8-7. Internal signature analysis "B" (Digital board).

r related signatures



3552-14

e analysis "B" (Digital board).

+5V SIGNATURES = 503H

SETUP CONDITIONS

Internal Signatures (Digital Board)

SA CLOCK — TP 1411 (Digital Board)

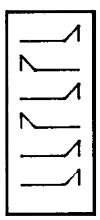
SA START, SA STOP — TP 1410 (Digital Board)

SA GND — TP 1420 (Digital Board)

NOTE

Power up DC 510 while holding in CH A ATTEN button to get signatures.

Address switch S1210 set to 20:



S1210

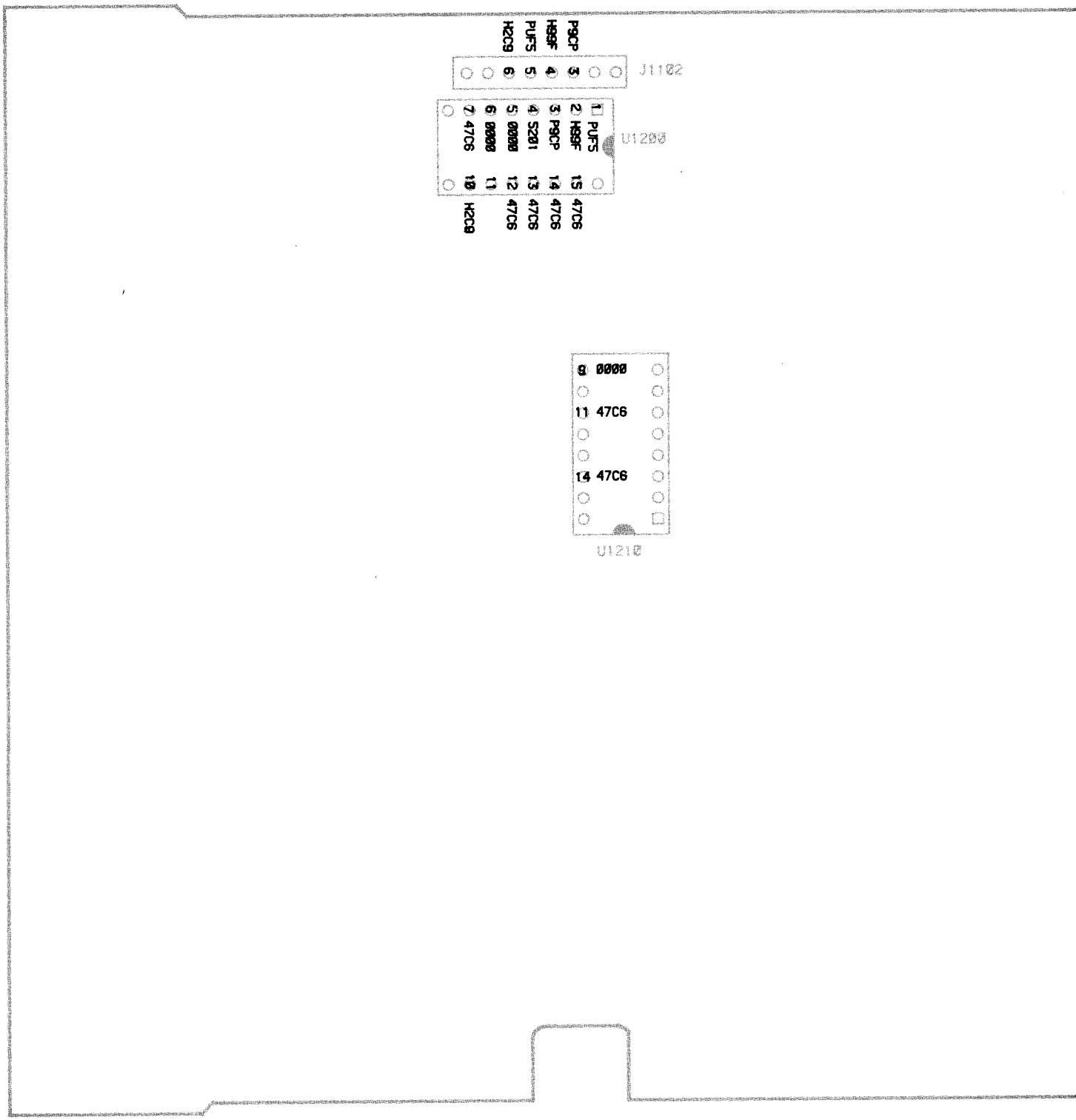
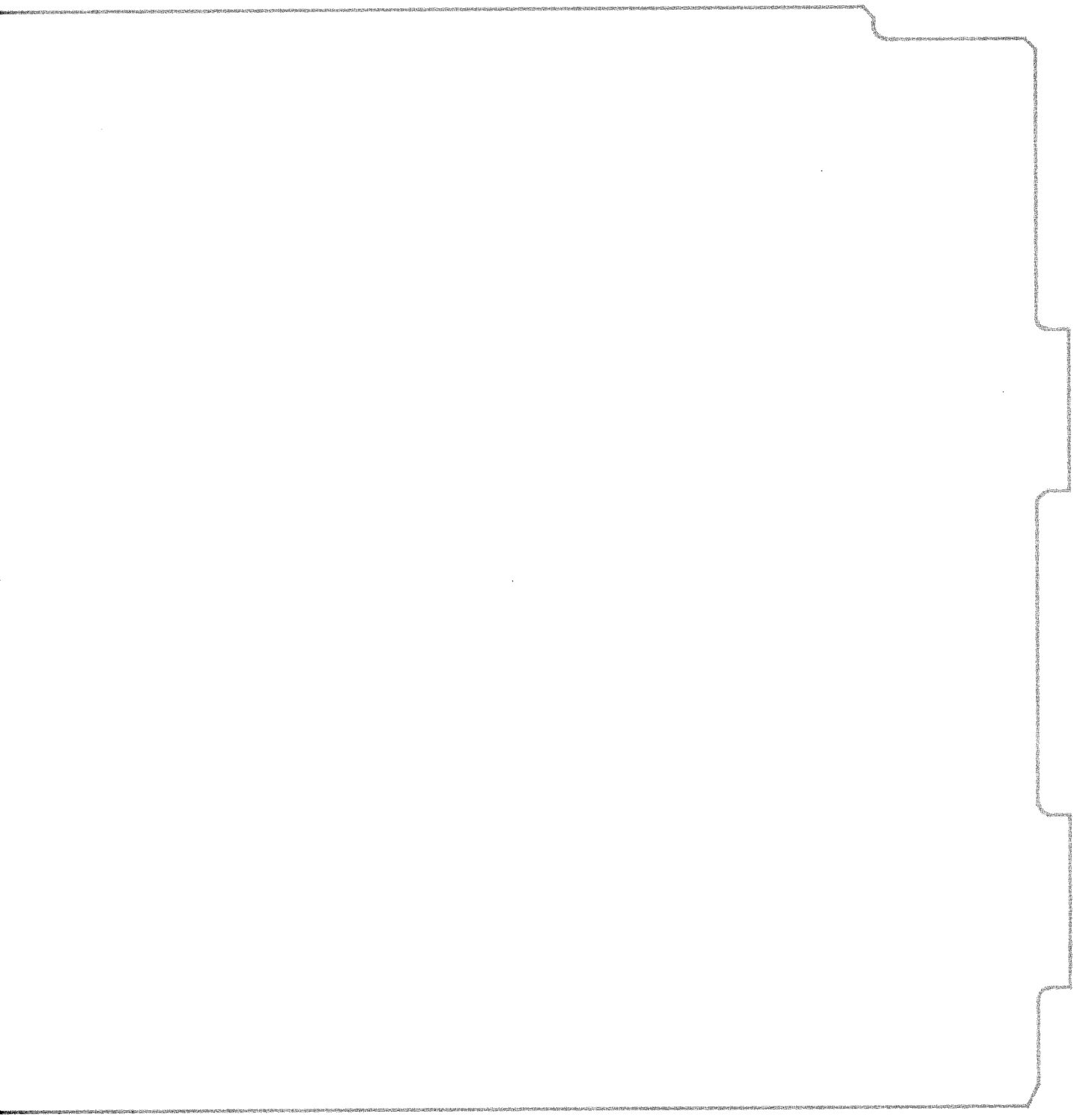


Fig. 8-8. Internal signature analysis (

Serial path signatures



3552-15

+5V SIGNATURE = 47C6

8-8. Internal signature analysis (Analog board).

@

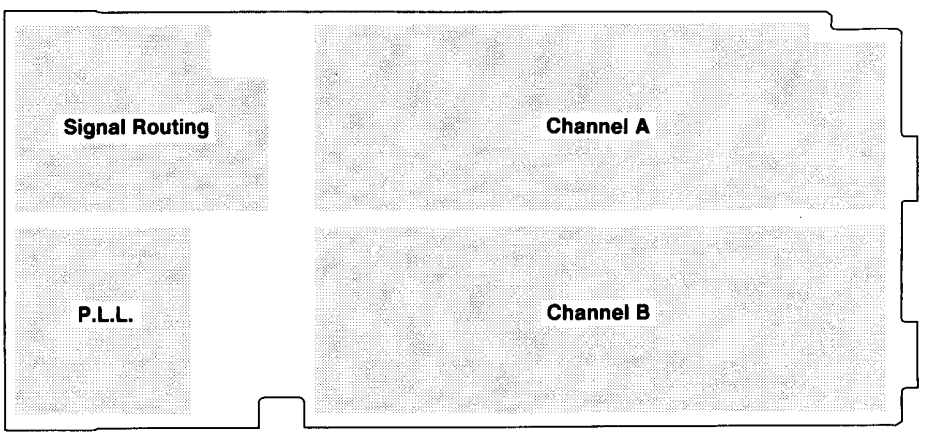
SETUP CONDITIONS

Internal Signatures (Analog Board)

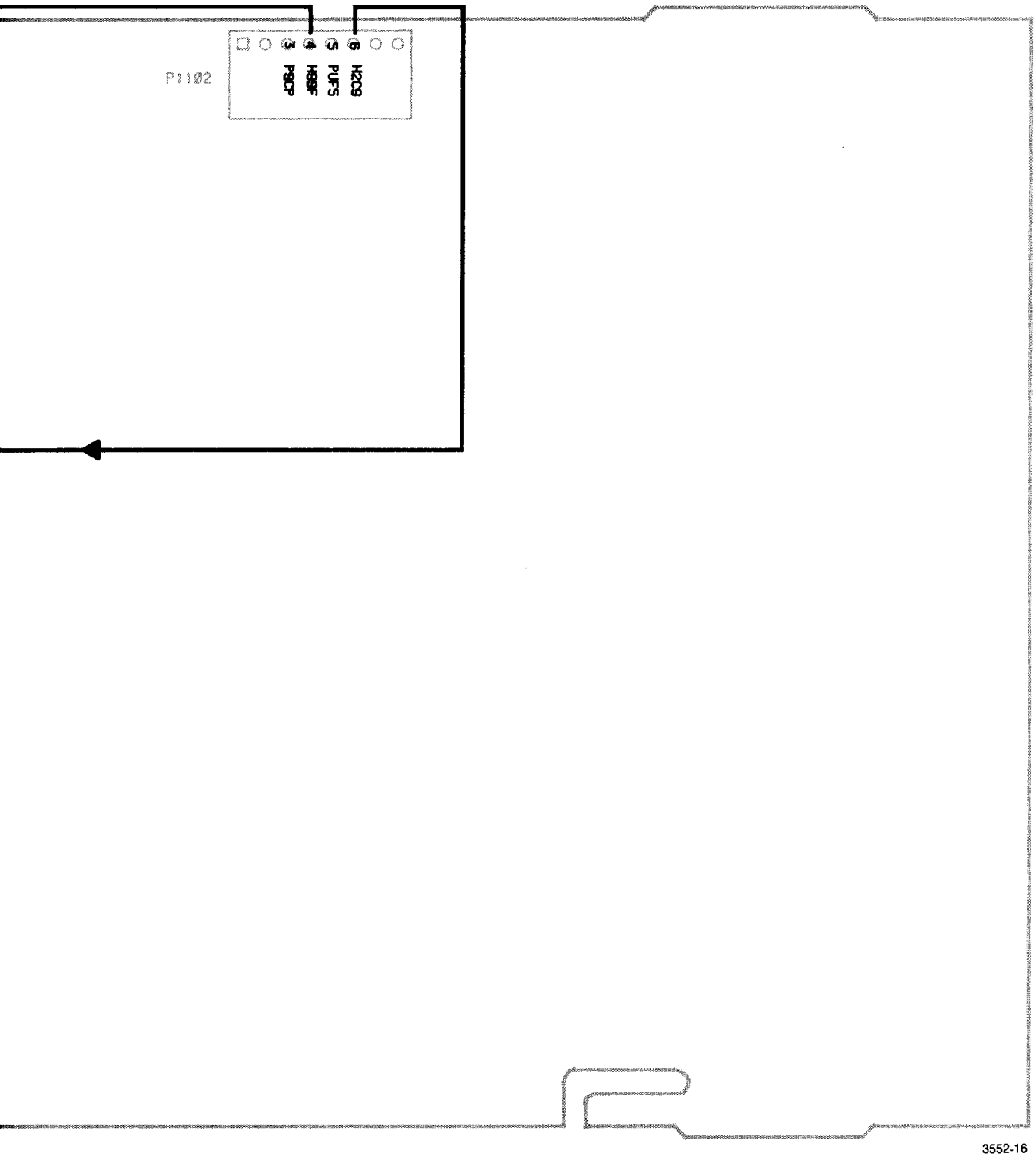
SA CLOCK	TP 1411 (Digital Board)
SA START	Pin 9 of U1510 (Digital Board)
SA STOP	Pin 9 of U1510 (Digital Board)
SA GND	TP 1420 (Digital Board)

NOTE

Power up DC 510 while holding CH A ATTEN button to get signature analysis.



Analog board circuit locations



3552-16

nature analysis (Auxiliary board).

+5V SIGNATURE = 47C6

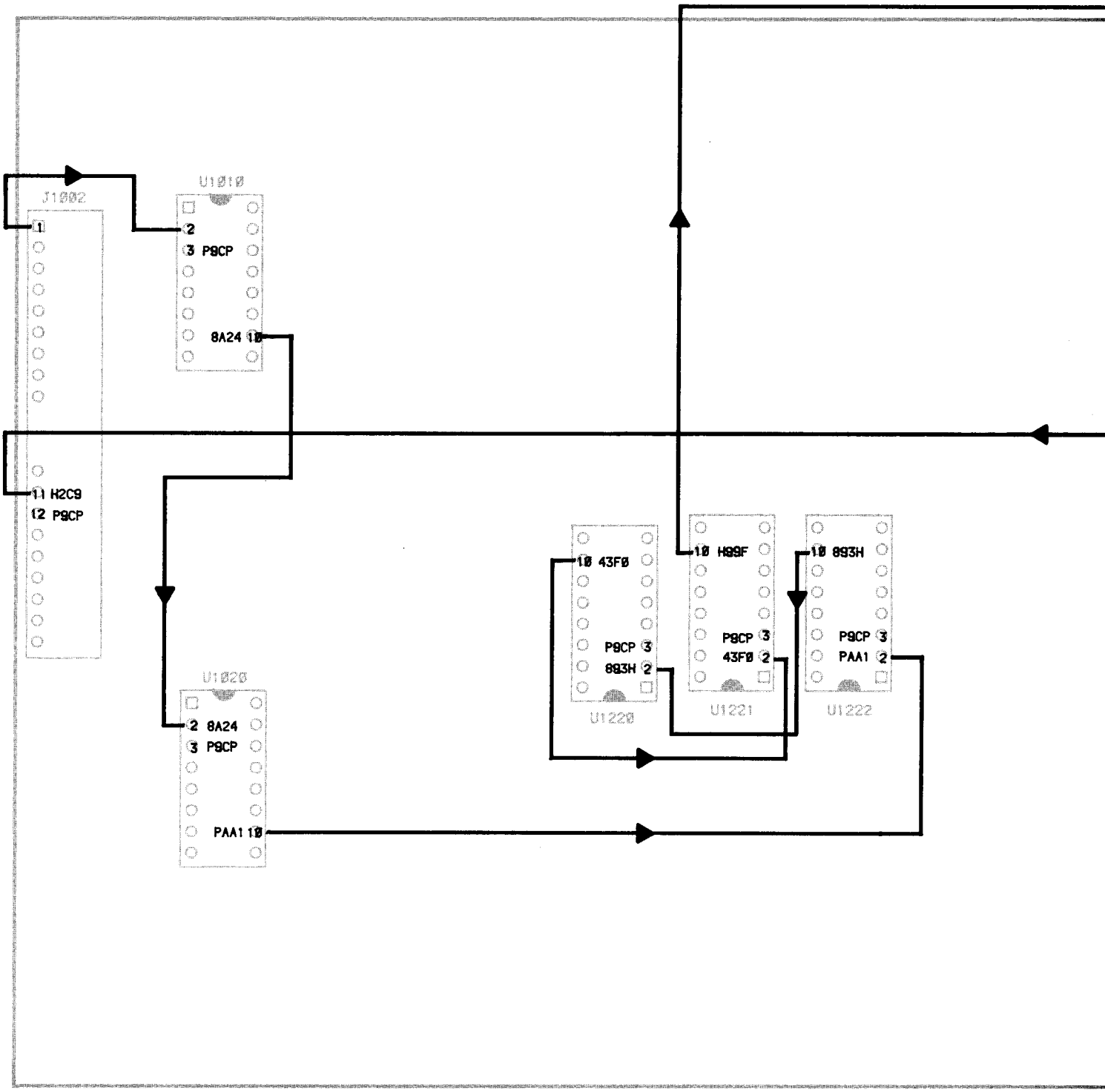


Fig. 8-9. Internal signature analysis (Auxili

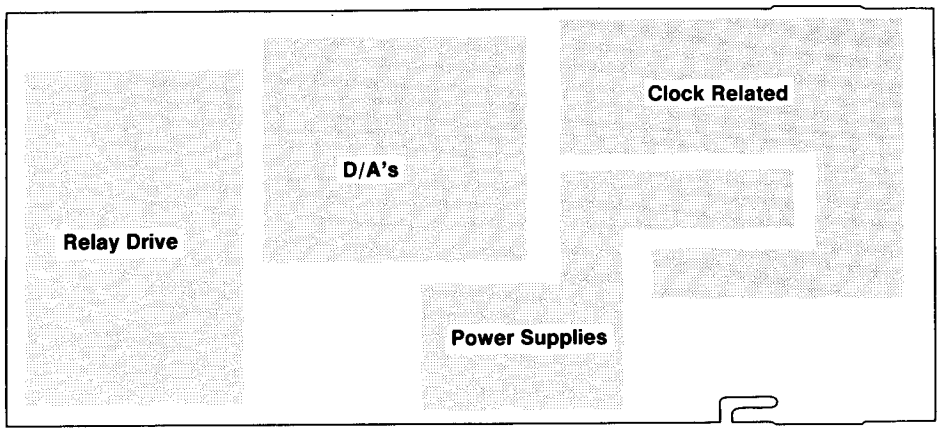
SETUP CONDITIONS

Internal Signatures (Auxiliary Board)

SA CLOCK	TP 1411 (Digital Board)
SA START	Pin 9 of U1520 (Digital Board)
SA STOP	Pin 9 of U1520 (Digital Board)
SA GND	TP 1420 (Digital Board)

NOTE

Power up DC 510 while holding in CH A ATTEN button to get signatures.



Auxiliary board circuit locations

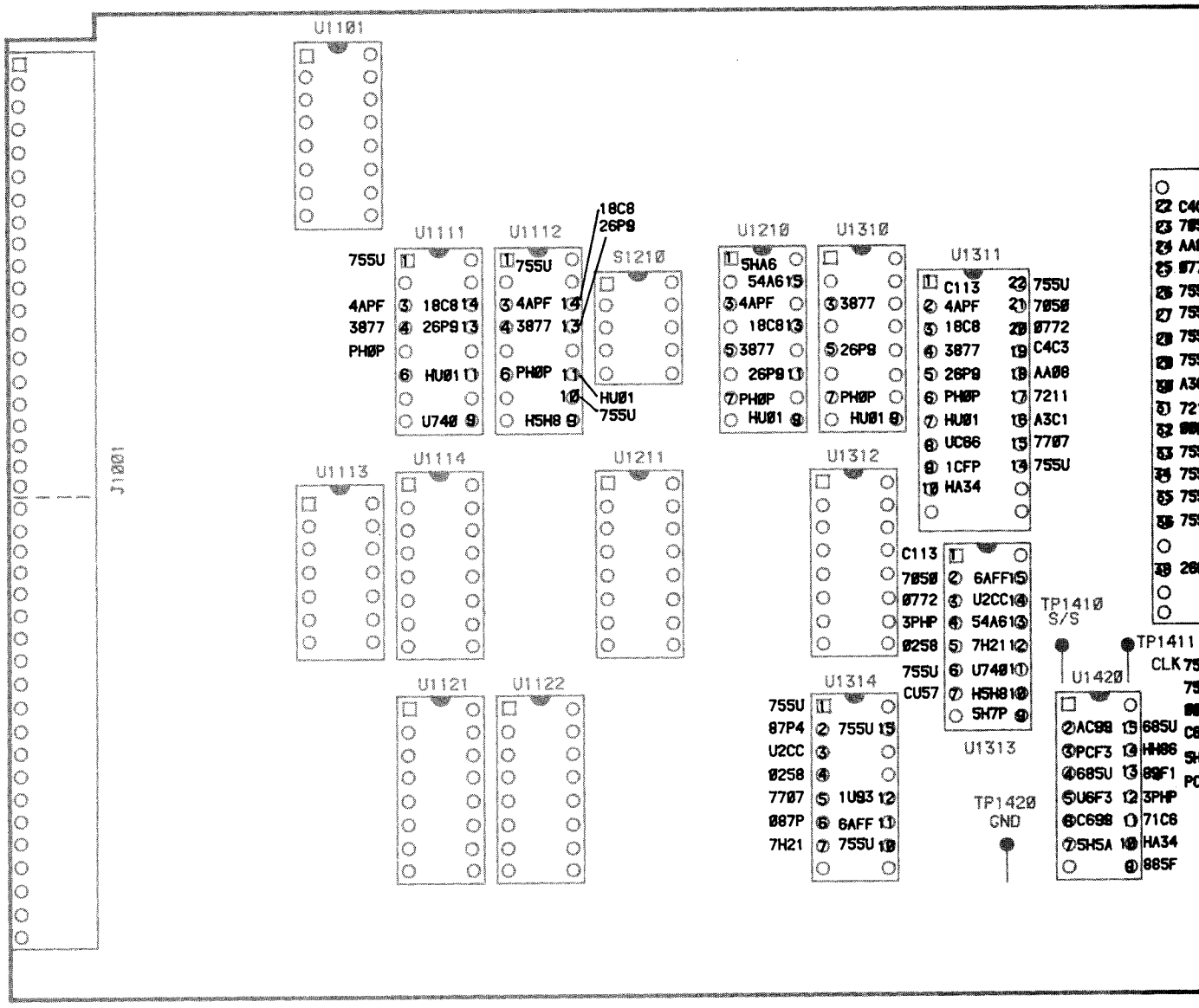
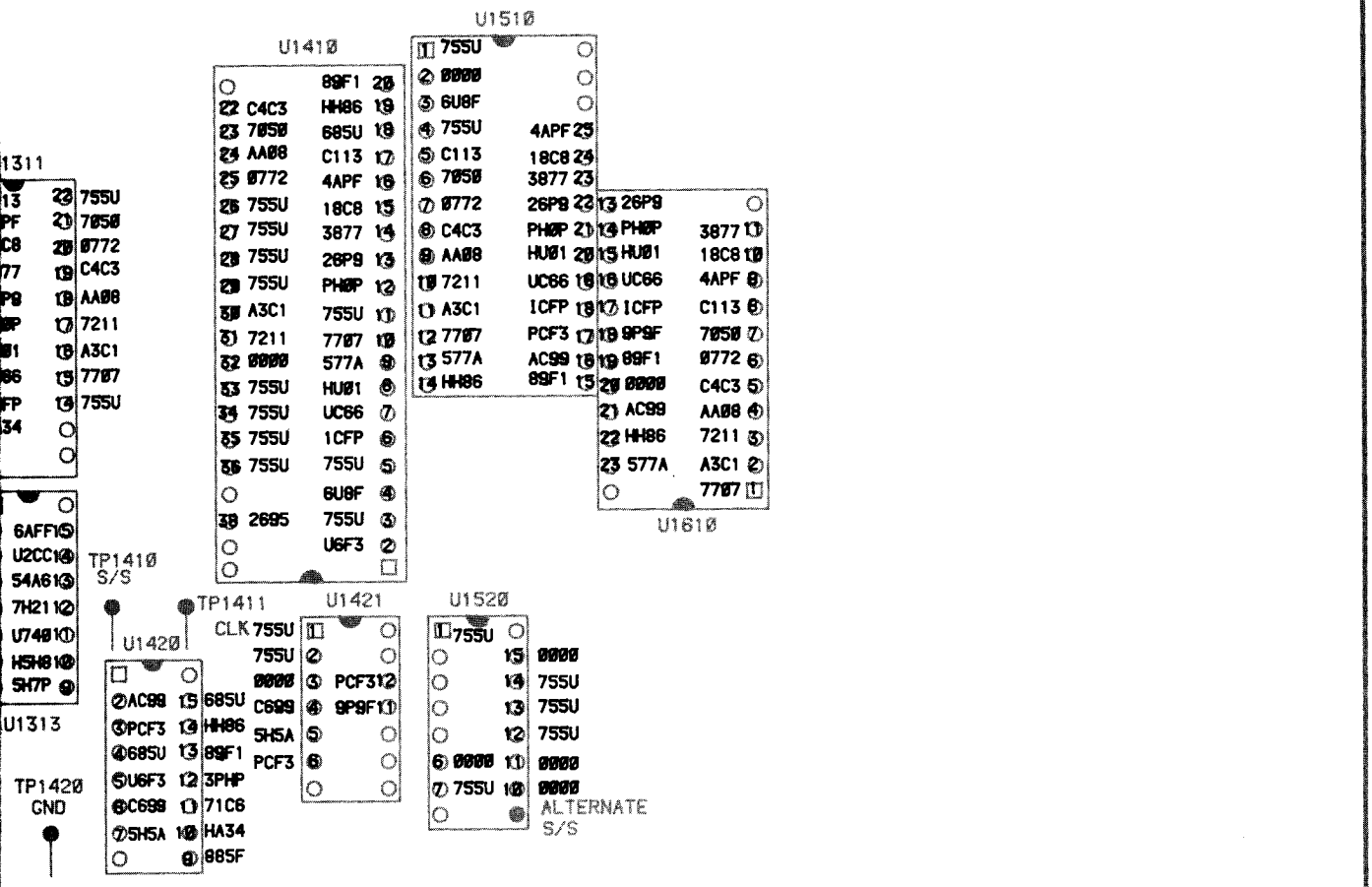


Fig. 8-10. Kernel signature analysis (D

Kernel test board signatures



3552-17

+5V SIGNATURES =755U

Kernel signature analysis (Digital board).

SETUP CONDITIONS

Kernel Test Signatures (Digital Board)

SA CLOCK — TP 1411 (Digital Board)

SA START, SA STOP — START/STOP (Kernel Board)

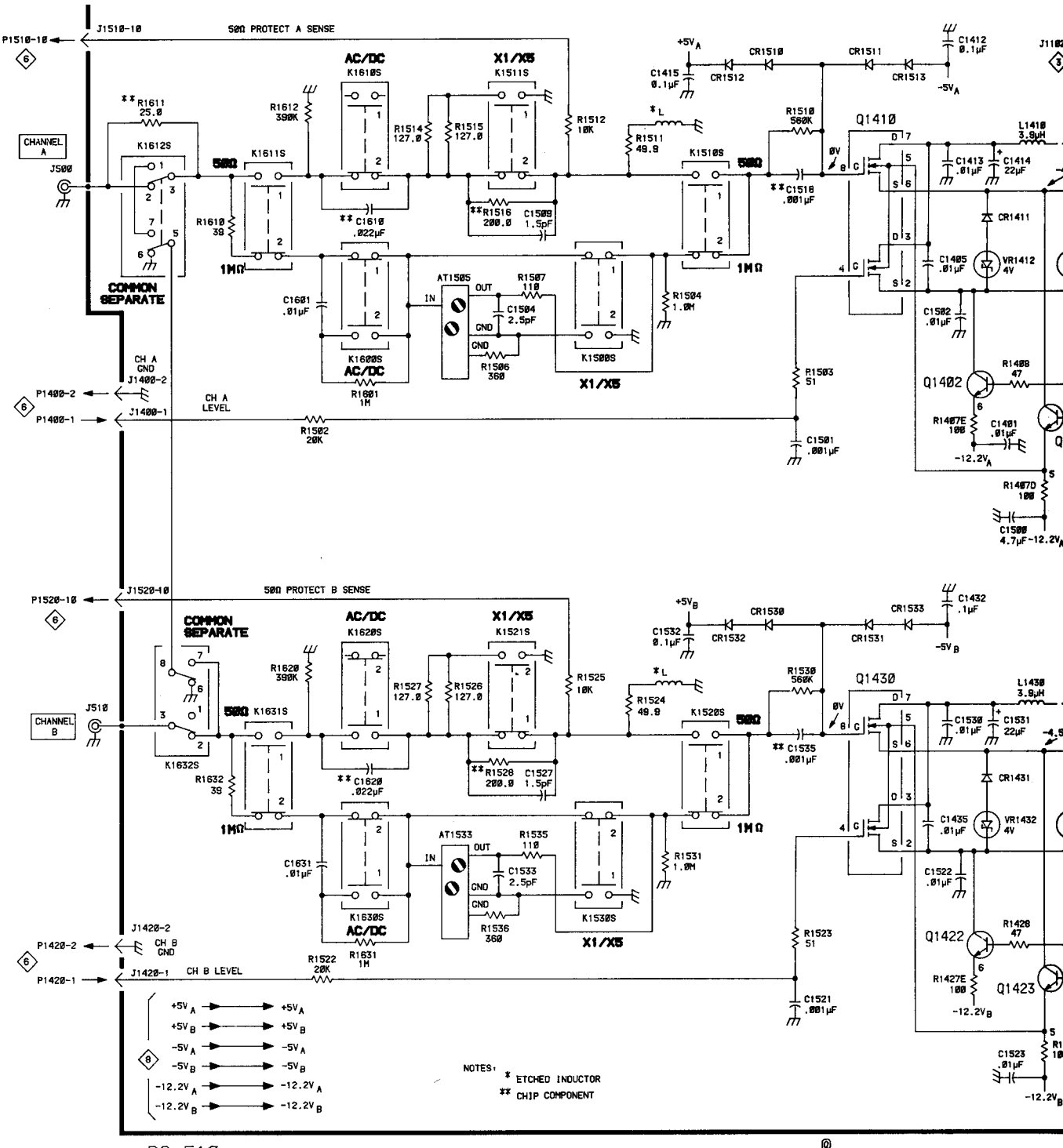
SA GND — TP 1420 (Digital Board)

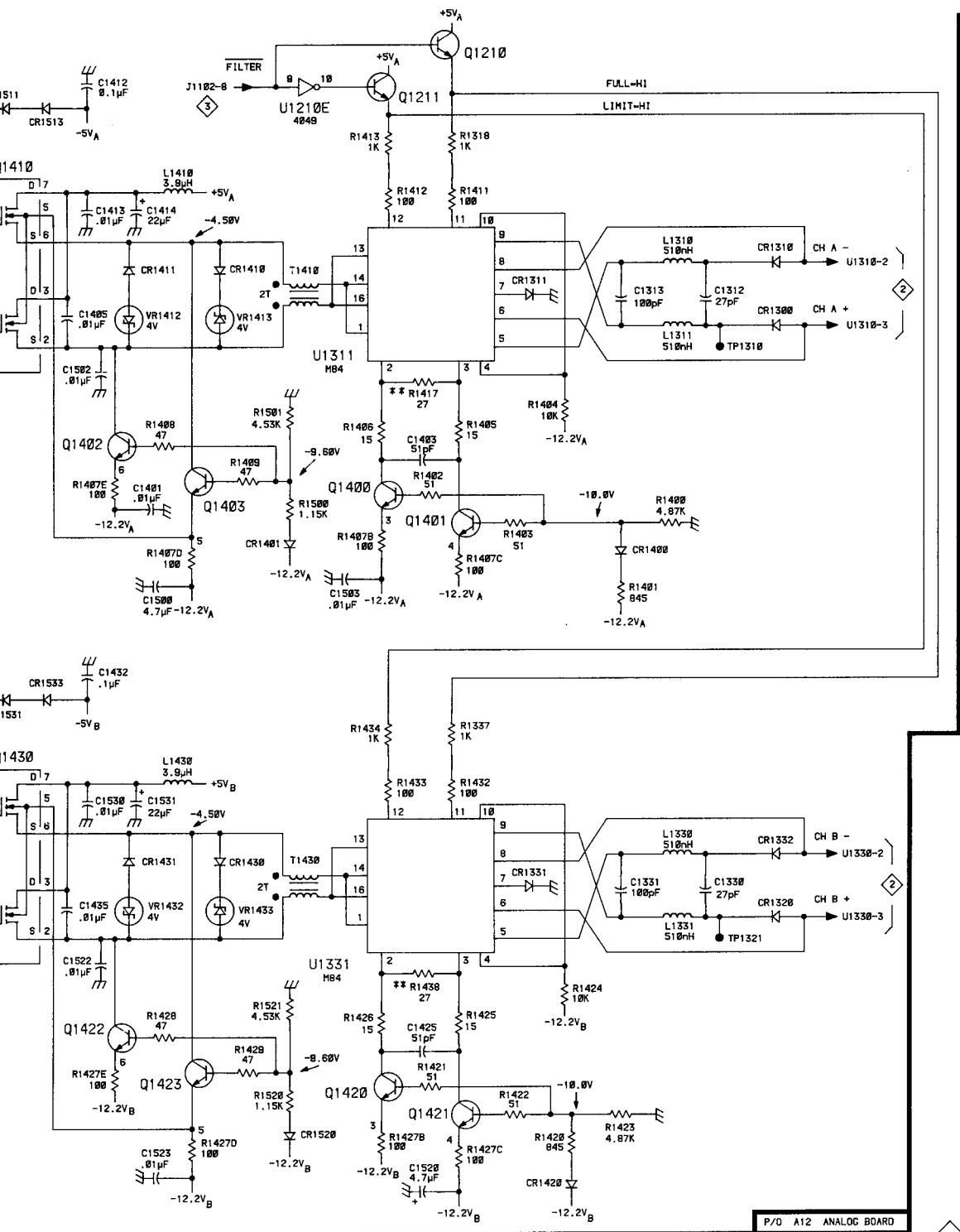
NOTE

Power up DC 510 while holding in CH A ATTEN button to get signatures.

Address switch S1210 set to 20:

S1210


50Ω PROTECT A SENSE
AC/DC
X1/X5
K1610S
K1511S
CHANNEL A
J500
K1612S
K1611S
50Ω
1MΩ
COMMON SEPARATE
CH A GND
CH A LEVEL
J1400-2
J1400-1
P1400-2
P1400-1
P1510-10
J1510-10
50Ω PROTECT B SENSE
P1520-10
J1520-10
CHANNEL B
J510
K1631S
K1632S
K1620S
K1521S
K1520S
K1630S
K1530S
CH B GND
CH B LEVEL
J1420-2
J1420-1
P1420-2
P1420-1
Q1410
Q1430
Q1402
Q1422
Q1423
CR1411
CR1431
VR1412 4V
VR1432 4V
AT1505
AT1533
IN
OUT
GND
+5V_A
+5V_B
-5V_A
-5V_B
-12.2V_A
-12.2V_B
NOTES: * ETCHED INDUCTOR
** CHIP COMPONENT
DC 510
3552-45

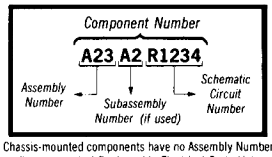


SIGNAL CONDITIONING & AMPLIFIERS

1 JCS

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

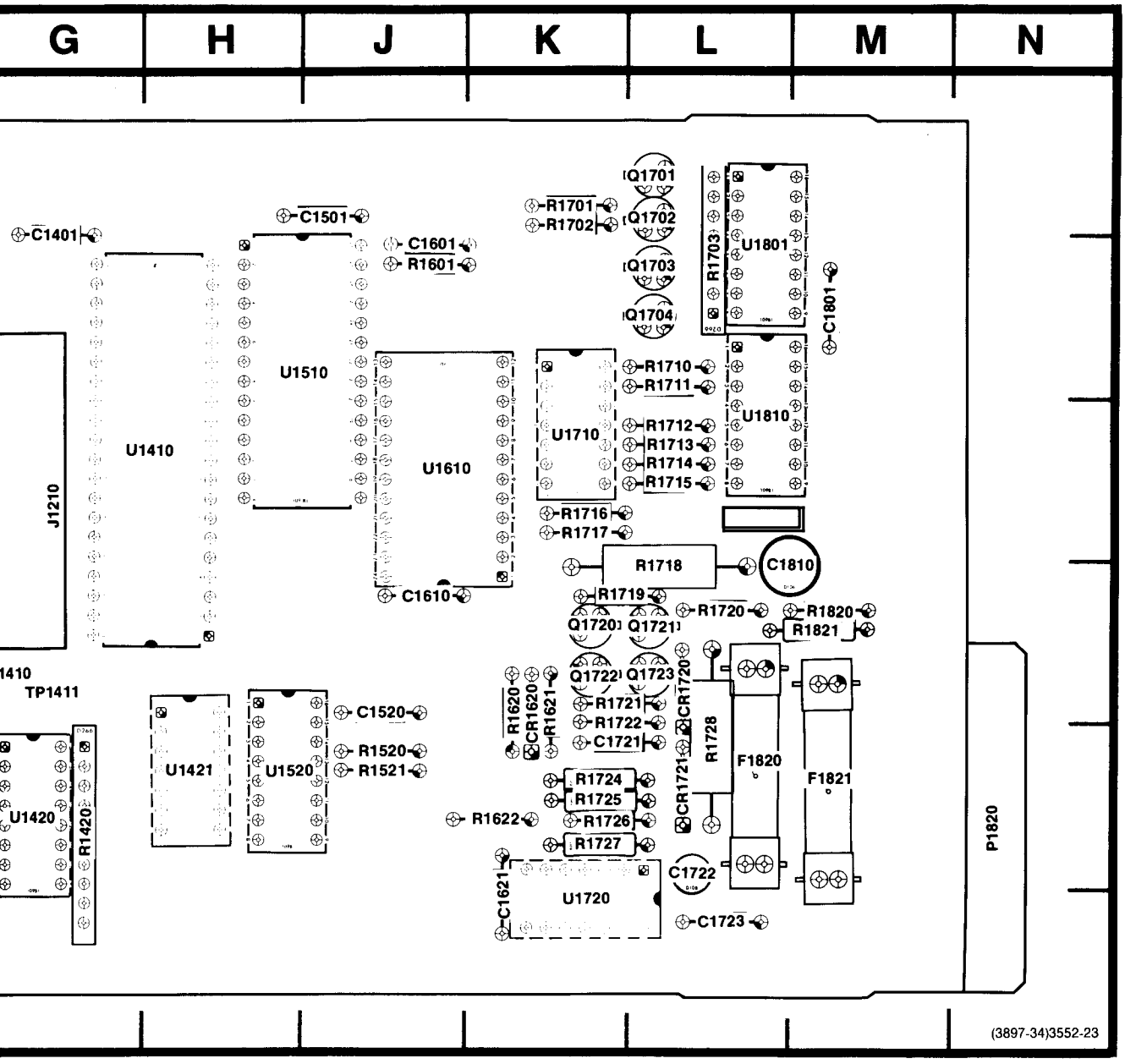
Table 8-4
COMPONENT REFERENCE CHART
(see Fig. 8-11)

P/O A12 ASSY — SCHMITT TRIGGERS ◇2

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1108	F5	C2
C1113	F10	D3
C1122	B9	D5
C1200	B4	E2
C1201	J2	E2
C1210	J2	F3
C1230	J7	E5
C1303	H3	F1
C1304	G3	F1
C1317	H1	G3
C1319	G2	G2
C1322	G8	F4
C1323	H8	F4
C1333	H6	G5
C1339	G7	G5
CR1200	I3	F2
CR1201	I3	F2
CR1220	I8	F4
CR1330	I8	F5
J1130	B10	D5
J1201	B5	E1
J520	A5	Chassis
J530	A10	Chassis
L1302	H3	G1
L1312	J2	F3
L1322	H8	G4
L1332	J7	F6
P1130	B10	D5
P1201	B4	E1
Q1122	C9	D4
Q1201	I5	F1
Q1202	J4	F1
Q1203	C5	E1
Q1204	G4	F2
Q1220	J9	E4
Q1221	I10	F4
Q1222	G9	F4
Q1300	E4	F2
Q1301	D4	F2
Q1302	G4	G2
Q1303	E3	G2
Q1320	E9	F4
Q1321	D9	F4
Q1322	G9	G4
Q1323	F8	G4
R1107	F5	C1
R1108	G5	C1
R1112	F10	D3
R1118	G5	D2
R1120	G10	D3
R1121	D9	D4
R1123	C10	D4
R1124	C9	D4
R1125	C9	D5
R1126	C10	D5
R1128	G10	D4
R1200	J5	E2
R1201	C4	E1
R1202	C4	E1
R1203	D4	E2
R1204	C5	E2
R1205	C5	F2
R1206	J4	F2
R1207	J4	F1
R1208	H4	F1
R1209	E4	F1
R1211	G5	E2
R1212	H2	F2
R1213	I3	E3
R1214	H3	F3
R1215	I2	F3
R1216	H2	F3
R1217	G10	D4
R1218	G5	E3
R1220	G10	D4
R1222	J10	E4
R1223	J9	F4
R1224	J9	F4
R1225	H9	F4
R1226	E9	F4
R1230	I8	E5
R1231	H8	F5
R1233	H7	F5
R1234	I7	F5
R1300	F2	G2
R1301	G3	F1
R1302	D4	F1
R1303	F4	F1
R1304	F3	G1
R1305	I3	G1
R1306	I4	G1
R1307	E2	G1
R1308	E3	G1
R1309	E3	G2
R1313	H2	F3
R1314	G1	F3
R1315	F1	G3
R1316	H1	G3
R1317	G1	G3
R1319	G1	G3
R1320	G8	F4
R1321	D9	F4
R1322	F9	G4
R1323	F8	G4
R1324	I8	G4
R1325	I9	G4
R1326	E8	G4
R1327	E8	G4
R1328	E8	G4
R1329	F7	G4
R1331	H7	F5
R1332	H7	F5
R1333	G6	F6
R1334	F6	F6
R1335	H6	G6
R1336	G6	G6
R1339	G6	G6
R1407	H4	H1
U1202	H5	E2
U1210	J9	E3
U1310	F1	G2
U1330	F7	G5
W500	B5	Chassis
W510	B10	Chassis

P/O A12 ASSY also shown on ◇1 ◇3 ◇5 ◇7 ◇8

ATION GRID

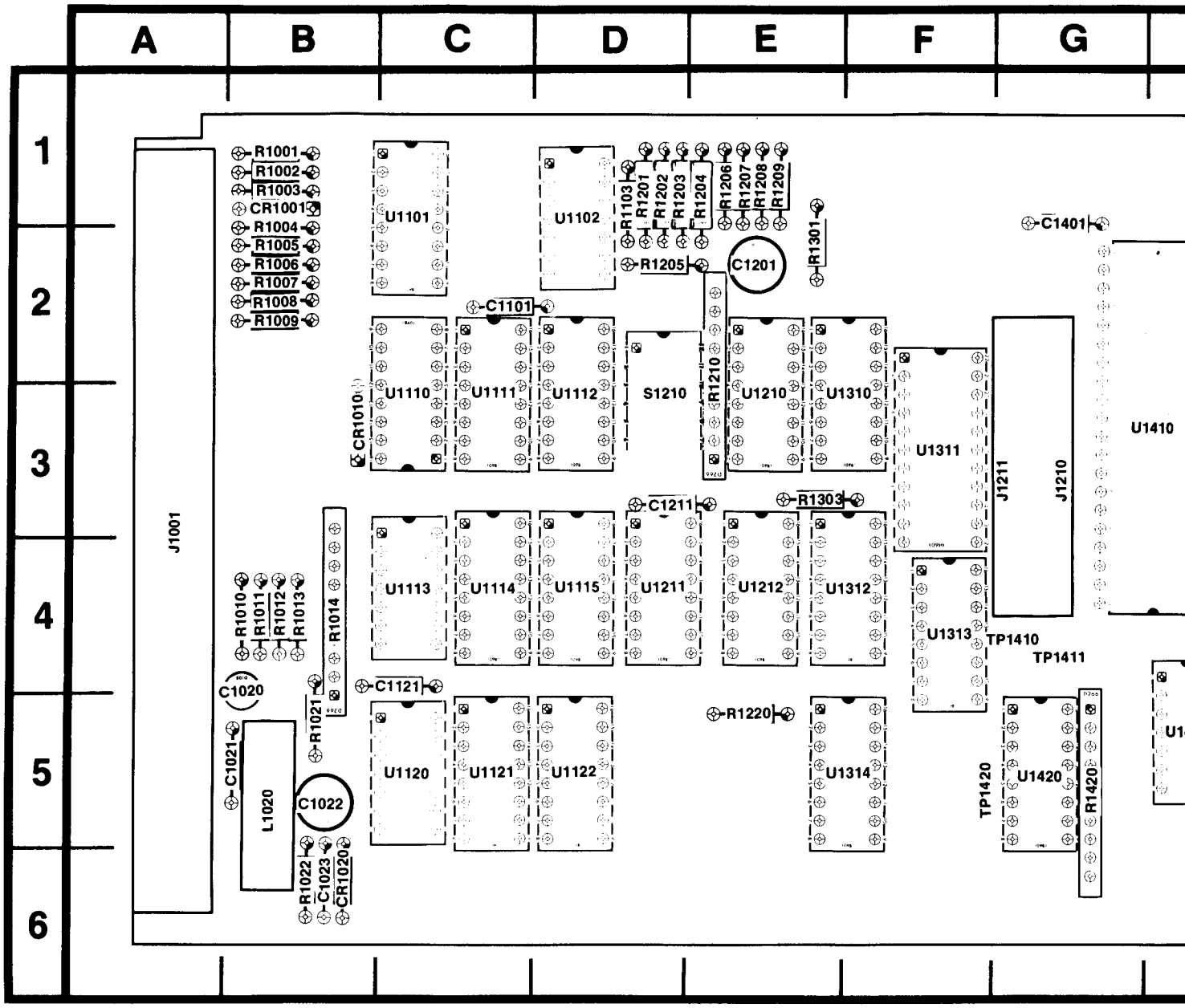


ital board (A16).

A16

@

PARTS LOCATION GR

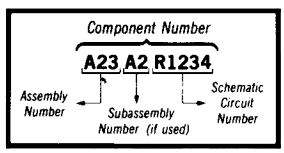


DIGITAL BOARD (A16)
PARTS LOCATION GRID

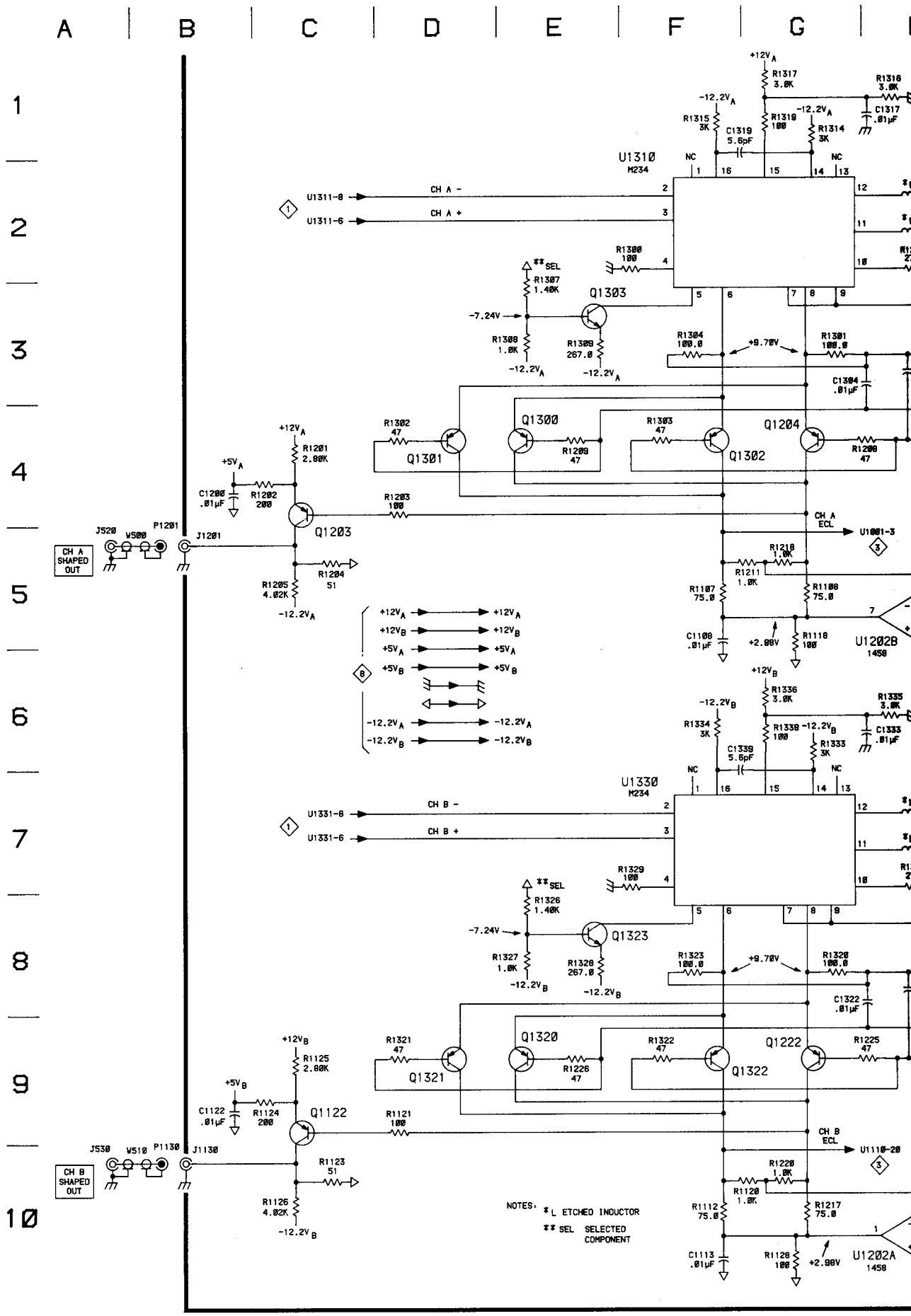
Fig. 8-12. Digital board (A16).

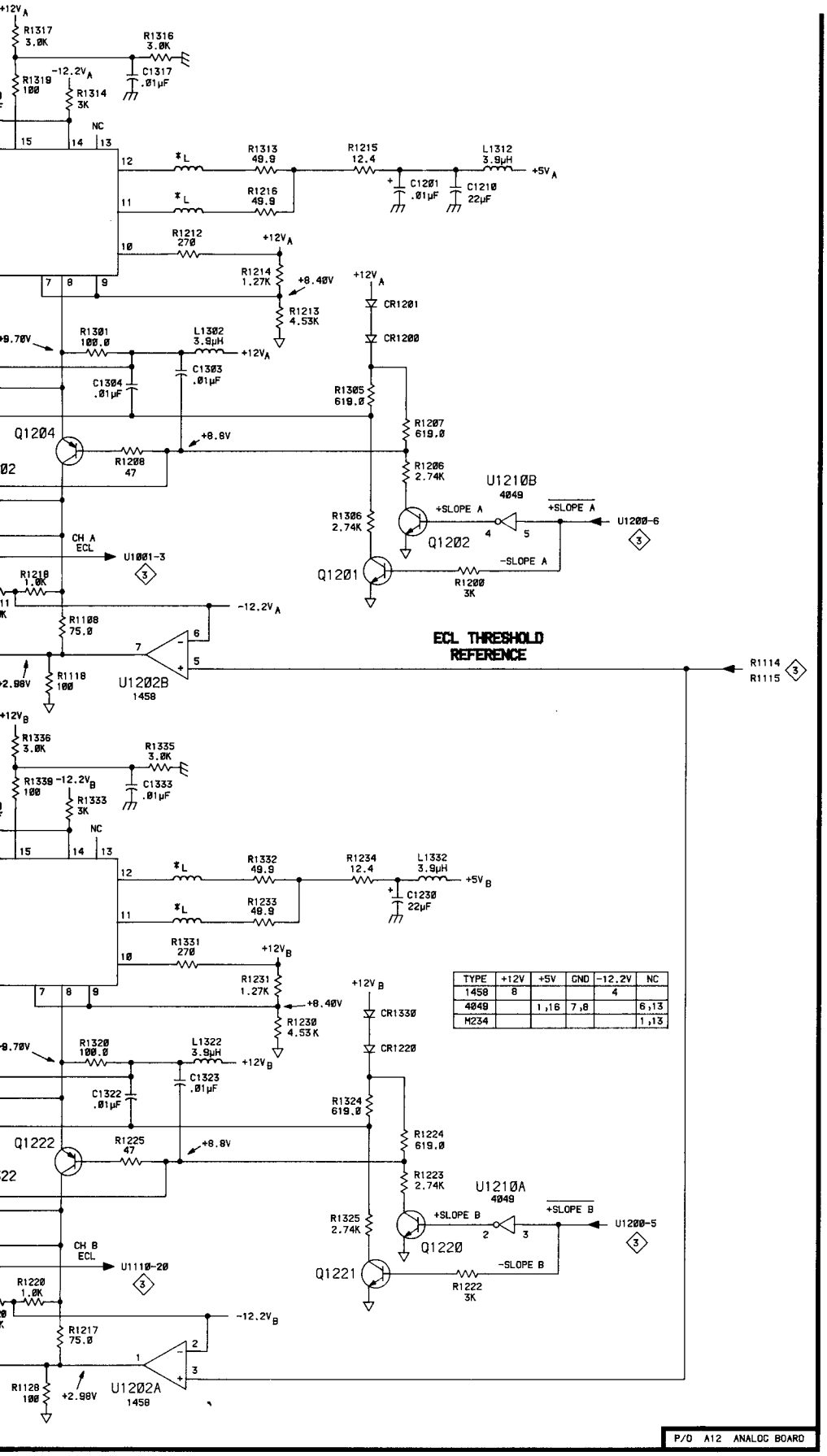
Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

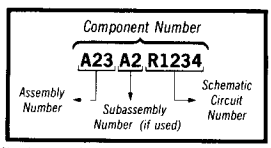

A
B
C
D
E
F
G
1
2
3
4
5
6
7
8
9
10
U1310
M234
U1330
M234
U1202B
1458
U1202A
1458
Q1303
Q1300
Q1204
Q1301
Q1302
Q1203
Q1323
Q1320
Q1222
Q1321
Q1322
Q1122
CH A SHAPED OUT
CH B SHAPED OUT
CH A ECL
CH B ECL
U1311-8
U1311-6
U1331-8
U1331-6
U1001-3
U1110-20
CH A -
CH A +
CH B -
CH B +
**SEL
-7.24V
+9.70V
+2.98V
NOTES: * L ETCHED INDUCTOR
** SEL SELECTED COMPONENT
DC 510
3552-46



TYPE	+12V	+5V	GND	-12.2V	NC
1458	8			4	
4049		1,16	7,8		6,13
M234					1,13

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

P/O A12 ANALOG BOARD

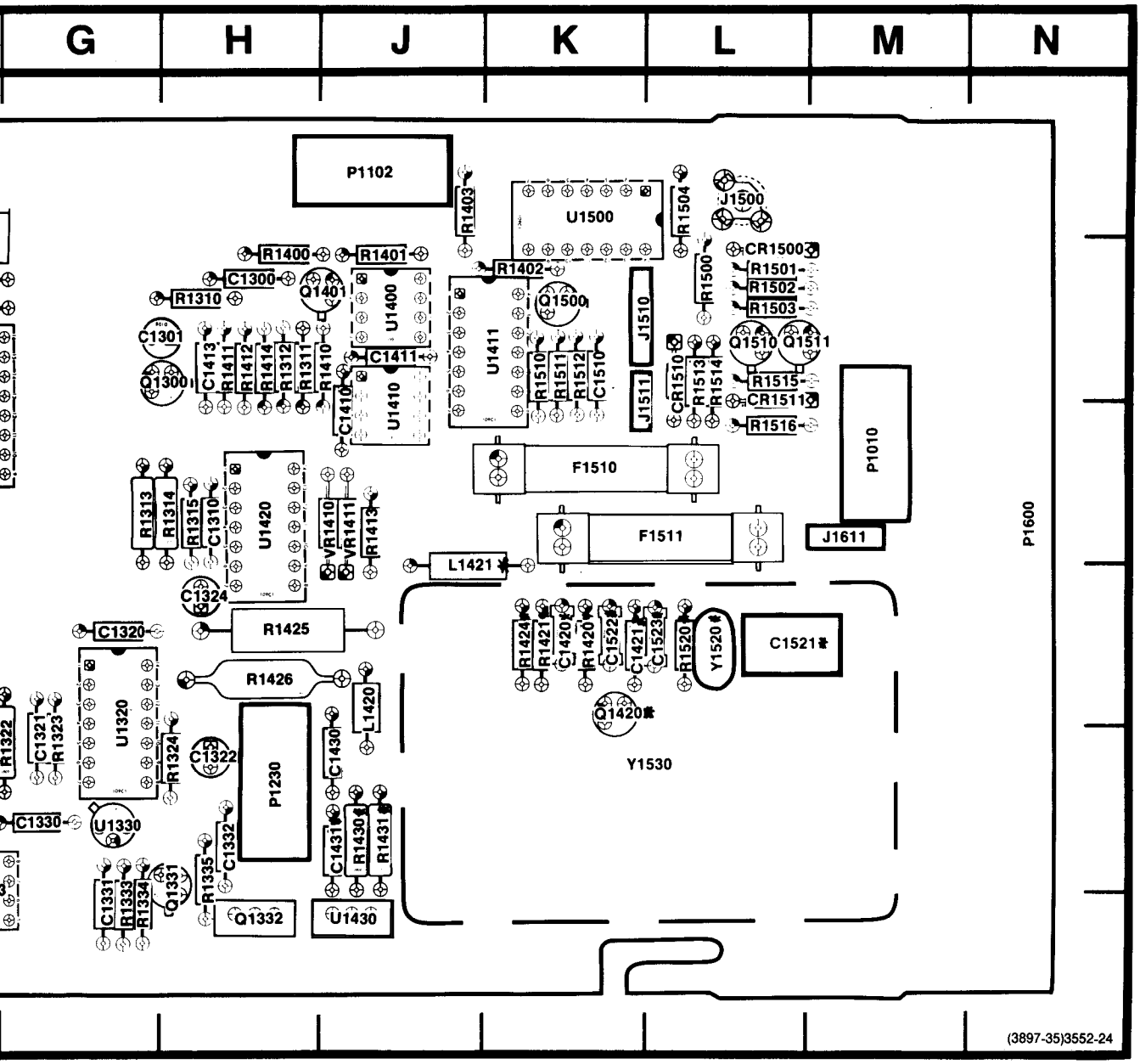
Table 8-5
COMPONENT REFERENCE CHART
(see Fig. 8-11 and 8-13)

P/O A12 ASSY — MAIN GATING ◇3

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1003	L7	B1
C1004	L8	A2
C1005	F3	B2
C1010	J4	B2
C1011	O7	B3
C1012	M6	B3
C1013	N8	C3
C1014	N7	C3
C1015	I3	A2
C1107	L8	C2
C1110	O9	C3
C1114	N10	D3
C1118	K5	D2
C1140	I7	D3
CR1111	H7	D2
DL500	E4	Chassis
J1010	N2	A3
J1102	B7	D1
L1009	J2	C2
Q1000	I3	B1
Q1100	F4	C1
Q1110	C3	C2
Q1111	C5	C2
Q1112	F5	D3
Q1114	D2	C2
Q1200	F8	E1
R1000	H3	A1
R1001	K4	B1
R1002	H3	B1
R1003	I4	C1
R1004	K2	C2
R1005	K3	B1
R1006	G4	B1
R1007	E2	B1
R1008	L2	B2
R1009	J2	C2
R1010	J3	B2
R1013	M1	B2
R1014	M1	B3
R1015	N2	B3
R1016	M4	B3
R1017	M5	B3
R1018	O6	B3
R1019	N2	B3
R1022	M6	B3
R1023	N6	B3
R1101	H8	D1
R1102	D3	D2
R1103	F5	C1
R1104	C4	D2
R1105	D6	C2
R1106	C6	C2
R1109	F3	D1
R1110	F6	D3
R1113	H7	D3
R1116	M2	B2
R1117	L6	C2
R1119	H6	C3
R1140	I7	D3
U1000	L8	B2
U1001	M8	C2
U1011	N8	B3
U1110	N9	D3
U1200	C6	D1
U1200	I8	D1

P/O A12 ASSY also shown on ◇1 ◇2 ◇5 ◇7 ◇8

CATION GRID



ary board (A18).

A18

*Removed for Option 01

PARTS LOCATION GR

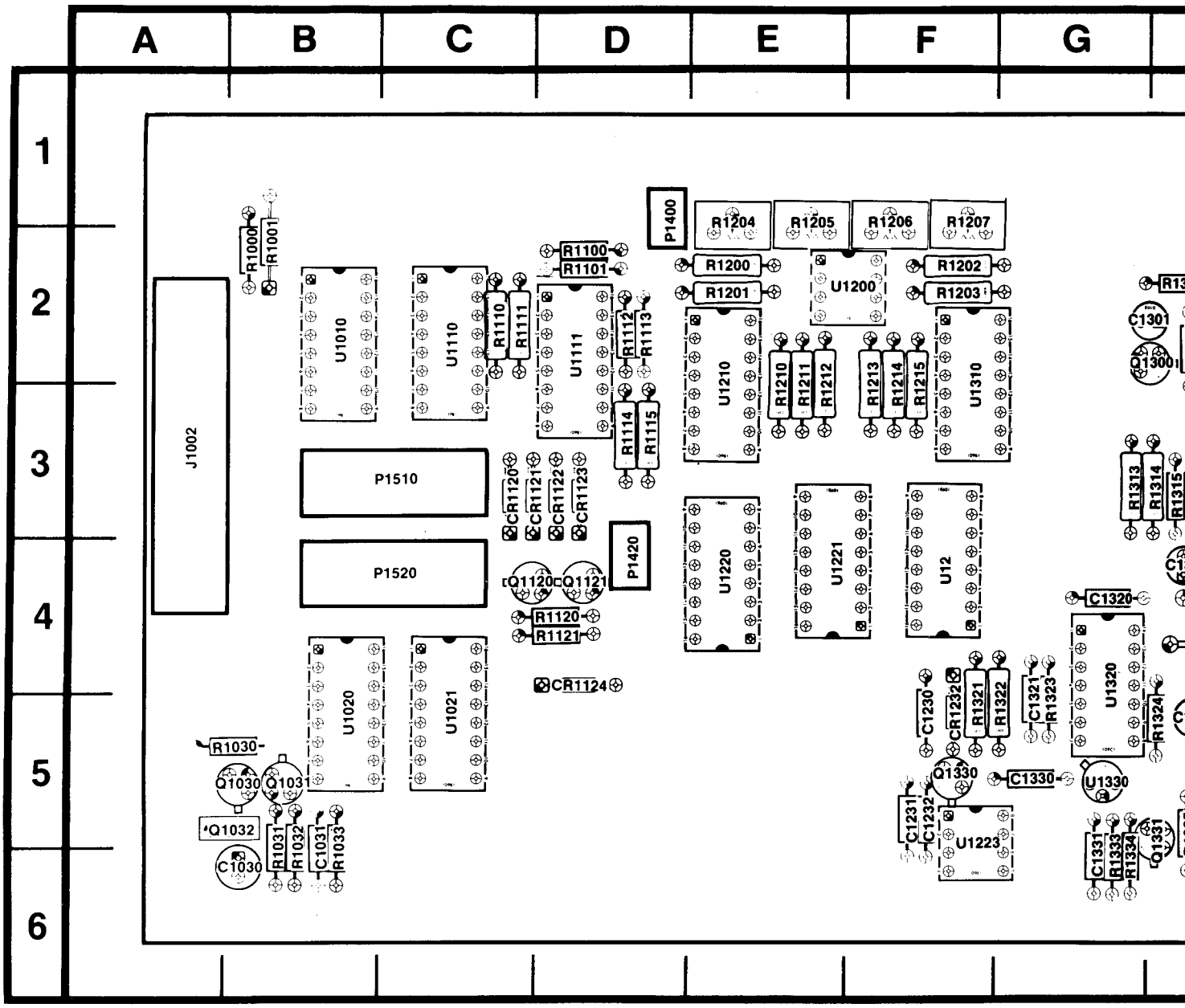
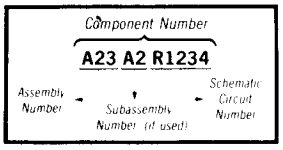


Fig. 8-13. Auxiliary board (A18).

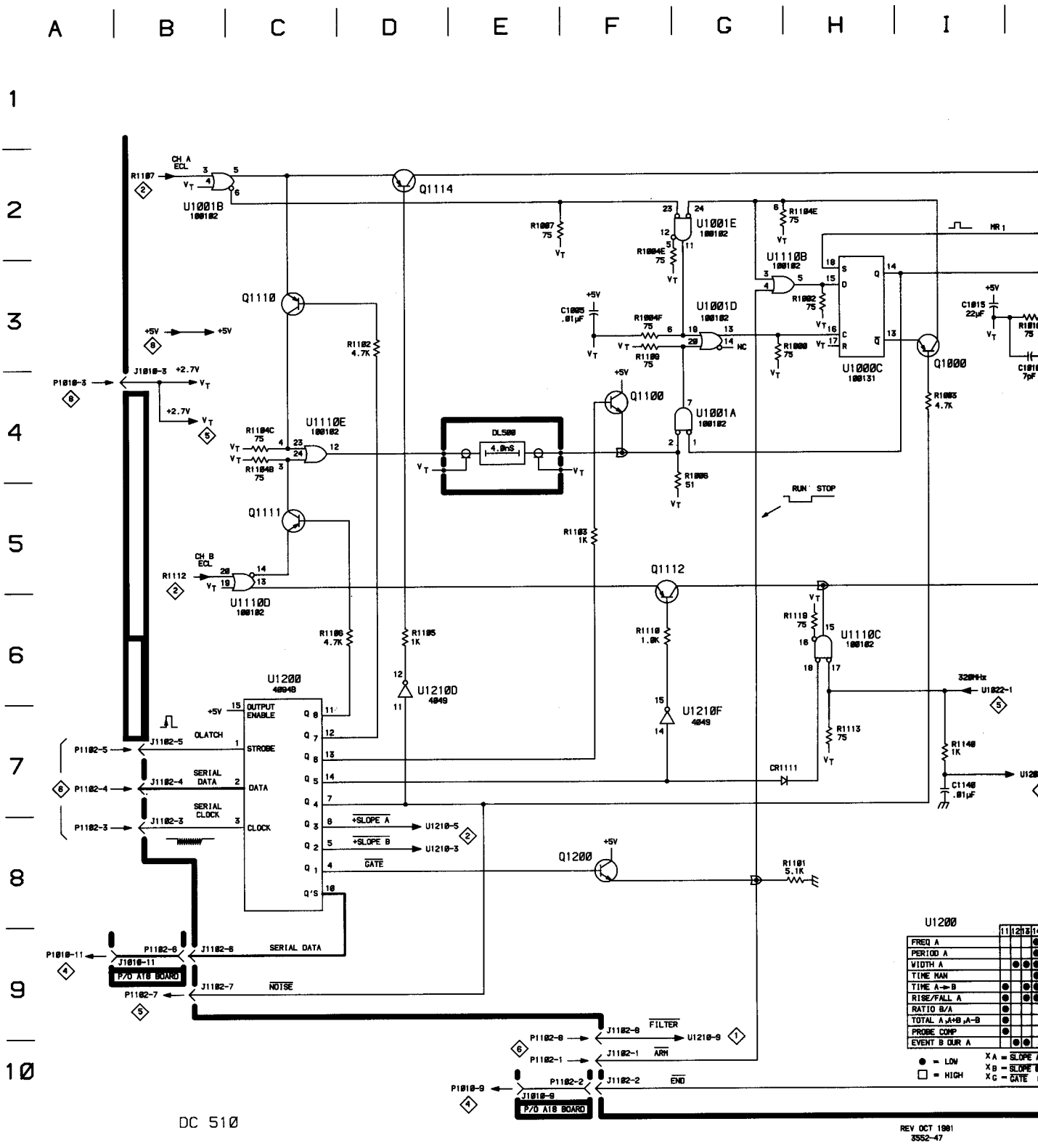
AUXILIARY BOARD (A18)
PARTS LOCATION GRID

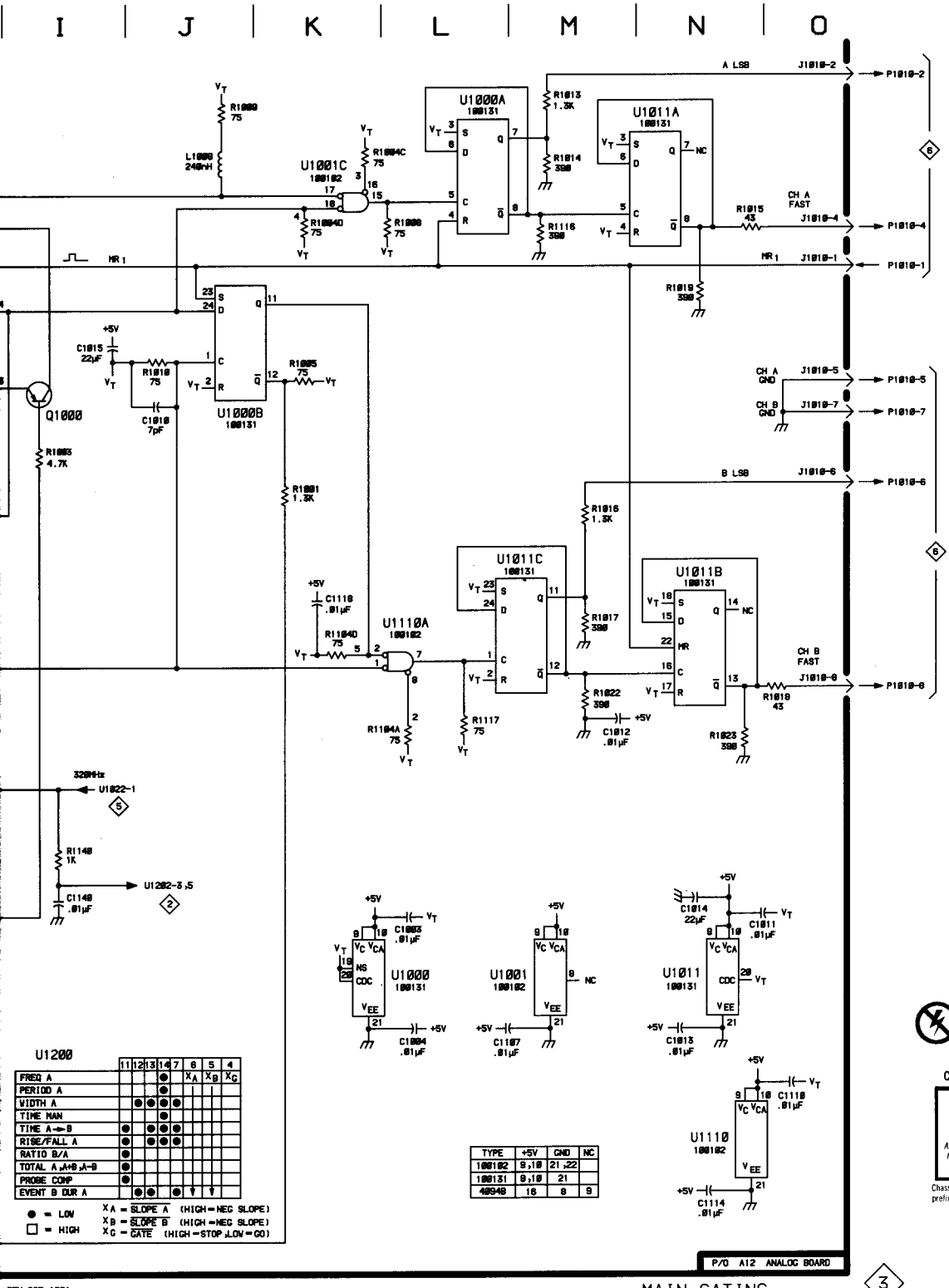
Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



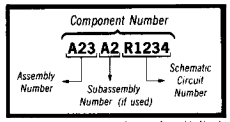
Chassis mounted components have no Assembly Number prefix - see end of Replaceable Electrical Parts List


A
B
C
D
E
F
G
H
I
1
2
3
4
5
6
7
8
9
10
CH A ECL
U1001B
Q1114
Q1110
U1001E
U1110B
U1001D
U1000C
Q1000
Q1100
U1001A
U1110E
DL500
4.8nS
Q1111
CH B ECL
U1110D
Q1112
U1110C
U1200
U1210D
U1210F
OUTPUT ENABLE
STROBE
DATA
CLOCK
SERIAL DATA
SERIAL CLOCK
OLATCH
+SLOPE A
+SLOPE B
GATE
Q1200
CR1111
RUN STOP
32MHz
U1822-1
SERIAL DATA
NOISE
FILTER
ARM
END
P/O A18 BOARD
U1200
FREQ A
PERIOD A
WIDTH A
TIME MAN
TIME A→B
RISE/FALL A
RATIO B/A
TOTAL A,A+B,A-B
PROBE COMP
EVENT B OUR A
● = LOW
□ = HIGH
DC 510
REV OCT 1981
3552-47



Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

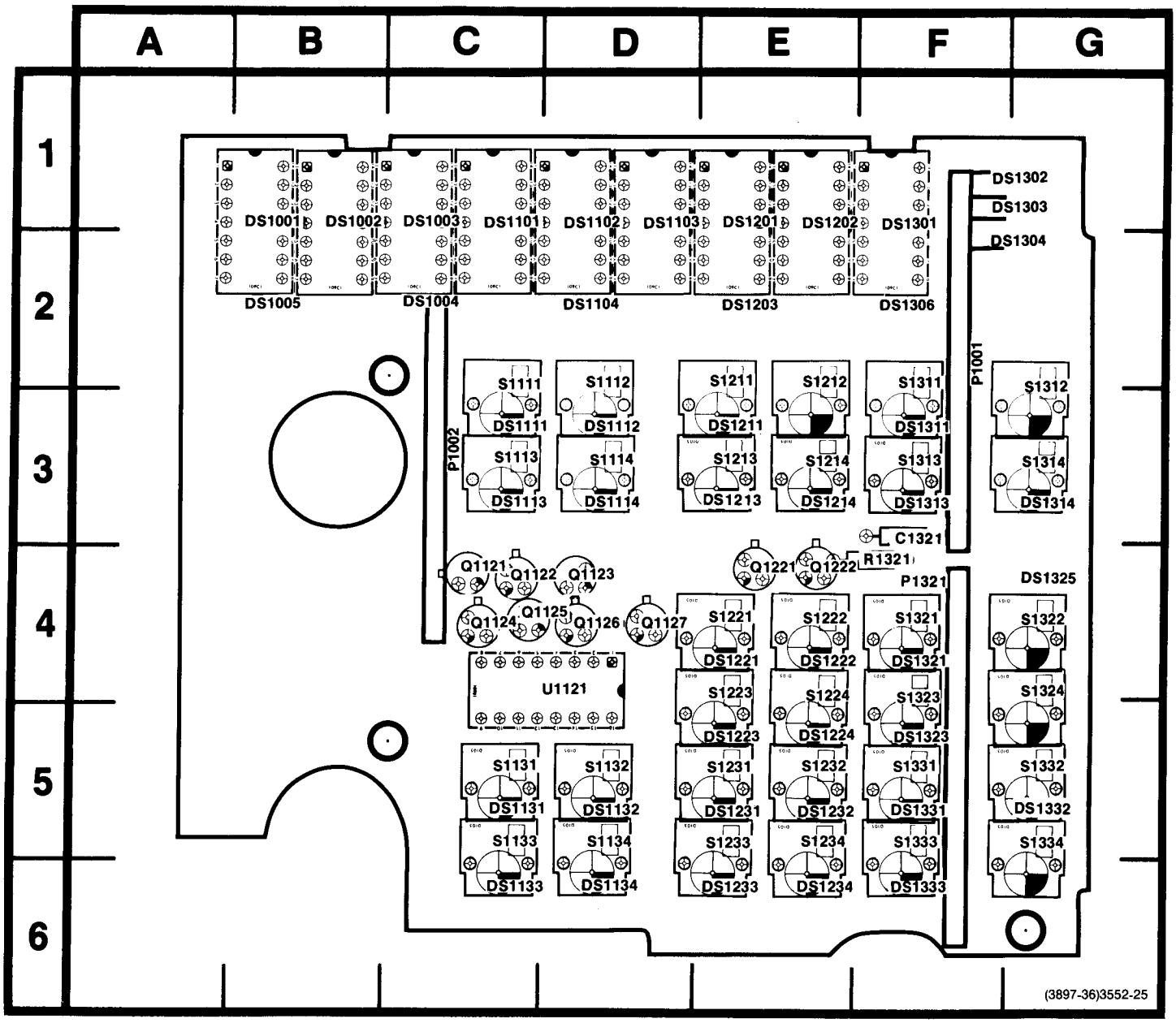
Table 8-6
COMPONENT REFERENCE CHART
(see Fig. 8-12)

P/O A16 ASSY — CH A & CH B COUNT CHAINS ◇4◇

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1121	L8	C4	R1714	D2	L3
C1211	M8	D3	R1715	C7	L3
C1801	M8	M2	R1716	G3	K3
			R1717	F9	K3
Q1701	G2	L1			
Q1702	F2	L1	U1102	E4	D1
Q1703	G8	L2	U1113	J2	C4
Q1704	F8	L2	U1114	K4	C4
			U1115	K2	D4
R1014	I7	B4	U1120	H2	C5
R1021	H8	B5	U1121	G4	C5
R1207	E4	E1	U1122	G6	D5
R1208	E6	E1	U1211	I6	D4
R1209	E4	E1	U1212	L8	E4
R1701	G1	K1	U1312	L6	F4
R1702	F8	K1	U1710	E7	K3
R1703	E2	L2	U1801	E2	L2
R1710	D3	L2	U1810	D2	L3
R1711	C7	L2			
R1712	D7	L3	W520A	B2	Chassis
R1713	C2	L3	W530A	B8	Chassis

P/O A16 ASSY also shown on ◇8◇

PARTS LOCATION GRID

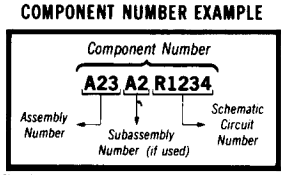


A10

Fig. 8-14. Display board (A10).

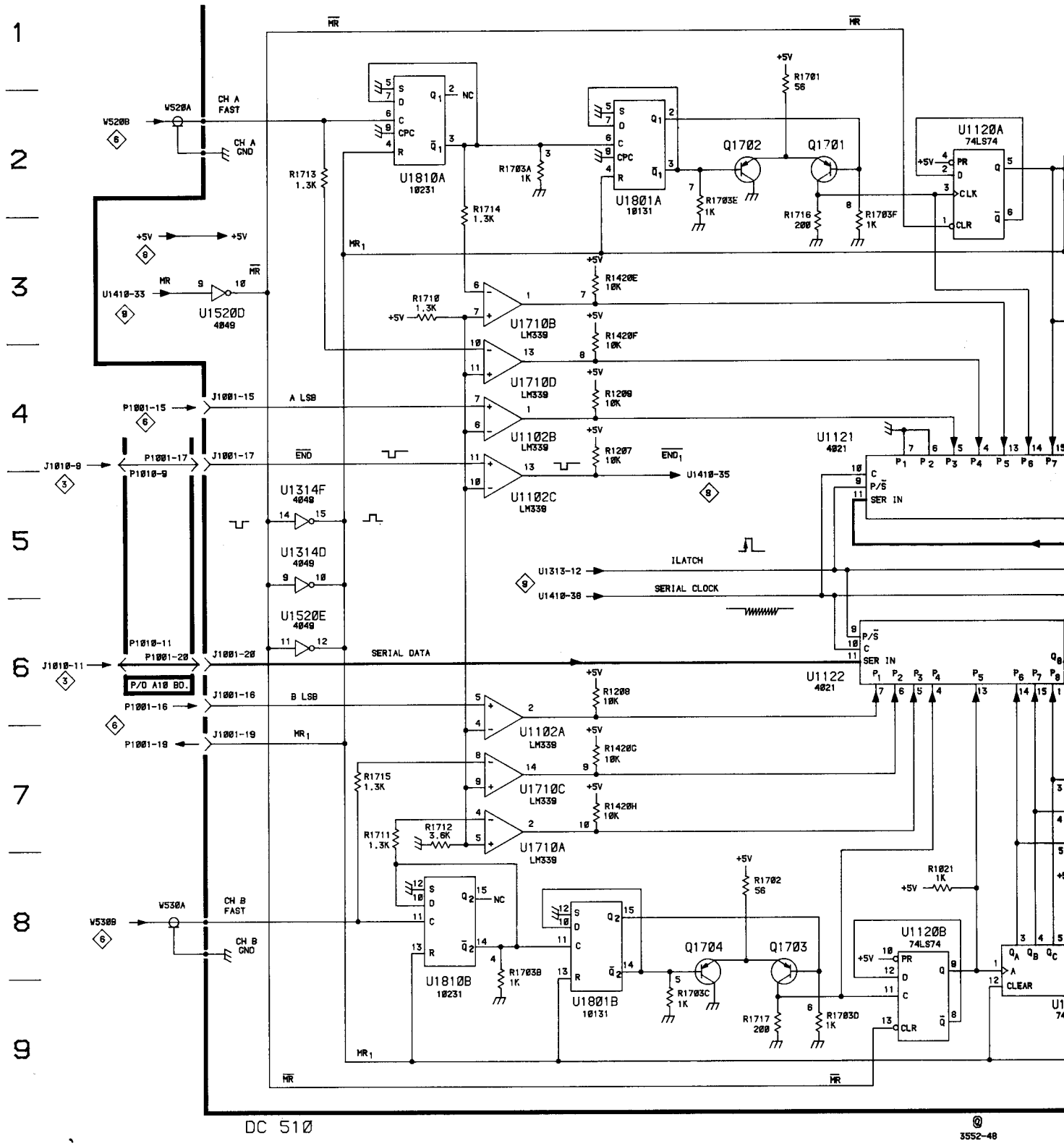
Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

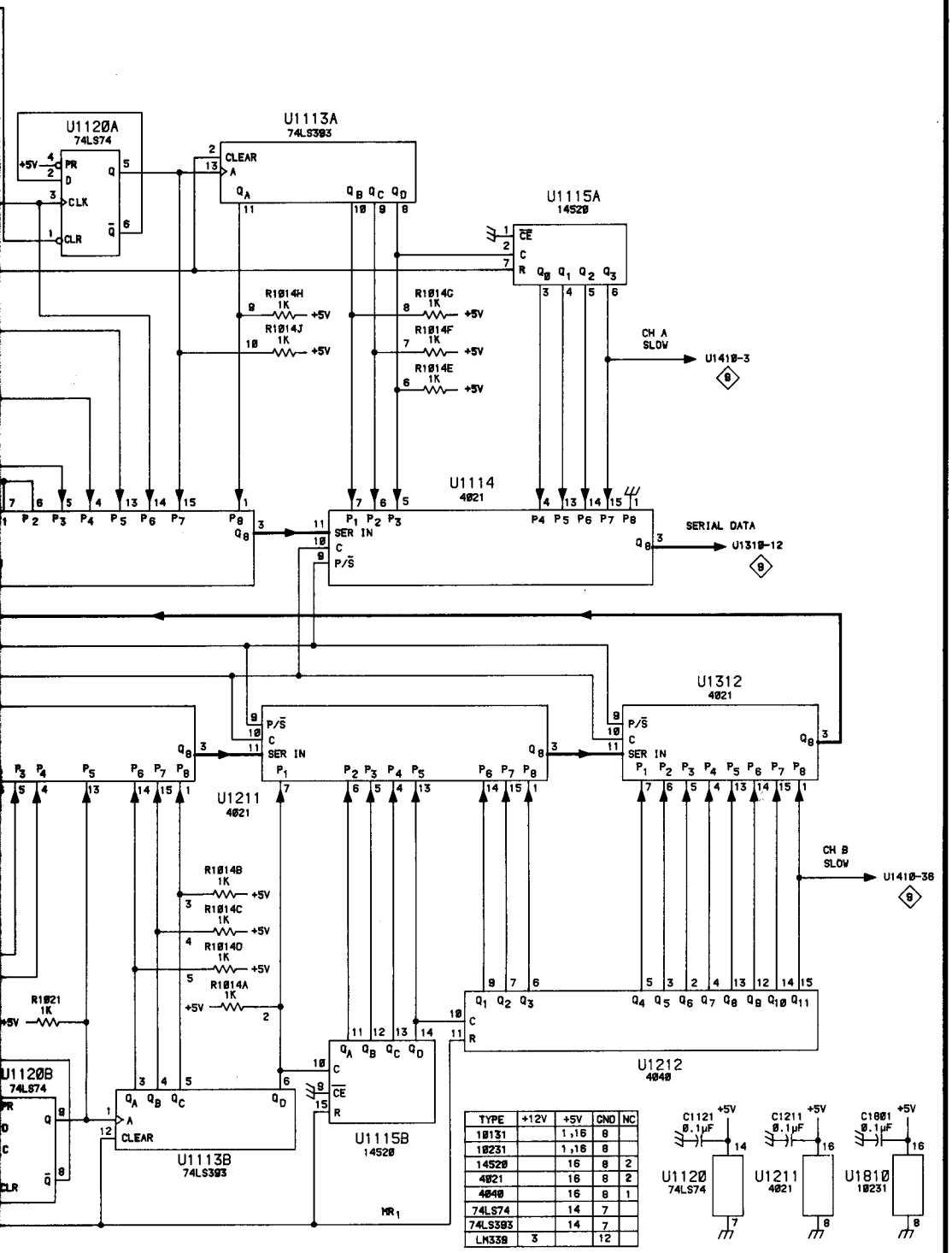


Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

@


A
B
C
D
E
F
G
H
1
2
3
4
5
6
7
8
9
MR
W520B
W520A
CH A FAST
CH A GND
U1810A
10231
U1801A
10131
R1713 1.3K
R1714 1.3K
R1703A 1K
R1703E 1K
R1703F 1K
R1716 200
R1701 56
Q1702
Q1701
U1120A
74LS74
+5V
MR1
U1410-33
U1520D
4049
R1710 1.3K
U1710B
LM339
U1710D
LM339
U1102B
LM339
U1102C
LM339
R1420E 10K
R1420F 10K
R1209 10K
R1207 10K
END1
U1410-35
P1001-15
J1001-15
A LSB
J1010-9
P1001-17
J1001-17
P1010-9
END
U1314F
4049
U1314D
4049
U1520E
4049
U1121
4021
ILATCH
U1313-12
SERIAL CLOCK
U1410-36
SER IN
P1010-11
P1001-20
J1001-20
J1010-11
SERIAL DATA
P/O A10 BD.
U1122
4021
P1001-16
J1001-16
B LSB
P1001-19
J1001-19
MR1
U1102A
LM339
U1710C
LM339
U1710A
LM339
R1209 10K
R1420C 10K
R1420H 10K
R1715 1.3K
R1711 1.3K
R1712 3.8K
W530B
W530A
CH B FAST
CH B GND
U1810B
10231
U1801B
10131
Q1704
Q1703
R1703B 1K
R1703C 1K
R1703D 1K
R1717 200
R1702 56
R1021 1K
U1120B
74LS74
CLEAR
DC 510
3552-48

H | I | J | K | L | M



TYPE	+12V	+5V	GND	NC
1013 1		1 , 16	8	
1023 1		1 , 16	8	
14528		16	8	2
4021		16	8	2
4040		16	8	1
74LS74		14	7	
74LS393		14	7	
LM339	3		12	

C1121 0.1µF +5V — U1120 74LS74
C1211 0.1µF +5V — U1211 4021
C1801 0.1µF +5V — U1810 10231

NOTE: U1102, U1710 ARE USED AS ECL TO CMOS CONVERTERS.

P/O A16 DIGITAL BOARD

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

Component Number
A23 A2 R1234
Assembly Number — *Subassembly Number (if used)* — *Schematic Circuit Number*

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Table 8-7
COMPONENT REFERENCE CHART
(see Fig. 8-11 and 8-13)

P/O A12 ASSY — **TIME BASE & 320 MHz PLL** ◇5◇

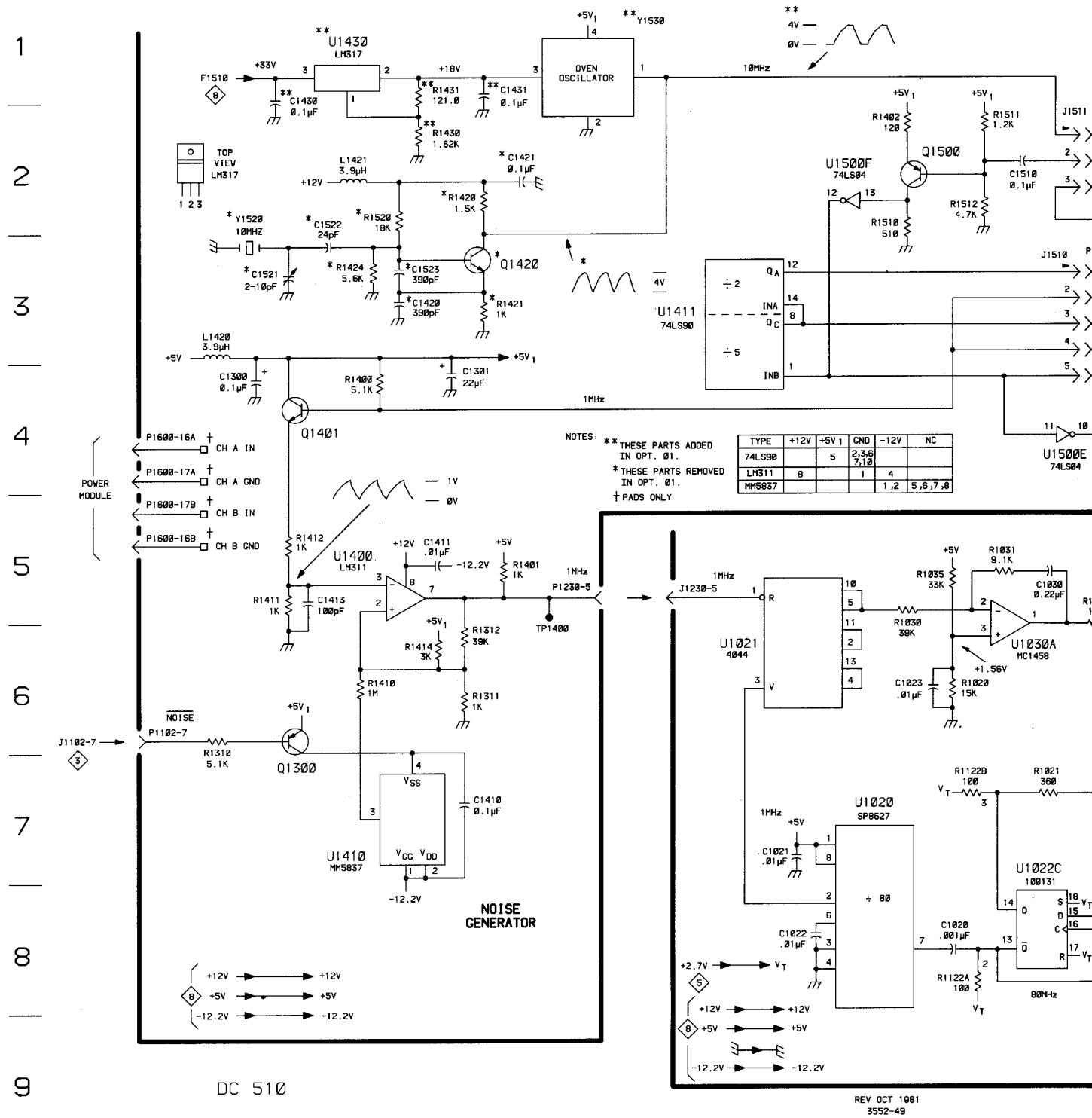
CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1020	H8	B4	R1030	G5	A5
C1021	F7	B4	R1031	H5	A5
C1022	G8	B4	R1032	I5	A5
C1023	G6	B5	R1033	J5	A6
C1024	L8	B4	R1034	J6	A6
C1025	L8	B4	R1035	H5	B5
C1030	I5	A5	R1036	I7	C5
C1031	K6	A6	R1037	K5	B5
C1032	L6	B5	R1122	J8	C4
C1034	M8	B6	R1127	L7	C5
C1120	K7	C5	R1130	K6	C5
C1121	L6	C5	R1131	M9	C5
C1123	L8	C4	R1132	M7	D5
C1130	K7	C5			
C1131	M8	C6	TP1020	J5	B6
CR1130	L5	C6	U1020	G7	B4
			U1021	F6	B4
Q1130	L7	C5	U1022	H7	C4
			U1030	J6	B5
R1020	H6	B5			
R1021	H7	C5			

P/O A12 ASSY also shown on ◇1◇ ◇2◇ ◇3◇ ◇7◇ ◇8◇

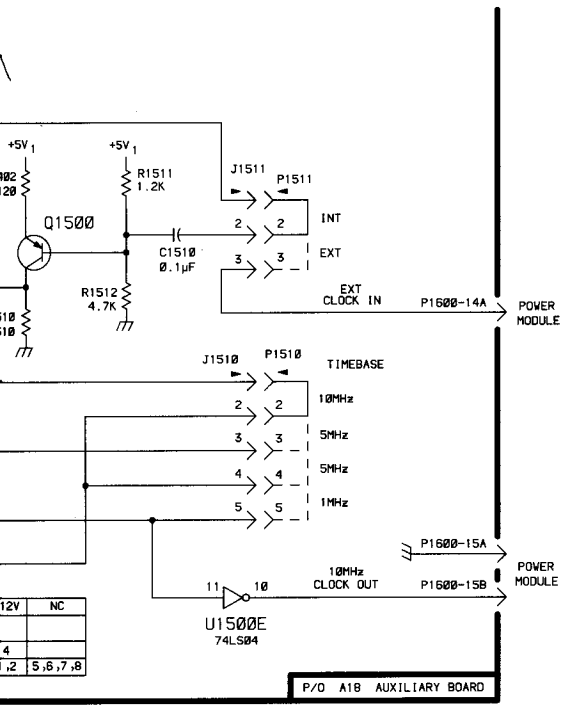
P/O A18 ASSY — **TIME BASE & 320 MHz PLL** ◇5◇

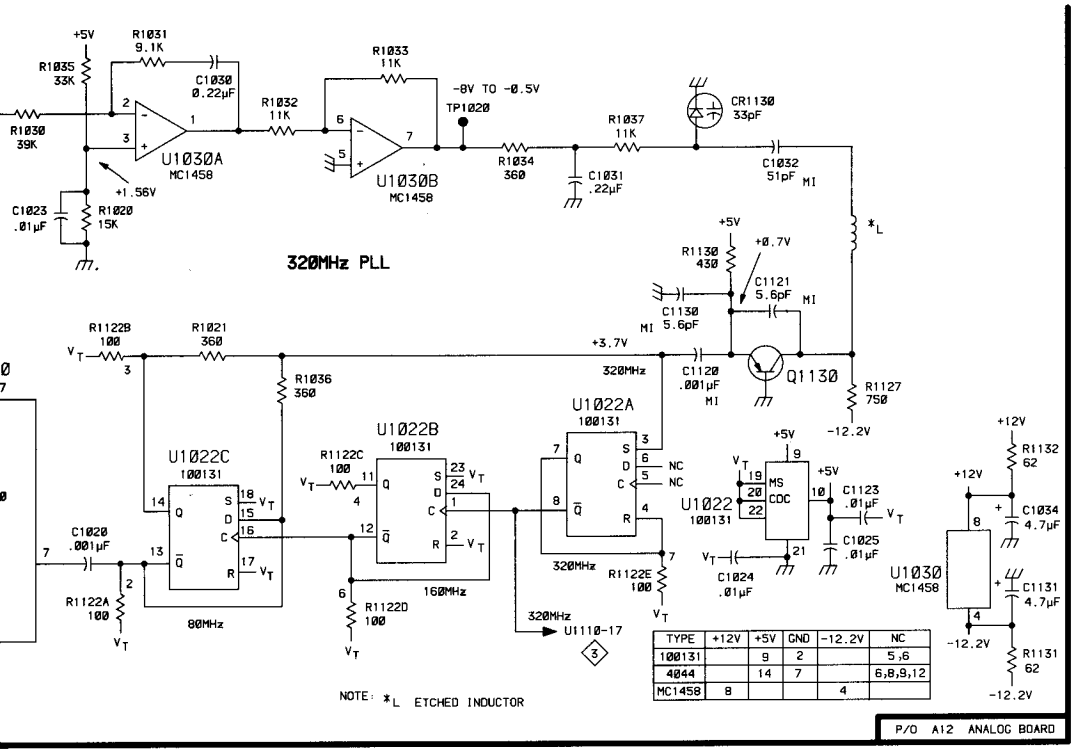
C1300	B4	H2	R1312	D6	H2
C1301	D4	H2	R1400	C4	H2
C1410	D7	J3	R1401	D5	J2
C1411	D5	J2	R1402	G2	K2
C1413	C5	H2	R1410	C6	J2
C1420	D3	K4	R1411	B5	H2
C1421	D2	K4	R1412	C5	H2
C1430	C1	J4	R1414	D6	H2
C1431	D1	J4	R1420	D2	K4
C1510	H2	K2	R1421	D3	K4
C1521	B3	L4	R1424	C3	K4
C1522	C2	K4	R1430	D2	J4
C1523	D3	L4	R1431	D1	J4
			R1510	G2	K2
J1510	I3	K2	R1511	H2	K2
J1511	I2	K2	R1512	H2	K2
			R1520	C2	L4
L1420	B3	J4			
L1421	C2	J3	TP1400	E6	J2
P1510	I3	C3	U1400	C5	J2
P1511	I2	K2	U1410	C7	J2
			U1411	F3	K2
Q1300	C7	H2	U1430	C1	J6
Q1401	C4	H2	U1500	I4	K1
Q1420	D3	K4	U1500	G2	K1
Q1500	H2	K2			
			Y1520	B2	L4
R1310	B6	H2	Y1530	E1	L5
R1311	D6	H2			

P/O A18 ASSY also shown on ◇3◇ ◇6◇ ◇7◇ ◇8◇


U1430
LM317
+33V
F1510
C1430 0.1µF
+18V
R1431 121.0
R1430 1.62K
C1431 0.1µF
+5V1
Y1530
OVEN OSCILLATOR
10MHz
4V
0V
TOP VIEW LM317
1 2 3
L1421 3.9µH
+12V
C1421 0.1µF
R1420 1.5K
Y1520 10MHz
C1522 24pF
R1520 18K
C1521 2-10pF
R1424 5.6K
C1523 390pF
Q1420
C1420 390pF
R1421 1K
L1420 3.9µH
+5V
C1300 0.1µF
R1400 5.1K
C1301 22µF
1MHz
Q1401
U1411
74LS90
÷2
÷5
INA
INB
QA
QC
U1500F
74LS04
Q1500
R1402 120
R1511 1.2K
C1510 0.1µF
R1512 4.7K
R1510 510
J1511
J1510
U1500E
74LS04
NOTES:
** THESE PARTS ADDED IN OPT. 01.
* THESE PARTS REMOVED IN OPT. 01.
† PADS ONLY
TYPE | +12V | +5V1 | GND | -12V | NC
74LS90 | | 5 | 2,3,6,7,10 | |
LM311 | 8 | | 1 | 4 |
MM5837 | | | | 1,2 | 5,6,7,8
POWER MODULE
P1600-16A CH A IN
P1600-17A CH A GND
P1600-17B CH B IN
P1600-16B CH B GND
R1412 1K
U1400
LM311
+12V
C1411 .01µF
-12.2V
+5V
R1401 1K
1MHz
P1230-5
TP1400
R1411 1K
C1413 100pF
R1312 39K
R1414 3K
R1410 1M
R1311 1K
NOISE
P1102-7
J1102-7
R1310 5.1K
Q1300
VSS
VCC VDD
C1410 0.1µF
U1410
MM5837
NOISE GENERATOR
+12V → +12V
+5V → +5V
-12.2V → -12.2V
J1230-5
U1021
4044
R
V
R1035 33K
R1031 9.1K
C1030 0.22µF
R1030 39K
U1030A
MC1458
+1.56V
C1023 .01µF
R1020 15K
U1020
SP8627
÷ 80
C1021 .01µF
C1022 .01µF
C1020 .001µF
R1122B 100
R1021 360
R1122A 100
U1022C
100131
80MHz
+2.7V
VT
REV OCT 1981
3552-49

DC 510





TYPE	+12V	+5V	GND	-12.2V	NC
100131		9	2		5,6
4044		14	7		6,8,9,12
MC1458	8			4	

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

Component Number: **A23 A2 R1234**
- A23 — Assembly Number
- A2 — Subassembly Number (if used)
- R1234 — Schematic Circuit Number

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

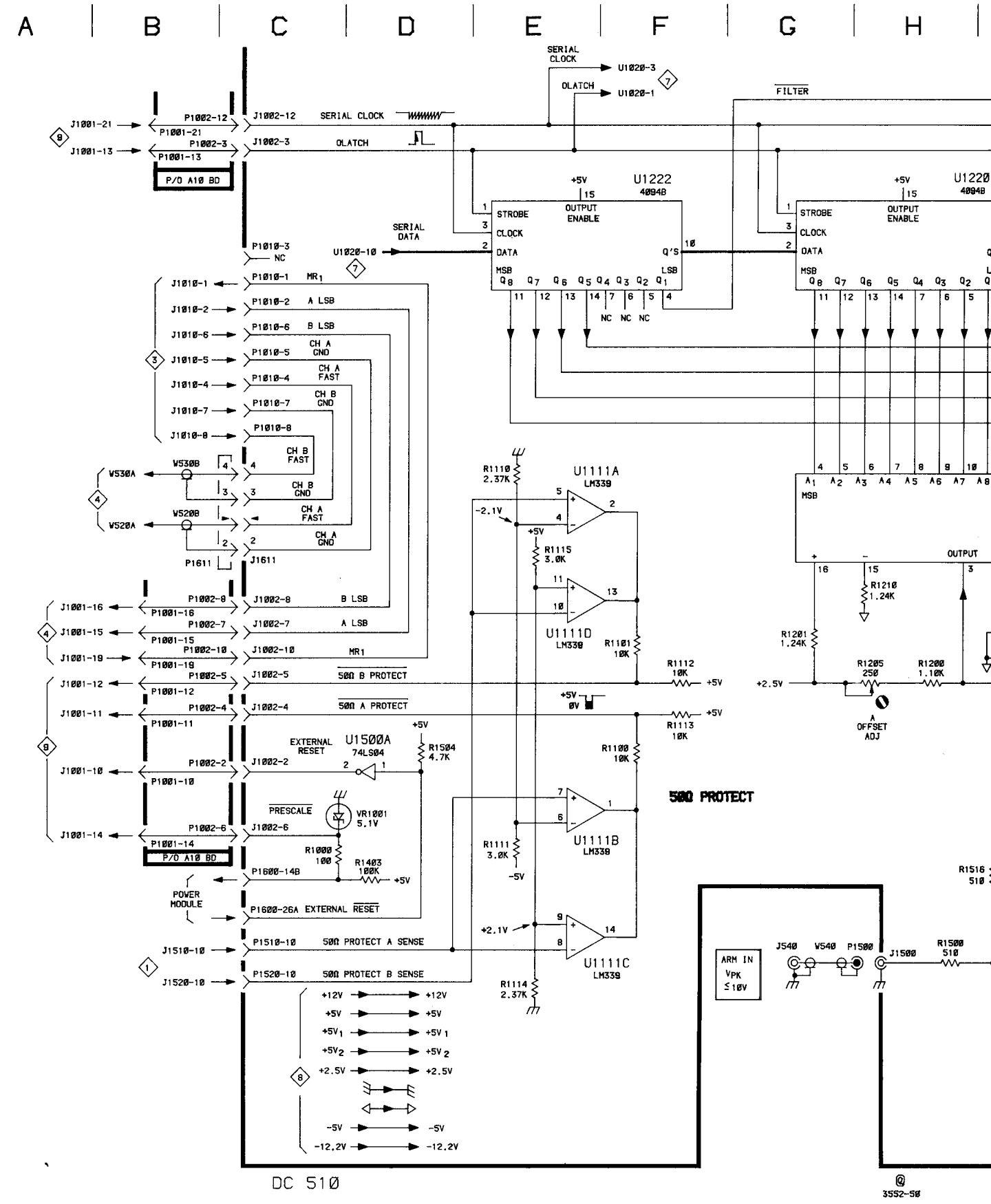
TIME BASE & 320 MHZ PLL 5

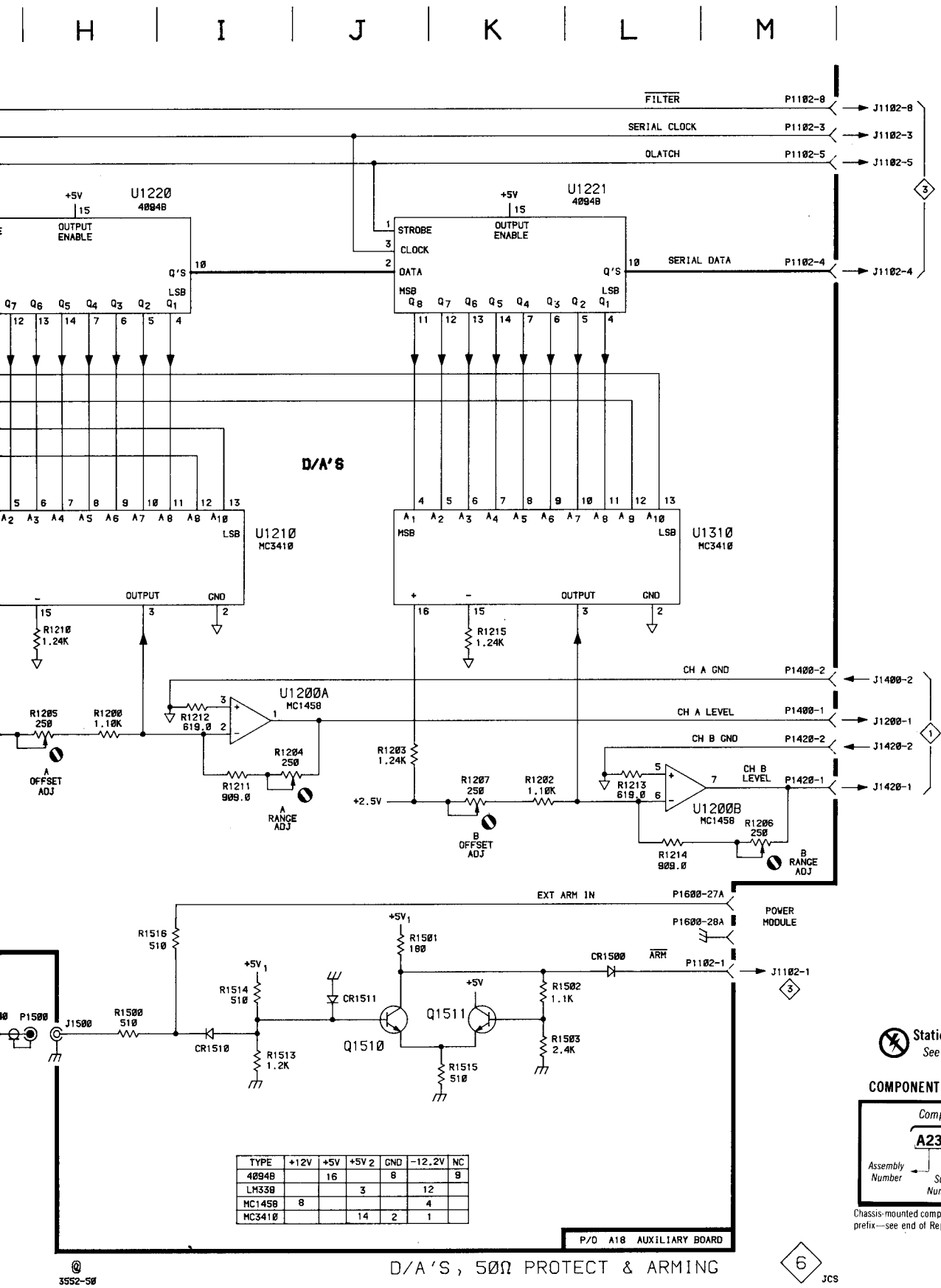
Table 8-8
COMPONENT REFERENCE CHART
(see Fig. 8-13)

P/O A18 ASSY — D/A'S, RELAY PROTECT & ARMING ◇6◇

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
CR1500	L7	L2	R1206	M6	F1
CR1510	I8	L2	R1207	K6	F1
CR1511	J8	L2	R1210	H5	E2
			R1211	I6	E2
J1500	H8	L1	R1212	I5	E2
J1611	C5	M3	R1213	L6	F2
J540	G8	Chassis	R1214	L6	F2
			R1215	K5	F2
P1400	M6	D1	R1403	D7	J1
P1420	M6	D4	R1500	H8	L2
P1500	H8	K1	R1501	J7	L2
P1520	C8	C4	R1502	L7	L2
P1611	B5	M3	R1503	L8	L2
			R1504	D6	L1
Q1510	J8	L2	R1513	I8	L2
Q1511	K8	L2	R1514	I7	L2
			R1515	K8	L2
R1000	C7	B2	R1516	H7	L3
R1100	F6	D2			
R1101	F5	D2	U1111	E7	D2
R1110	E4	C2	U1200	J5	E2
R1111	E7	C2	U1210	I4	E2
R1112	F5	D2	U1220	H2	E4
R1113	F6	D2	U1221	L2	E4
R1114	E8	D3	U1222	F2	F4
R1115	E5	D3	U1310	M4	F2
R1200	H5	E2			
R1201	G5	E2	VR1001	D7	B2
R1202	K6	F2	W520B	B4	Chassis
R1203	J6	F2	W530B	B4	Chassis
R1204	I6	E1	W540	G8	Chassis
R1205	H5	E1			

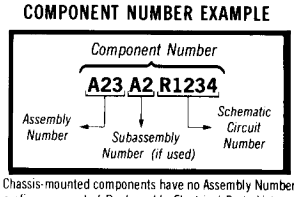
P/O A18 ASSY also shown on ◇3◇ ◇5◇ ◇7◇ ◇8◇


SERIAL CLOCK
OLATCH
FILTER
U1020-3
U1020-1
J1001-21
J1001-13
P1002-12
P1001-21
P1002-3
P1001-13
P/O A10 BD
J1002-12
SERIAL CLOCK
J1002-3
OLATCH
+5V
U1222
4094B
STROBE
OUTPUT ENABLE
CLOCK
DATA
MSB
LSB
Q'S
Q8 Q7 Q6 Q5 Q4 Q3 Q2 Q1
NC NC NC
SERIAL DATA
U1020-10
P1010-3
NC
P1010-1
MR1
P1010-2
A LSB
P1010-6
B LSB
P1010-5
CH A GND
P1010-4
CH A FAST
P1010-7
CH B GND
P1010-8
CH B FAST
W530B
W530A
W520B
W520A
P1611
J1611
P1002-8
P1001-16
J1002-8
B LSB
P1002-7
P1001-15
J1002-7
A LSB
P1002-10
P1001-19
J1002-10
MR1
P1002-5
P1001-12
J1002-5
50Ω B PROTECT
P1002-4
P1001-11
J1002-4
50Ω A PROTECT
EXTERNAL RESET
U1500A
74LS04
R1504
4.7K
P1002-2
P1001-10
J1002-2
PRESCALE
VR1001
5.1V
P1002-6
P1001-14
J1002-6
R1000
100
R1403
100K
P/O A10 BD
P1600-14B
POWER MODULE
P1600-26A EXTERNAL RESET
P1510-10
J1510-10
50Ω PROTECT A SENSE
P1520-10
J1520-10
50Ω PROTECT B SENSE
+12V
+5V
+5V1
+5V2
+2.5V
-5V
-12.2V
R1110
2.37K
U1111A
LM339
-2.1V
R1115
3.0K
U1111D
LM339
R1101
10K
R1112
10K
R1113
10K
R1100
10K
U1111B
LM339
R1111
3.0K
U1111C
LM339
+2.1V
R1114
2.37K
500 PROTECT
R1210
1.24K
R1201
1.24K
R1205
250
R1200
1.10K
+2.5V
A OFFSET ADJ
OUTPUT
ARM IN
VPK
≤10V
J540
W540
P1500
J1500
R1500
510
R1516
510
DC 510
3552-50



Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Table 8-9
COMPONENT REFERENCE CHART
(see Fig. 8-11 and 8-13)

P/O A12 ASSY — **RELAY DRIVE ◇7**

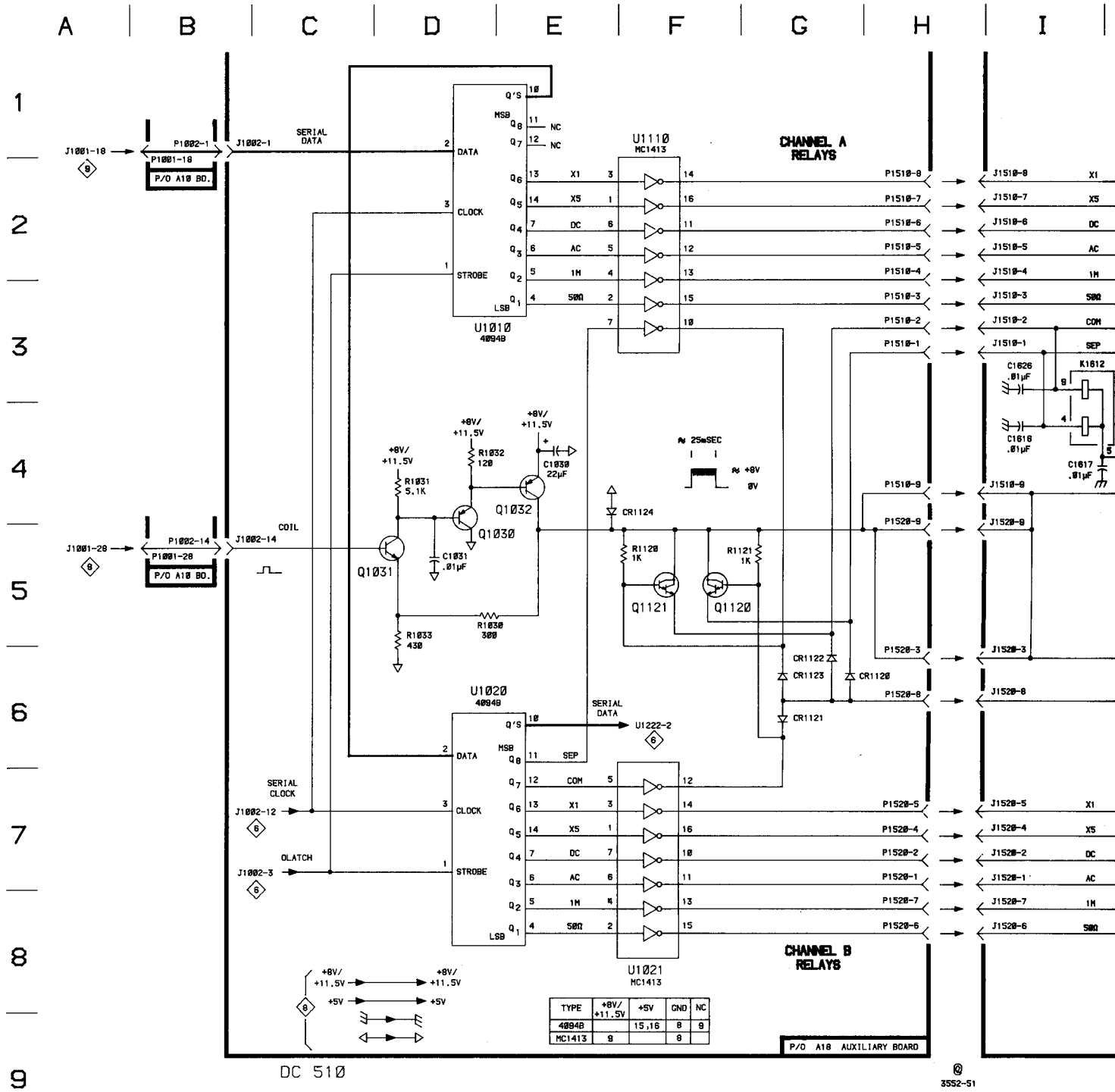
CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1506	L4	K1	C1625	M8	L4
C1507	O4	K1	C1626	I3	M4
C1512	L3	K3	C1632	M7	L5
C1513	M4	L3	C1633	M6	L5
C1514	L4	L3	C1634	M5	L6
C1515	O2	K2	C1635	K5	M6
C1516	N4	K2	C1636	M5	M6
C1517	N2	L2	C1637	J4	M5
C1519	K4	K3	C1639	J6	N5
C1524	L8	J4			
C1525	K6	J4	J1510	I2	L3
C1536	O7	K5	J1520	I7	L4
C1537	N7	K5			
C1538	N5	L5	K1500	O3	K2
C1539	L5	K5	K1510	L3	K2
C1607	N4	L2	K1511	N3	L2
C1611	K4	M3	K1520	L7	K5
C1612	M2	L2	K1521	N7	L4
C1613	N4	M1	K1530	O7	K5
C1614	K3	L3	K1600	M3	L2
C1615	M4	L3	K1610	L3	M2
C1616	I4	M3	K1611	K3	M2
C1617	I4	M3	K1612	I3	M3
C1621	J3	N3	K1620	L7	M4
C1622	J6	M4	K1630	M7	L5
C1623	K6	M5	K1631	K7	M5
C1624	L6	L4	K1632	J3	M5

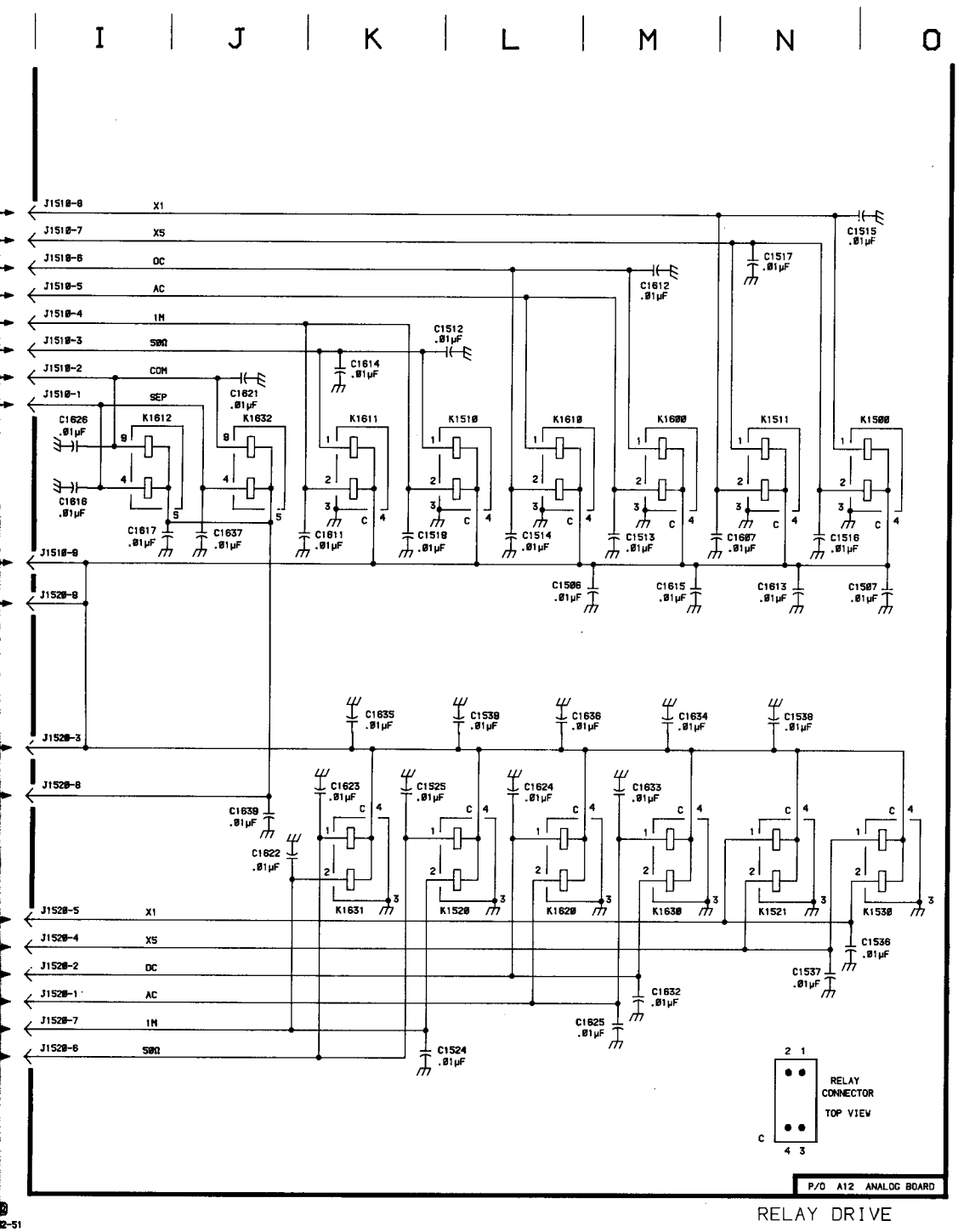
P/O A12 ASSY also shown on ◇1 ◇2 ◇3 ◇5 ◇8

P/O A18 ASSY — **RELAY DRIVE ◇7**

C1030	E4	B6	R1030	D5	B5
C1031	D5	B5	R1031	D4	B5
			R1032	D4	B5
CR1120	H6	C3	R1033	D5	B5
CR1121	G6	C3	R1120	F5	D4
CR1122	G6	D3	R1121	G5	D4
CR1123	G6	D3			
CR1124	F4	D4	U1010	D3	B2
			U1020	D6	B5
Q1030	E5	B5	U1021	F8	C5
Q1031	D5	B5	U1110	F1	C2
Q1032	E4	B5			
Q1120	F5	C4			
Q1121	F5	D4			

P/O A18 ASSY also shown on ◇3 ◇5 ◇6 ◇8


A
B
C
D
E
F
G
H
I
1
2
3
4
5
6
7
8
9
J1001-18
P1001-18
P/O A10 BD.
P1002-1
J1002-1
SERIAL DATA
U1010
4094B
DATA
CLOCK
STROBE
Q'S
MSB
LSB
U1110
MC1413
CHANNEL A RELAYS
X1
X5
DC
AC
1M
50Ω
NC
COM
SEP
P1510-8
P1510-7
P1510-6
P1510-5
P1510-4
P1510-3
P1510-2
P1510-1
P1510-9
J1510-8
J1510-7
J1510-6
J1510-5
J1510-4
J1510-3
J1510-2
J1510-1
K1612
C1626 .01µF
C1616 .01µF
C1617 .01µF
+8V/ +11.5V
R1031 5.1K
R1032 120
C1030 22µF
Q1032
Q1030
Q1031
C1031 .01µF
R1033 430
R1030 300
≈ 25mSEC
≈ +8V
0V
CR1124
R1120 1K
R1121 1K
Q1121
Q1120
P1520-9
P1520-3
P1520-8
J1520-9
J1520-3
J1520-8
J1001-28
P1001-28
P1002-14
J1002-14
COIL
CR1122
CR1123
CR1120
CR1121
U1020
4094B
SERIAL DATA
U1222-2
SERIAL CLOCK
J1002-12
OLATCH
J1002-3
U1021
MC1413
P1520-5
P1520-4
P1520-2
P1520-1
P1520-7
P1520-6
J1520-5
J1520-4
J1520-2
J1520-1
J1520-7
J1520-6
CHANNEL B RELAYS
+5V
TYPE
GND
NC
4094B
MC1413
P/O A18 AUXILIARY BOARD
DC 510
3552-51

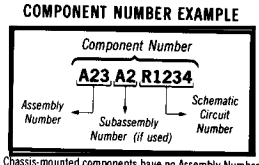


RELAY DRIVE

7 JCS

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Table 8-10
COMPONENT REFERENCE CHART
(see Fig. 8-11, 8-12 and 8-13)

P/O A16 ASSY — **POWER SUPPLIES** ⑧

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1020	H8	B4
C1021	I8	B5
C1022	H8	B5
C1023	I8	B6
C1621	C9	K5
C1721	D6	K5
C1722	H8	L5
C1723	G8	L6
C1810	G6	L4
CR1020	J8	B6
CR1620	D5	K4
CR1720	F7	L4
CR1721	G8	L5
F1820	B6	L5
F1821	B8	M5
L1020	H8	B5
P1820	A6	N5
Q1720	D6	K4
Q1721	E6	L4
Q1722	C6	K4
Q1723	C5	L4
R1022	I7	B6
R1620	C5	K4
R1621	D6	K4
R1622	C8	K5
R1718	E6	L4
R1719	E6	K4
R1720	E6	L4
R1721	D6	K4
R1722	C6	K4
R1724	B5	K5
R1725	B9	K5
R1726	E9	K5
R1727	B8	K5
R1728	F8	L5
R1820	F6	M4
R1821	B6	M4
U1720	D8	K6

P/O A16 ASSY also shown on ④ ⑨

P/O A12 ASSY — **POWER SUPPLIES** ⑧

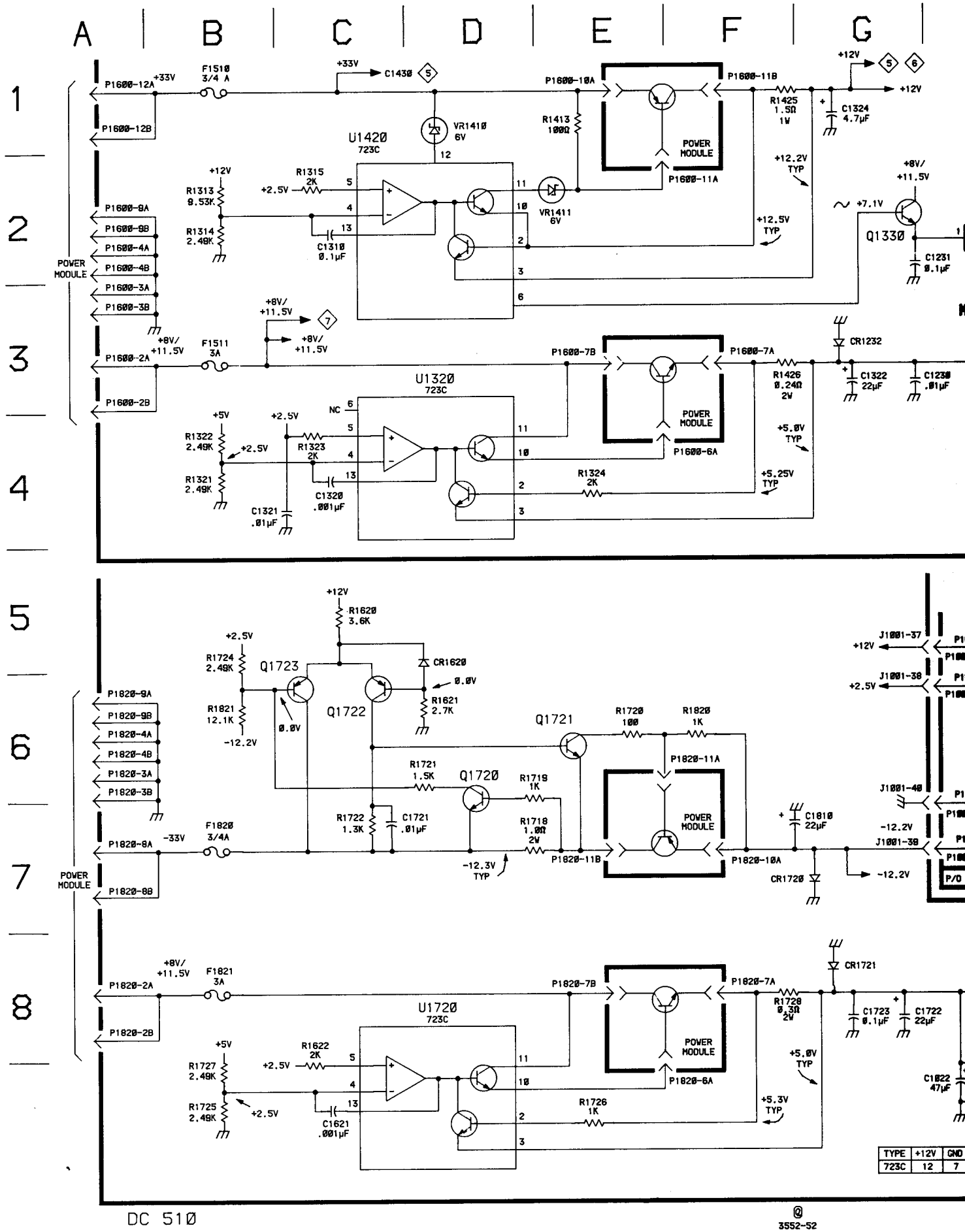
CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1211	K6	E4
C1212	K6	E4
C1213	K4	E4
C1220	K4	E4
C1221	K3	D4
C1231	K7	F6
C1233	K6	E5
C1234	K5	E5
J1230	K4	E5
L1120	K4	D4
L1220	K4	E4
L1221	K6	E4
L1230	K3	D5
L1231	K4	E5
L1232	K3	E5
L1233	K7	E6
R1133	K6	D5
R1221	K6	E4

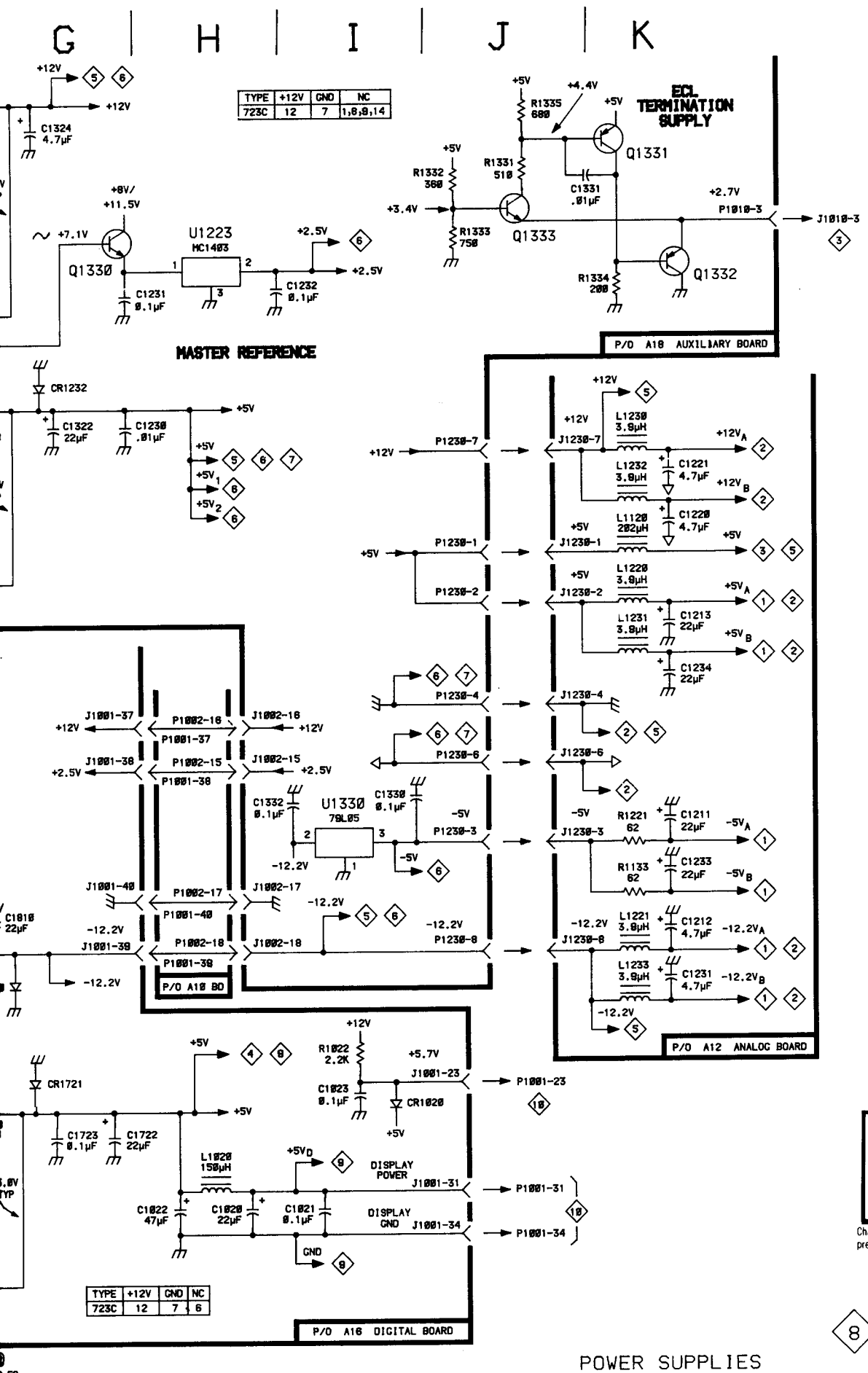
P/O A12 ASSY also shown on ① ② ③ ⑤ ⑦

P/O A18 ASSY — **POWER SUPPLIES** ⑧

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1230	H3	F5
C1231	H2	F5
C1232	I2	F5
C1310	C2	H3
C1320	C4	G4
C1321	B4	G5
C1322	G3	H5
C1324	G1	H4
C1330	I6	G5
C1331	J2	G6
C1332	H6	H5
CR1232	G3	F5
F1510	B1	K3
F1511	B3	L3
J1002	H5	A3
P1010	K2	M3
P1230	J4	H5
P1600	A3	N3
Q1330	G2	F5
Q1331	K1	H5
Q1332	K2	H6
Q1333	J2	H6
R1313	B2	G3
R1314	B2	H3
R1315	C1	H3
R1321	B4	F5
R1322	B3	G5
R1323	C4	G5
R1324	E4	H5
R1331	J2	H6
R1332	J2	H5
R1333	J2	G6
R1334	J2	G6
R1335	J1	H5
R1413	E1	J3
R1425	F1	H4
R1426	F3	H4
U1223	H2	F5
U1320	D3	G4
U1330	I6	G5
U1420	C1	H3
VR1410	D1	J3
VR1411	E2	J3

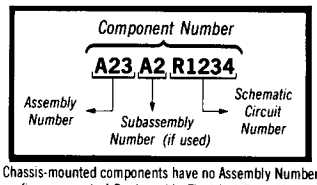
P/O A18 ASSY also shown on ③ ⑤ ⑥ ⑦


A
B
C
D
E
F
G
1
2
3
4
5
6
7
8
P1600-12A
+33V
F1510
3/4 A
P1600-12B
C1430
VR1410
6V
U1420
723C
R1315
2K
R1313
9.53K
R1314
2.49K
C1310
0.1µF
VR1411
6V
R1413
100Ω
P1600-10A
P1600-11B
P1600-11A
POWER MODULE
R1425
1.5Ω
1W
C1324
4.7µF
+12V
+12.2V TYP
+12.5V TYP
+8V/
+11.5V
+7.1V
Q1330
C1231
0.1µF
P1600-9A
P1600-9B
P1600-4A
P1600-4B
P1600-3A
P1600-3B
P1600-2A
P1600-2B
F1511
3A
U1320
723C
R1322
2.49K
R1321
2.49K
R1323
2K
C1320
.001µF
C1321
.01µF
R1324
2K
P1600-7B
P1600-7A
P1600-6A
CR1232
R1426
0.24Ω
2W
C1322
22µF
C1238
.01µF
+5V
+2.5V
+5.0V TYP
+5.25V TYP
NC
P1820-9A
P1820-9B
P1820-4A
P1820-4B
P1820-3A
P1820-3B
P1820-8A
P1820-8B
P1820-2A
P1820-2B
F1820
3/4A
-33V
F1821
3A
Q1723
Q1722
Q1721
Q1720
R1620
3.6K
CR1620
R1621
2.7K
R1724
2.49K
R1821
12.1K
-12.2V
0.0V
R1720
100
R1820
1K
R1721
1.5K
R1719
1K
R1722
1.3K
C1721
.01µF
R1718
1.0Ω
2W
-12.3V TYP
P1820-11A
P1820-11B
P1820-10A
C1810
22µF
CR1720
J1001-37
J1001-38
J1001-48
P/O
U1720
723C
R1622
2K
R1727
2.49K
R1725
2.49K
C1621
.001µF
R1726
1K
P1820-7B
P1820-7A
P1820-6A
CR1721
R1728
0.3Ω
2W
C1723
0.1µF
C1722
22µF
C1822
47µF
+5.3V TYP
TYPE
+12V
GND
723C
12
7
DC 510
3552-52



Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



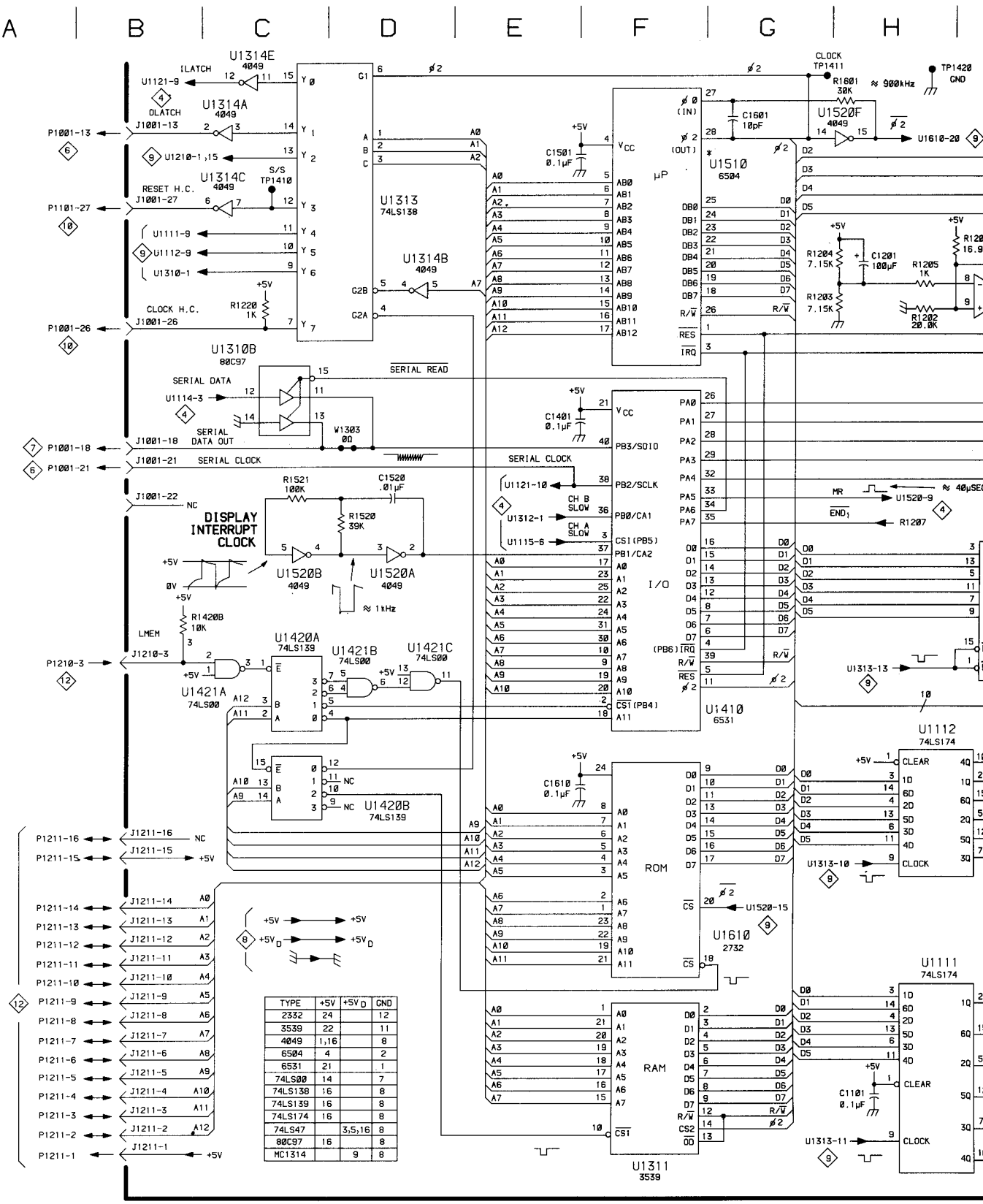
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

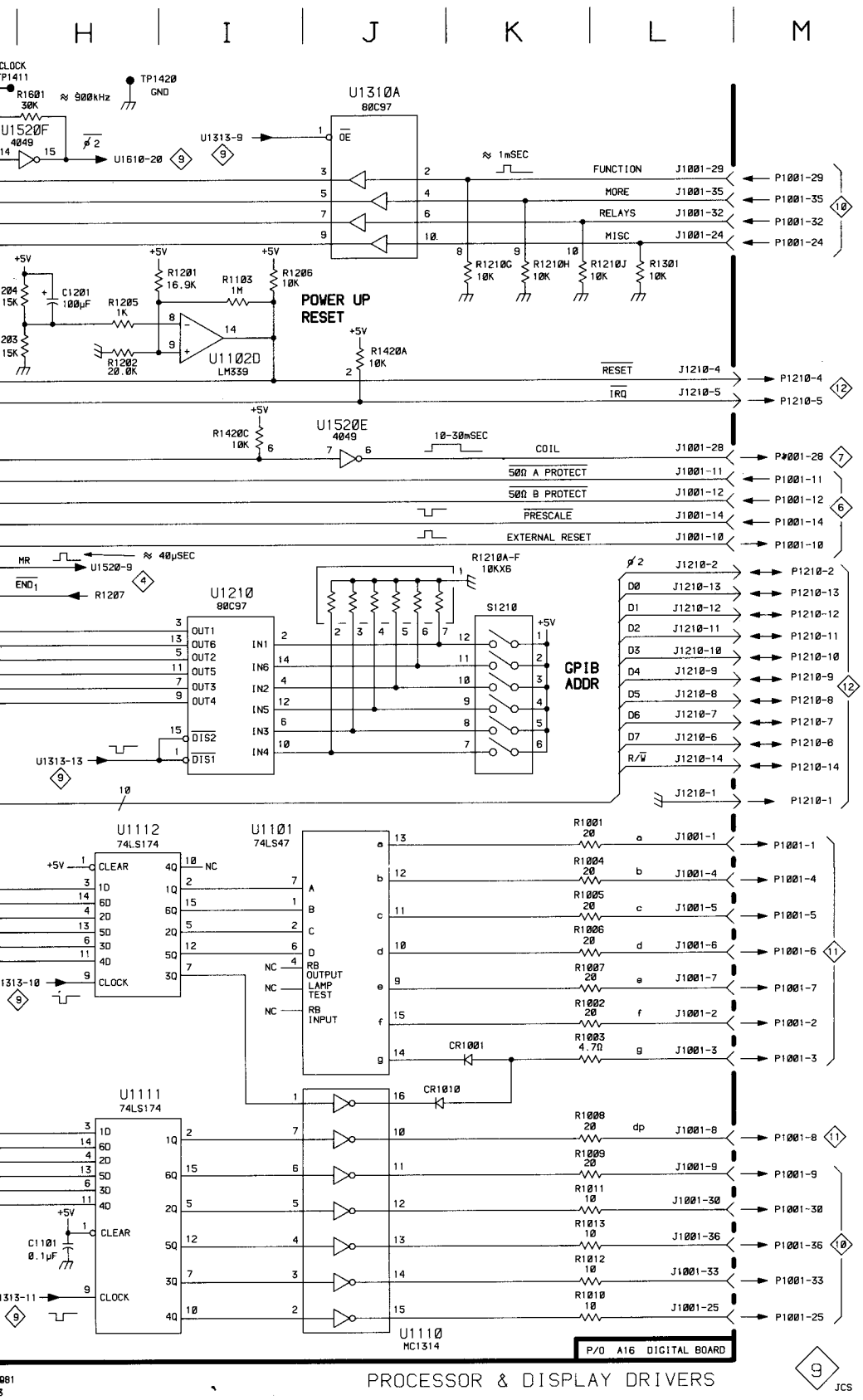
Table 8-11
COMPONENT REFERENCE CHART
(see Fig. 8-12)

P/O A16 ASSY — PROCESSOR AND DISPLAY DRIVERS ◇9◇

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1101	H9	C2	R1205	H2	D2
C1201	H2	E2	R1206	I2	E1
C1401	E3	G1	R1210	K2	E3
C1501	E1	J1	R1220	C3	E5
C1520	D4	J4	R1301	L2	E2
C1601	G1	J2	R1420	J3	G5
C1610	E6	J4	R1520	D4	J5
			R1521	C4	J5
CR1001	K7	B1	R1601	H1	J2
CR1010	J8	B3			
			S1210	K4	D3
J1001	L7	A3			
J1210	L5	G3	TP1410	C2	G4
J1211	B8	G3	TP1411	G1	G4
			TP1420	I1	F5
R1001	L6	B1			
R1002	L7	B1	U1101	I6	C1
R1003	L7	B1	U1110	J9	C3
R1004	L6	B2	U1111	H8	C3
R1005	L6	B2	U1112	H6	D3
R1006	L7	B2	U1210	I4	E3
R1007	L7	B2	U1310	J1	F3
R1008	L8	B2	U1311	F9	F3
R1009	L8	B2	U1313	D2	F4
R1010	L9	B4	U1314	C1	F5
R1011	L8	B4	U1410	G6	H3
R1012	L9	B4	U1420	C5	G5
R1013	L9	B4	U1421	C6	H5
R1103	I2	D1	U1510	G1	J2
R1201	I2	D1	U1520	D5	H5
R1202	H3	D1	U1610	G7	J3
R1203	G2	D1			
R1204	G2	E1	W1303	D3	E3

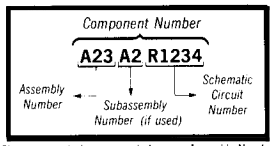
P/O A16 ASSY also shown on ◇4◇ ◇8◇


A
B
C
D
E
F
G
H
1
2
3
4
5
6
7
8
9
U1314E
4049
ILATCH
U1121-9
DLATCH
U1314A
4049
P1001-13
J1001-13
U1210-1,15
U1314C
4049
RESET H.C.
P1101-27
J1001-27
U1111-9
U1112-9
U1310-1
S/S
TP1410
CLOCK H.C.
P1001-26
J1001-26
R1220
1K
+5V
U1313
74LS138
U1314B
4049
U1310B
80C97
SERIAL DATA
U1114-3
SERIAL
DATA OUT
SERIAL READ
W1303
00
P1001-18
J1001-18
P1001-21
J1001-21
SERIAL CLOCK
J1001-22
NC
DISPLAY
INTERRUPT
CLOCK
R1521
100K
C1520
.01µF
R1520
39K
U1520B
4049
U1520A
4049
≈ 1kHz
0V
R1420B
10K
LMEM
P1210-3
J1210-3
U1420A
74LS139
U1421B
74LS00
U1421C
74LS00
U1421A
74LS00
A12
A11
A10
A9
U1420B
74LS139
NC
P1211-16
J1211-16
P1211-15
J1211-15
+5V
P1211-14
J1211-14
P1211-13
J1211-13
P1211-12
J1211-12
P1211-11
J1211-11
P1211-10
J1211-10
P1211-9
J1211-9
P1211-8
J1211-8
P1211-7
J1211-7
P1211-6
J1211-6
P1211-5
J1211-5
P1211-4
J1211-4
P1211-3
J1211-3
P1211-2
J1211-2
P1211-1
J1211-1
+5V
+5V_D
TYPE | +5V | +5V_D | GND
2332 | 24 | | 12
3539 | 22 | | 11
4049 | 1,16 | | 8
6504 | 4 | | 2
6531 | 21 | | 1
74LS00 | 14 | | 7
74LS138 | 16 | | 8
74LS139 | 16 | | 8
74LS174 | 16 | | 8
74LS47 | | 3,5,16 | 8
80C97 | 16 | | 8
MC1314 | | 9 | 8
CLOCK
TP1411
TP1420
GND
R1601
30K
≈ 900kHz
C1601
10pF
U1520F
4049
U1610-20
U1510
6504
µP
C1501
0.1µF
C1201
100µF
R1204
7.15K
R1203
7.15K
R1205
1K
R1202
20.0K
R120
16.9
C1401
0.1µF
U1410
6531
I/O
U1121-10
U1312-1
CH B
SLOW
U1115-6
CH A
SLOW
MR
≈ 40µSEC
U1520-9
END1
R1207
U1313-13
U1112
74LS174
C1610
0.1µF
ROM
U1610
2732
U1520-15
U1313-10
U1111
74LS174
C1101
0.1µF
U1313-11
RAM
U1311
3539
DC 510
REV OCT 1981
3552-53



Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



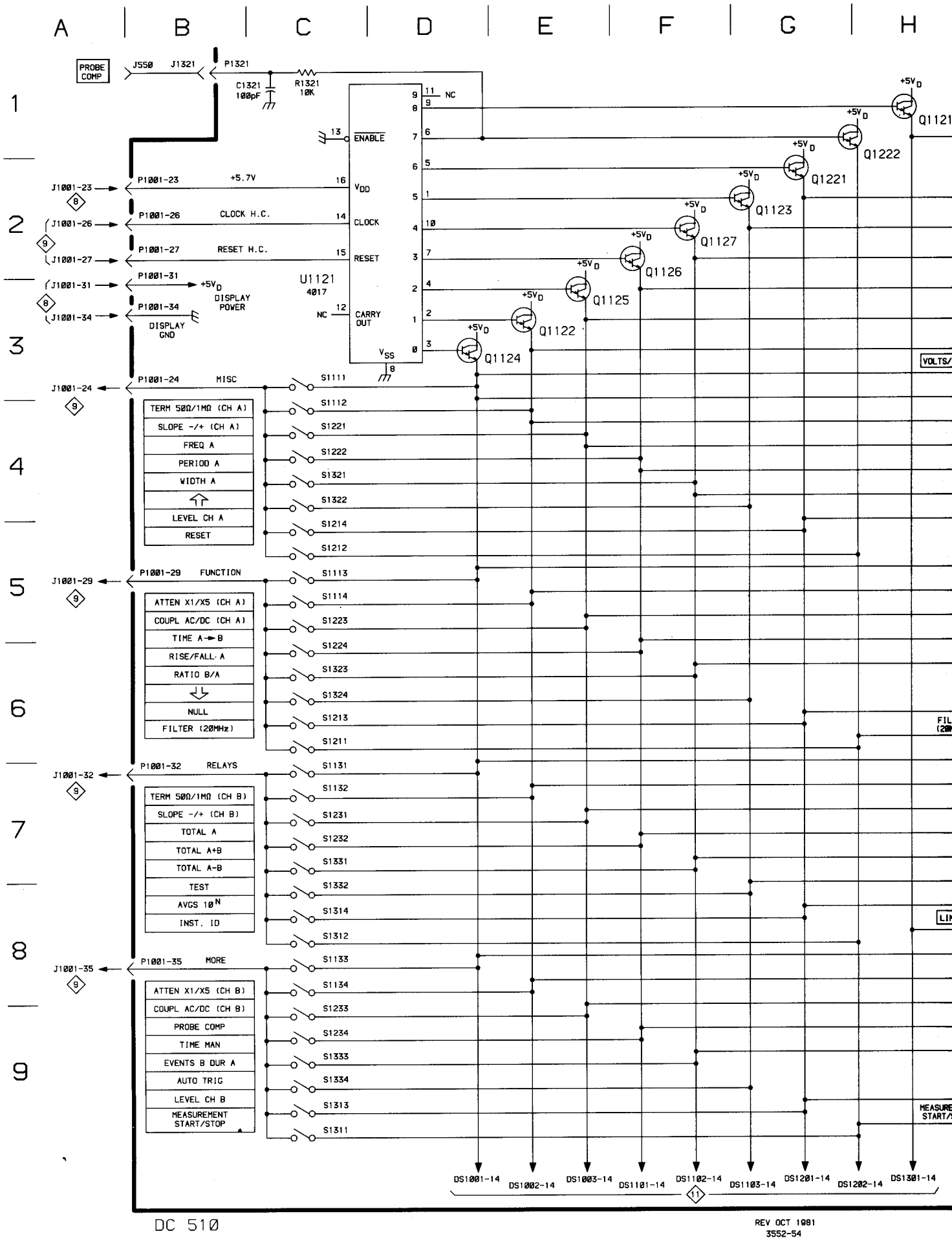
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Table 8-12
COMPONENT REFERENCE CHART
(see Fig. 8-14)

P/O A10 ASSY — PUSH BUTTONS AND LED's ◇10◇

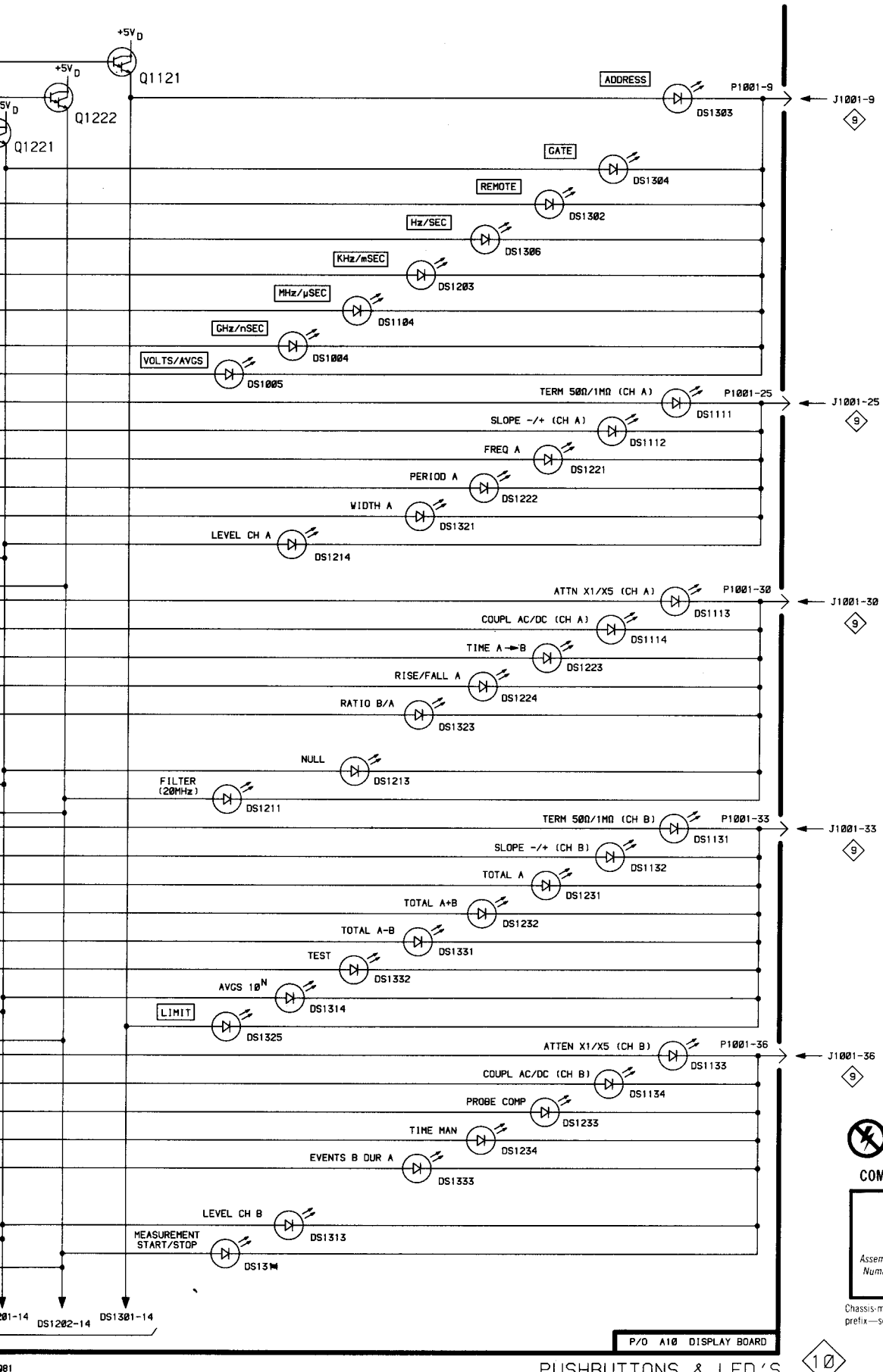
CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1321	C1	F3
DS1004	I3	C2
DS1005	I3	B2
DS1104	J3	D2
DS1111	L4	C3
DS1112	L4	D3
DS1113	L5	C3
DS1114	L5	D3
DS1131	L7	C5
DS1132	L7	D5
DS1133	L8	C6
DS1134	L8	D6
DS1203	J3	E2
DS1211	I6	E3
DS1213	J6	E3
DS1214	I5	E3
DS1221	K4	E4
DS1222	K4	E4
DS1223	K5	E5
DS1224	K6	E5
DS1231	K7	E5
DS1232	K7	E5
DS1233	K9	E6
DS1234	K9	E6
DS1302	K2	G1
DS1303	L1	G1
DS1304	L2	G2
DS1306	K2	F2
DS1311	I10	F3
DS1313	I9	F3
DS1314	I8	G3
DS1321	J4	F4
DS1323	J6	F5
DS1325	I8	G4
DS1331	J7	F5
DS1332	J8	G5
DS1333	J9	F6
J1321	B1	F4
J550	B1	Chassis
P1321	B1	F4
Q1121	H1	C4
Q1122	E3	C4
Q1123	G2	D4
Q1124	E3	C4
Q1125	F3	C4
Q1126	F2	D4
Q1127	F2	D4
Q1221	G2	E4
Q1222	H1	E4
R1321	C1	F4
S1111	C3	C2
S1112	C4	D2
S1113	C5	C3
S1114	C5	D3
S1131	C7	C5
S1132	C7	D5
S1133	C8	C5
S1134	C8	D5
S1211	C6	E2
S1212	C5	E2
S1213	C6	E3
S1214	C5	E3
S1221	C4	E4
S1222	C4	E4
S1223	C5	E4
S1224	C6	E4
S1231	C7	E5
S1232	C7	E5
S1233	C9	E5
S1234	C9	E5
S1311	C10	F2
S1312	C8	G2
S1313	C9	F3
S1314	C8	G3
S1321	C4	F4
S1322	C4	G4
S1323	C6	F4
S1324	C6	G4
S1331	C7	F5
S1332	C8	G5
S1333	C9	F5
S1334	C9	G5
U1121	C2	D4

P/O A10 ASSY also shown on ◇4◇ ◇6◇ ◇8◇ ◇11◇



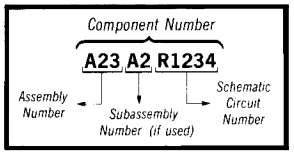
DC 510

REV OCT 1981
3552-54



Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

PUSHBUTTONS & LED'S 10 JCS

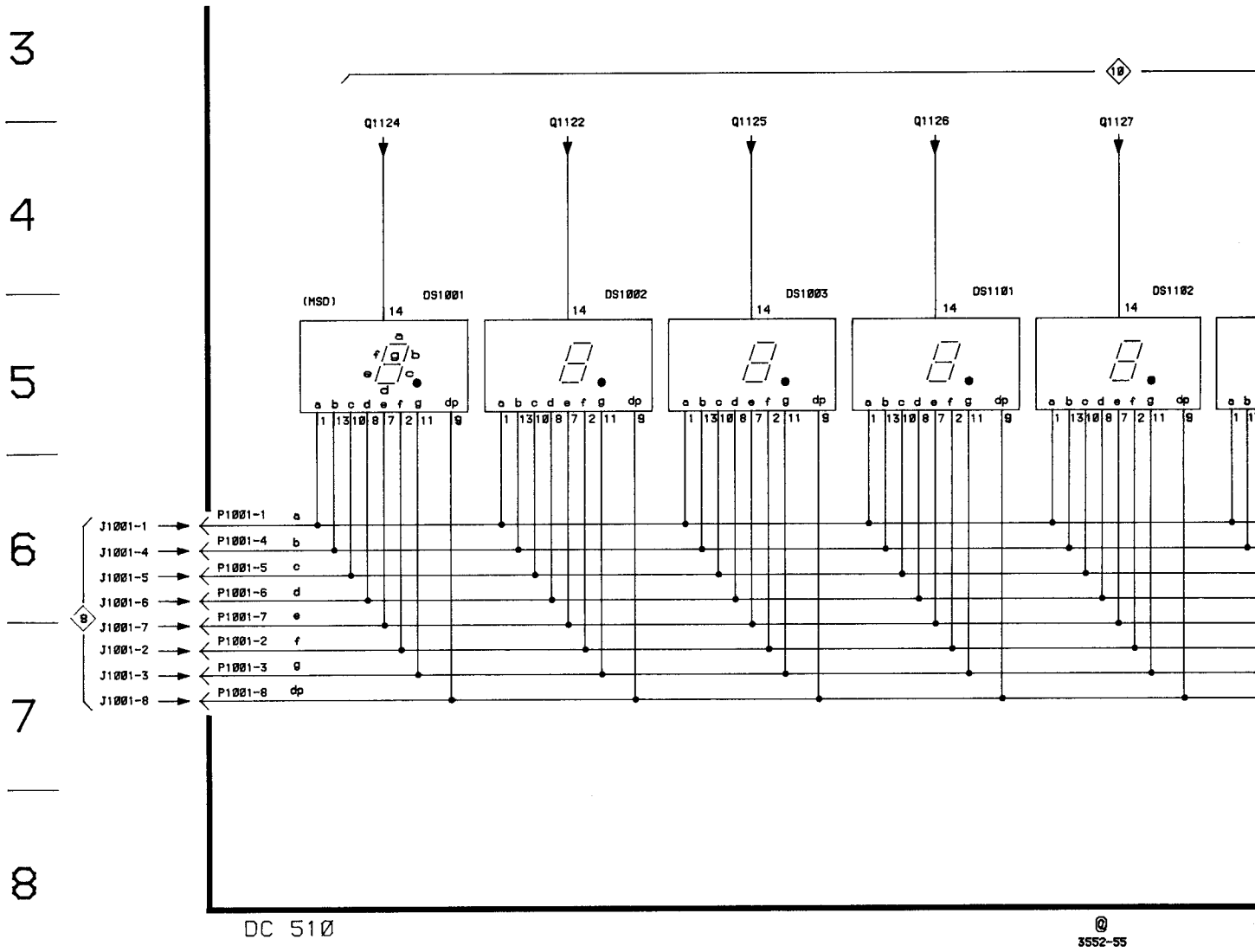
PUSHBUTTONS AND LEDS 10

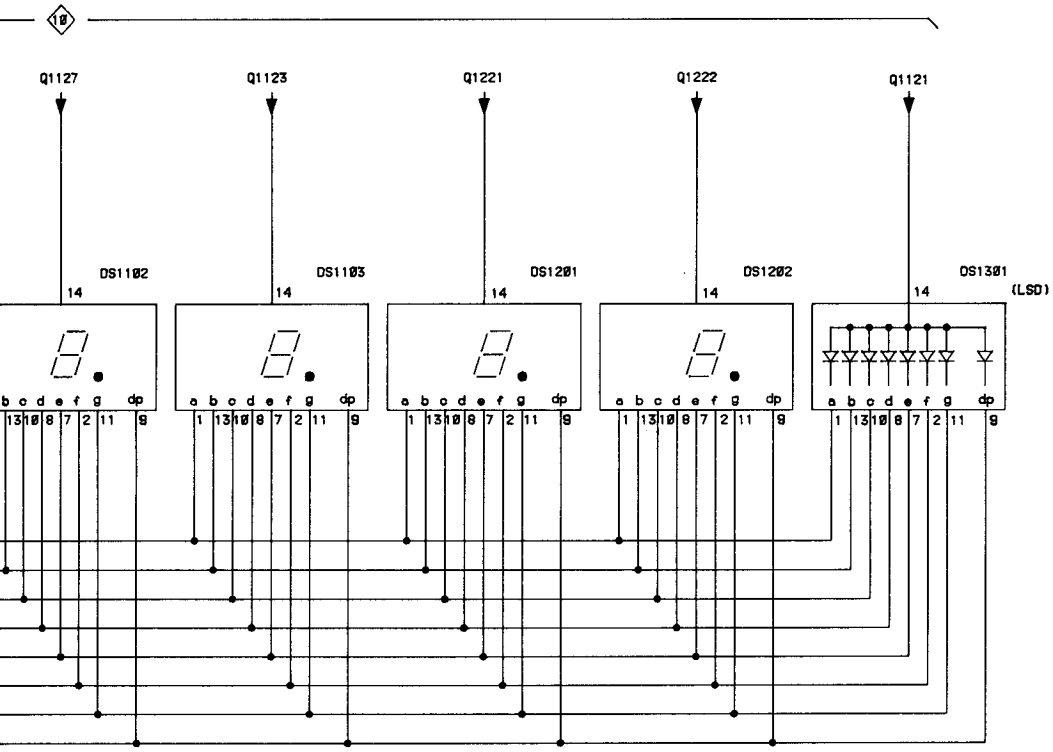
Table 8-13
COMPONENT REFERENCE CHART
(see Fig. 8-14)

P/O A10 ASSY — DISPLAY ◇11◇

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
DS1001	C5	B1	DS1201	J5	E1
DS1002	D5	B1	DS1202	K5	E1
DS1003	E5	C1	DS1301	L5	F1
DS1101	F5	C1			
DS1102	G5	D1	P1001	B6	G2
DS1103	I5	D1			

P/O A10 ASSY also shown on ◇4◇ ◇6◇ ◇8◇ ◇10◇


A
B
C
D
E
F
G
1
2
3
4
5
6
7
8
10
Q1124
Q1122
Q1125
Q1126
Q1127
(MSD)
DS1001
DS1002
DS1003
DS1101
DS1102
14
a
f/g/b
e/c
d
a b c d e f g dp
1 13 10 8 7 2 11 9
J1001-1
J1001-4
J1001-5
J1001-6
J1001-7
J1001-2
J1001-3
J1001-8
P1001-1 a
P1001-4 b
P1001-5 c
P1001-6 d
P1001-7 e
P1001-2 f
P1001-3 g
P1001-8 dp
8
DC 510
3552-55



Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

Component Number

A23 A2 R1234

Assembly Number — *Subassembly Number (if used)* — *Schematic Circuit Number*

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

P/O A10 DISPLAY BOARD

REPLACEABLE MECHANICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

1 2 3 4 5 Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
- - - * - - -
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
- - - * - - -
Parts of Detail Part
Attaching parts for Parts of Detail Part
- - - * - - -

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

"	INCH	ELCTRN	ELECTRON	IN	INCH	SE	SINGLE END
#	NUMBER SIZE	ELEC	ELECTRICAL	INCAND	INCANDESCENT	SECT	SECTION
ACTR	ACTUATOR	ELCTLT	ELECTROLYTIC	INSUL	INSULATOR	SEMICOND	SEMICONDUCTOR
ADPTR	ADAPTER	ELEM	ELEMENT	INTL	INTERNAL	SHLD	SHIELD
ALIGN	ALIGNMENT	EPL	ELECTRICAL PARTS LIST	LPHLDR	LAMPHOLDER	SHLDR	SHOULDERED
AL	ALUMINUM	EQPT	EQUIPMENT	MACH	MACHINE	SKT	SOCKET
ASSEM	ASSEMBLED	EXT	EXTERNAL	MECH	MECHANICAL	SL	SLIDE
ASSY	ASSEMBLY	FIL	FILLISTER HEAD	MTG	MOUNTING	SLFLKG	SELF-LOCKING
ATTEN	ATTENUATOR	FLEX	FLEXIBLE	NIP	NIPPLE	SLVG	SLEEVING
AWG	AMERICAN WIRE GAGE	FLH	FLAT HEAD	NON WIRE	NOT WIRE WOUND	SPR	SPRING
BD	BOARD	FLTR	FILTER	OBD	ORDER BY DESCRIPTION	SQ	SQUARE
BRKT	BRACKET	FR	FRAME or FRONT	OD	OUTSIDE DIAMETER	SST	STAINLESS STEEL
BRS	BRASS	FSTNR	FASTENER	OVH	OVAL HEAD	STL	STEEL
BRZ	BRONZE	FT	FOOT	PH BRZ	PHOSPHOR BRONZE	SW	SWITCH
BSHG	BUSHING	FXD	FIXED	PL	PLAIN or PLATE	T	TUBE
CAB	CABINET	GSKT	GASKET	PLSTC	PLASTIC	TERM	TERMINAL
CAP	CAPACITOR	HDL	HANDLE	PN	PART NUMBER	THD	THREAD
CER	CERAMIC	HEX	HEXAGON	PNH	PAN HEAD	THK	THICK
CHAS	CHASSIS	HEX HD	HEXAGONAL HEAD	PWR	POWER	TNSN	TENSION
CKT	CIRCUIT	HEX SOC	HEXAGONAL SOCKET	RCPT	RECEPTACLE	TPG	TAPPING
COMP	COMPOSITION	HLCPS	HELICAL COMPRESSION	RES	RESISTOR	TRH	TRUSS HEAD
CONN	CONNECTOR	HLEXT	HELICAL EXTENSION	RGD	RIGID	V	VOLTAGE
COV	COVER	HV	HIGH VOLTAGE	RLF	RELIEF	VAR	VARIABLE
CPLG	COUPLING	IC	INTEGRATED CIRCUIT	RTNR	RETAINER	W/	WITH
CRT	CATHODE RAY TUBE	ID	INSIDE DIAMETER	SCH	SOCKET HEAD	WSHR	WASHER
DEG	DEGREE	IDENT	IDENTIFICATION	SCOPE	OSCILLOSCOPE	XFMR	TRANSFORMER
DWR	DRAWER	IMPLR	IMPELLER	SCR	SCREW	XSTR	TRANSISTOR

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
000BB	BERQUIST COMPANY	4350 WEST 78TH	MINNEAPOLIS, MN 55435
00779	AMP, INC.	P O BOX 3608	HARRISBURG, PA 17105
05820	WAKEFIELD ENGINEERING, INC.	AUDUBON ROAD	WAKEFIELD, MA 01880
22526	BERG ELECTRONICS, INC.	YOUK EXPRESSWAY	NEW CUMBERLAND, PA 17070
49671	RCA CORPORATION	30 ROCKEFELLER PLAZA	NEW YORK, NY 10020
71279	CAMBRIDGE THERMIONIC CORP.	445 CONCORD AVE.	CAMBRIDGE, MA 02138
71785	TRW, CINCH CONNECTORS	1501 MORSE AVENUE	ELK GROVE VILLAGE, IL 60007
73803	TEXAS INSTRUMENTS, INC., METALLURGICAL MATERIALS DIV.	34 FOREST STREET	ATTLEBORO, MA 02703
78189	ILLINOIS TOOL WORKS, INC. SHAKEPROOF DIVISION	ST. CHARLES ROAD	ELGIN, IL 60120
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
83385	CENTRAL SCREW CO.	2530 CRESCENT DR.	BROADVIEW, IL 60153
93907	TEXTRON INC. CAMCAR DIV	600 18TH AVE	ROCKFORD, IL 61101

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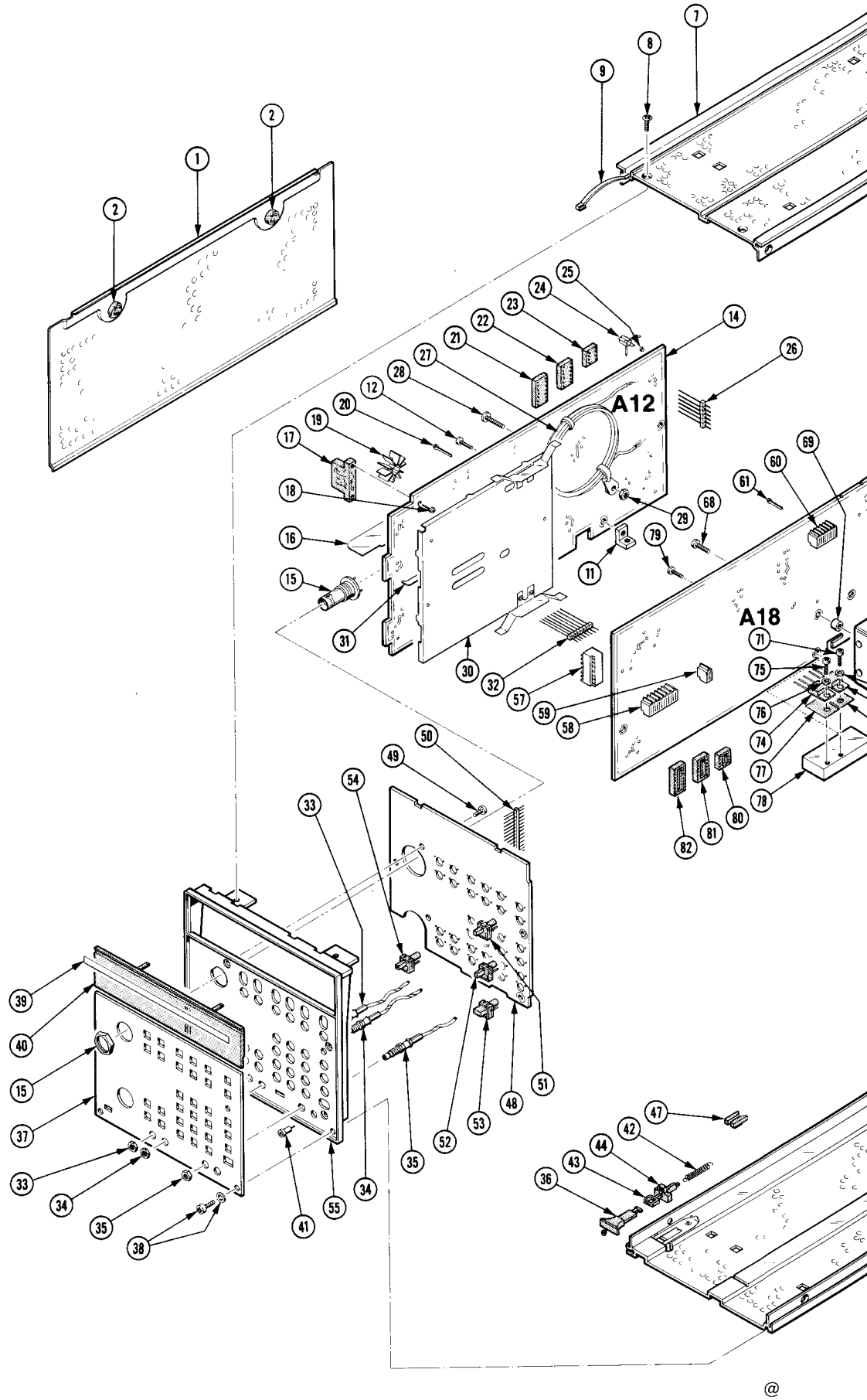
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-1	337-2807-02			2		SHIELD,ELEC:SIDE,PLUG-IN UNIT	80009	337-2807-02
-2	105-0932-00			4		LATCH,PANEL:SIDE	80009	105-0932-00
	214-3364-00			4		FASTENER,LATCH:ACETAL,SIL GRAY	80009	214-3364-00
-3	334-4224-00			1		MARKER,IDENT:GPIB INSTRUCTION	80009	334-4224-00
-4	333-2670-00			1		PANEL,REAR:	80009	333-2670-00
						(ATTACHING PARTS)		
-5	213-0868-00			2		SCREW,TPG,TF:6-32 X 0.375 L,FILM,STEEL	93907	OBD
-6	386-3657-01			2		SUPPORT,PLUG IN:	93907	OBD
						- - - * - - -		
-7	426-1801-00			1		FR SECT,PLUG-IN:TOP	80009	426-1801-00
						(ATTACHING PARTS)		
-8	211-0541-00			2		SCREW,MACHINE:6-32 X 0.25"100 DEG,FLH STL	83385	OBD
						- - - * - - -		
-9	214-1061-00			1		SPRING,GROUND:FLAT	80009	214-1061-00
-10	351-0672-00			6		GUIDE,CKT BOARD:PLASTIC	80009	351-0672-00
-11	407-2556-00			2		BRACKET,ANGLE:CIRCUIT BOARD,AL	80009	407-2556-00
						(ATTACHING PARTS)		
-12	211-0007-00			2		SCREW,MACHINE:4-40 X 0.188 INCH,PNH STL	83385	OBD
-13	211-0105-00			2		SCREW,MACHINE:4-40 X 0.188,100 DEG,FLH STL	83385	OBD
						- - - * - - -		
-14	----- -----			1		CKT BOARD ASSY:ANALOG(SEE A12 REPL)		
-15	----- -----			2		. CONNECTOR,RCPT:(SEE A12J500,J510 REPL)		
-16	337-2850-01			1		. SHIELD,ELEC:CIRCUIT BD W/SPRING	80009	337-2850-01
-17	----- -----			12		. RELAY,ARMATURE:(SEE A12K1500,K1510,K1511,		
	----- -----			-		. K1520,K1521,K1530,K1600,K1610,K1611,K1620,		
	----- -----			-		. K1630,K1631 REPL)		
						(ATTACHING PARTS)		
-18	213-0848-00			24		. SCREW,TPG,TF:0-40 X 0.25,PLASTITE	93907	OBD
						- - - * - - -		
-19	214-1291-00			2		. HEAT SINK,ELEC:XSTR,0.72 OD X 0.375"H	05820	207-AB
-20	----- -----			3		. TERM,TEST POINT:(SEE A12TP1020,TP1310,		
	----- -----			-		. TP1330 REPL)		
-21	136-0260-02			2		. SKT,PL-IN ELEK:MICROCIRCUIT,16 DIP,LOW CLE	71785	133-51-92-008
-22	136-0269-02			1		. SKT,PL-IN ELEK:MICROCIRCUIT,14 DIP,LOW CLE	73803	CS9002-14
-23	136-0514-00			3		. SKT,PL-IN ELEC:MICROCIRCUIT,8 DIP	73803	CS9002-8
-24	----- -----			2		. CONN,RCPT,ELEC:(SEE A12J1130,J1201 REPL)		
-25	136-0252-07			154		. SOCKET,PIN CONN:W/O DIMPLE	22526	75060-012
-26	----- -----			1		. CONN,RCPT,ELEC:(SEE A12J1010,J1102,J1510,		
	----- -----			-		. J1520 REPL)		
-27	----- -----			1		. DELAY LINE,ELEC:(SEE A12J1100,J1101 REPL)		
						(ATTACHING PARTS)		
-28	211-0173-00			1		. SCREW,MACHINE:4-40 X 0.375,FLH,STL	83385	OBD
-29	210-0551-00			1		. NUT,PLAIN,HEX.:4-40 X 0.25 INCH,STL	83385	OBD
						- - - * - - -		
-30	337-2852-01			1		. SHIELD,ELEC:CIRCUIT BOARD W/SPRING	80009	337-2852-01
-31	337-2851-00			1		. SHIELD,ELEC:CIRCUIT BOARD	80009	337-2851-00
-32	----- -----			1		. CONN,RCPT,ELEC:(SEE A12J1230,J1400,		
	----- -----			-		. J1420 REPL)		
-33	175-3448-00			1		CABLE ASSY,RF:50 OHM COAX,18.0L,9-2	80009	175-3448-00
	----- -----			-		(FROM J520 TO A12J1201)		
-34	175-3449-00			1		CABLE ASSY,RF:50 OHM COAX,15.0L,9-3	80009	175-3449-00
	----- -----			-		(FROM J530 TO A12J1130)		
-35	175-3450-00			1		CABLE ASSY,RF:50 OHM COAX,14.0L,9-4	80009	175-3450-00
	----- -----			-		(FROM J540 TO A18J1500)		
	195-1597-00			1		LEAD,ELECTRICAL:26 AWG,3.5 L,9-1	80009	195-1597-00
	----- -----			-		(FROM J550 TO A10P1321)		
	352-0171-00			1		. HLDR,TERM CONN:1 WIRE BLACK	80009	352-0171-00
-36	366-1851-00	B010100	B010239	1		KNOB,LATCH:SIL GY,0.625 X 0.25 X 1.09	80009	366-1851-00
	366-1851-01	B010240		1		KNOB,LATCH:IVORY GY,0.625 X 0.25	80009	366-1851-01
-37	333-2746-00			1		PANEL,FRONT:	80009	333-2746-00
						(ATTACHING PARTS)		
-38	213-0875-00			2		SCR ASSEM WSHR:6-32 X 0.5,TAPTITE,PNH	93907	OBD
	210-1365-00			2		WASHER,FLAT:0.141 ID X 0.5 THK,AL	80009	210-1365-00
						- - - * - - -		

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-39	334-3965-00			1		PLATE,IDENT:	80009	334-3965-00
-40	378-0159-03			1		LENS,LED DSPL:RED W/MARKINGS	80009	378-0159-03
-41	136-0387-00			1		JACK,TIP:GRAY	71279	450-4352-01-0318
-42	214-3143-00			1		SPRING,HLEXT:0.125 OD X 0.545 L, X LOOP	80009	214-3143-00
-43	105-0865-00			1		BAR,LATCH RLSE:	80009	105-0865-00
-44	105-0866-00			1		LATCH,RETAINING:SAFETY	80009	105-0866-00
-45	426-1802-01			1		FR SECT,PLUG-IN:BOTTOM W/SPRING	80009	426-1802-01
						(ATTACHING PARTS)		
-46	211-0105-00			1		SCREW,MACHINE:4-40 X 0.188,100 DEG,FLH STL	83385	OBD
						- - - * - - -		
-47	351-0672-00			3		GUIDE,CKT BOARD:PLASTIC	80009	351-0672-00
-48	----- -----			1		CKT BOARD ASSY:DISPLAY(SEE A10 REPL)		
						(ATTACHING PARTS)		
-49	211-0005-00			4		SCREW,MACHINE:4-40 X 0.125 INCH,PNH STL	83385	OBD
						- - - * - - -		
	----- -----			-		. CKT BOARD ASSY INCLUDES:		
-50	----- -----			1		. TERM SET,PIN:(SEE A10P1001,P1002,P1321 REPL)		
-51	----- -----			1		. SWITCH,PB ASSY:(SEE A10S1312 REPL)		
-52	----- -----			3		. ACTR ASSY,PB:(SEE A10S1212,S1322,S1324 REPL)		
-53	----- -----			1		. ACTR ASSY,PB:(SEE A10S1334 REPL)		
-54	----- -----			27		. ACTR ASSY,PB:(SEE A10S1111,S1112,S1113,		
	----- -----			-		. S1114,S1131,S1132,S1133,S1134,S1211,S1213,		
	----- -----			-		. S1214,S1221,S1222,S1223,S1224,S1231,S1232,		
	----- -----			-		. S1233,S1234,S1311,S1313,S1314,S1321,S1323,		
	----- -----			-		. S1331,S1332,S1333 REPL)		
-55	386-4581-00			1		SUBPANEL,FRONT:	80009	386-4581-00
-56	----- -----			1		CKT BOARD ASSY:AUXILIARY(SEE A18 REPL)		
-57	136-0631-00			2		. SOCKET,PLUG-IN:9 PIN FEMALE	00779	1-380949-9
-58	136-0499-10			2		. CONNECTOR,RCPT,:10 CONTACT	00779	4-380949-0
-59	136-0499-02			2		. CONNECTOR,RCPT,:2 CONTACT	00779	3-380949-2
-60	136-0499-08			3		. CONNECTOR,RCPT,:8 CONTACT	00779	30380949-8
-61	----- -----			1		. TERM TEST POINT:(SEE A18TP1400 REPL)		
-62	136-0252-07			1		. SOCKET,PIN CONN:W/O DIMPLE	22526	75060-012
-63	----- -----			1		. CONN,RCPT,ELEC:(SEE A18J1500 REPL)		
-64	344-0154-03			4		. CLIP,ELECTRICAL:FUSE,CKT BD MT	80009	344-0154-03
-65	----- -----			1		. TERM SET,PIN:(SEE A18J1510,J1511,J1611 REPL)		
-66	131-0993-00			2		. BUS,CONDUCTOR:2 WIRE BLACK	00779	530153-8
-67	----- -----			1		. OSCILLATOR,RF:(SEE A18Y1530 REPL)		
	----- -----			-		. (OPTION 01 ONLY)		
						(ATTACHING PARTS)		
-68	211-0097-00			2		. SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	OBD
	----- -----			-		. (OPTION 01 ONLY)		
-69	361-0548-00			2		. SPACER,RING:0.125 ID X 0.25 OD X 0.110 ID	80009	361-0548-00
	----- -----			-		. (OPTION 01 ONLY)		
						- - - * - - -		
-70	----- -----			1		. MICROCIRCUIT:(SEE A18U1430 REPL)		
	----- -----			-		. (OPTION 01 ONLY)		
						(ATTACHING PARTS)		
-71	211-0097-00			1		. SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	OBD
	----- -----			-		. (OPTION 01 ONLY)		
-72	210-1178-00			2		. WSHR,SHOULDERED:FOR MTG TO-220 TRANSISTOR	49671	DF 137A
	----- -----			-		. (OPTION 01 ONLY)		
-73	342-0355-00			1		. INSULATOR,PLATE:TRANSISTOR,SILICONE RUBBER	000BB	7403-09FR-51
	----- -----			-		. (OPTION 01 ONLY)		
						- - - * - - -		
-74	----- -----			1		. TRANSISTOR:(SEE A18Q1332 REPL)		
						(ATTACHING PARTS)		
-75	211-0097-00			1		. SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	OBD
-76	210-1178-00			1		. WSHR,SHOULDERED:FOR MTG TO-220 TRANSISTOR	49671	DF 137A
-77	342-0355-00			1		. INSULATOR,PLATE:TRANSISTOR,SILICONE RUBBER	000BB	7403-09FR-51
						- - - * - - -		
-78	214-3134-00			1		. HT SK,MICROCKT:TO-220,AL	80009	214-3134-00
						(ATTACHING PARTS)		
-79	211-0097-00			1		. SCREW,MACHINE:4-40 X 0.312 INCH,PNH STL	83385	OBD
						- - - * - - -		
-80	136-0514-00			4		. SKT,PL-IN ELEC:MICROCIRCUIT,8 DIP	73803	CS9002-8
-81	136-0269-02			5		. SKT,PL-IN ELEK:MICROCIRCUIT,14 DIP,LOW CLE	73803	CS9002-14
-82	136-0260-02			9		. SKT,PL-IN ELEK:MICROCIRCUIT,16 DIP,LOW CLE	71785	133-51-92-008

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-83	----- -----			1		CKT BOARD ASSY:DIGITAL(SEE A16 REPL)		
-84	129-0425-00			2		. SPACER,POST:0.90 L X 0.25 HEX	80009	129-0425-00
						(ATTACHING PARTS)		
-85	211-0678-00			2		. SCR,ASSEM WSHR:4-40 X 0.281 L,PNH STEEL	78189	OBD
						- - - * - - -		
-86	344-0154-03			4		. CLIP,ELECTRICAL:FUSE,CKT BD MT	80009	344-0154-03
-87	----- -----			3		. TERM TEST POINT:(SEE A16TP1410,TP1411,		
	----- -----			-		. TP1420 REPL)		
-88	136-0694-00			1		. SKT,PL-IN ELEK:MICROCIRCUIT,28 CONTACT	73803	CS9002-28
-89	136-0621-00			1		. SOCKET,PLUG-IN:22 CONTACT	73803	CS9002-22
-90	136-0578-00			1		. SKT,PL-IN ELEK:MICROCKT,24 PIN,LOW PROFILE	73803	C S9002-24
-91	136-0623-00			1		. SOCKET,PLUG-IN:40 DIP,LOW PROFILE	73803	CS9002-40
-92	136-0269-02			6		. SKT,PL-IN ELEK:MICROCIRCUIT,14 DIP,LOW CLE	73803	CS9002-14
-93	136-0260-02			19		. SKT,PL-IN ELEK:MICROCIRCUIT,16 DIP,LOW CLE	71785	133-51-92-008
-94	----- -----			2		. CONNECTOR,RCPT:(SEE A16J1001 REPL)		
-95	----- -----			1		. CONN,RCPT,ELEC:(SEE A16J1210,J1211 REPL)		
	198-4522-00			1		. WIRE SET,ELEC:	80009	198-4522-00
	----- -----			-		. (FROM A16 TO A18J1611)		
	352-0162-05			1		. . CONN BODY,PL,EL:4 WIRE GREEN	80009	352-0162-05


A12
A18

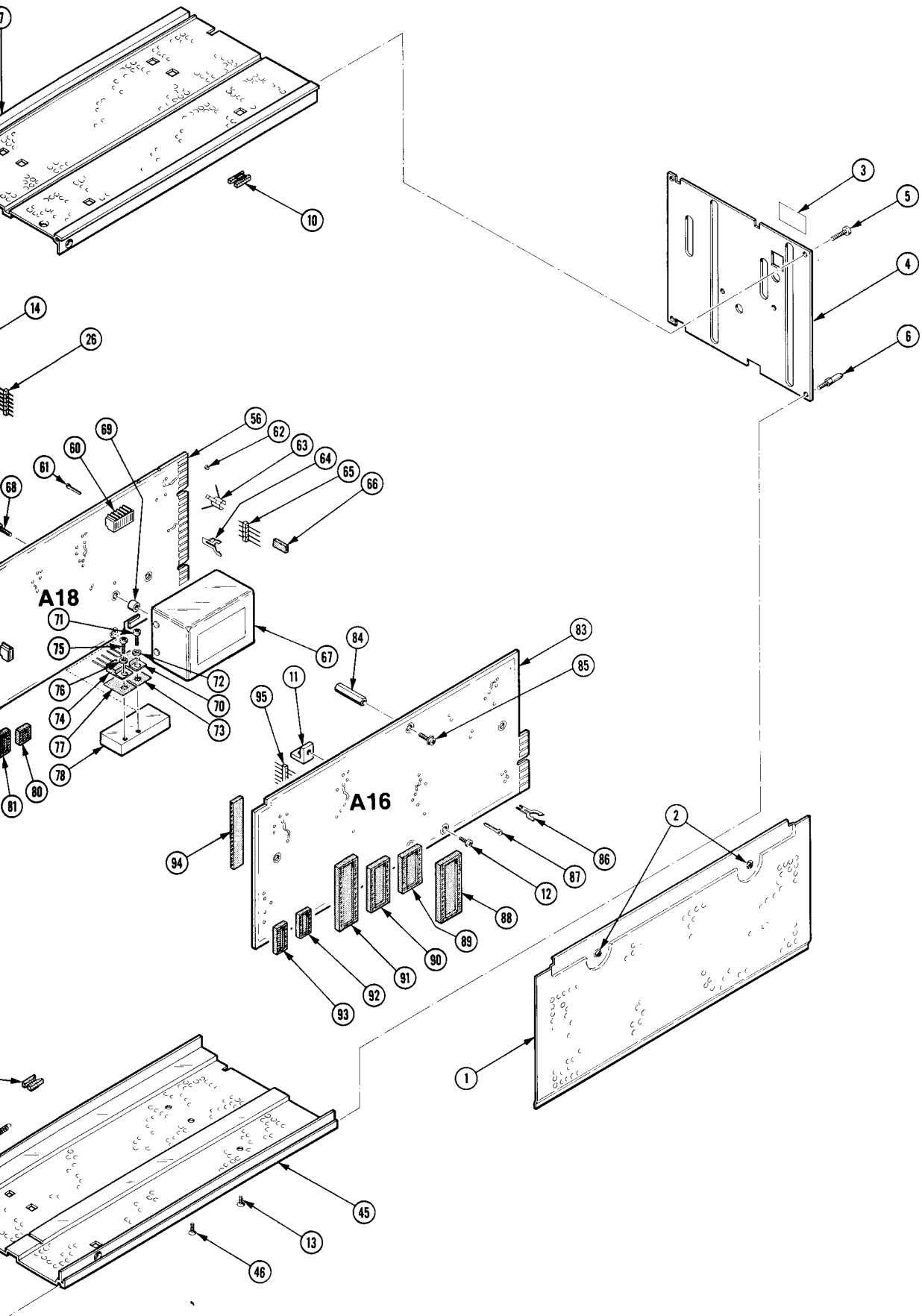

A18
A16

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
						ACCESSORIES		
	070-3552-01			1		MANUAL,TECH:INSTRUCTION	80009	070-3552-01
	070-3553-00			1		MANUAL,TECH:REFERENCE GUIDE	80009	070-3553-00
	012-0532-00			1		CABLE,INTCON:50 OHM COAX,42.0 L	80009	012-0532-00
						OPTIONAL ACCESSORIES		
	010-6125-01			1		PROBE,COUNTER:P6125,1.5 METER	80009	010-6125-01

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

Tektronix®
COMMITTED TO EXCELLENCE

MANUAL CHANGE INFORMATION

Date: 10-7-81 Change Reference: C2/1081

Product: DC 510 UNIVERSAL COUNTER/TIMER Manual Part No.: 070-3552-01

DESCRIPTION

All references to the SA 501 in this manual now apply to the 067-1090-00 Signature Analyzer.

Tektronix®
COMMITTED TO EXCELLENCE

MANUAL CHANGE INFORMATION

Date: 10-20-81 Change Reference: C3/1081

Product: DC 510 UNIVERSAL COUNTER/TIMER Manual Part No.: 070-3552-01

DESCRIPTION

Pilot Changes #13 and #14

REPLACEABLE ELECTRICAL PARTS LIST CHANGE

CHANGE TO: (EFFECTIVE SN B010470 - Pilot Change #13)

A18C1331 281-0773-00 CAP.,FXD,CER DI:0.01UF,10%,100V
(located on the AUXILIARY board and shown on diagram 8)

DIAGRAM <9> PROCESSOR AND DISPLAY DRIVERS - Partial

(EFFECTIVE SN B020000 - Pilot Change #14)

Use a 74LS00 inverter in the clock (Ø2) instead of a CMOS 4049