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.

TEKTRONIX®

475A OSCILLOSCOPE

WITH OPTIONS

SERVICE

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

Serial Number [redacted]

WARRANTY

All TEKTRONIX instruments are warranted against defective materials and workmanship for one year. Any questions with respect to the warranty should be taken up with your TEKTRONIX Field Engineer or representative.

All requests for repairs and replacement parts should be directed to the TEKTRONIX Field Office or representative in your area. This will assure you the fastest possible service. Please include the instrument Type Number or Part Number and Serial Number with all requests for parts or service.

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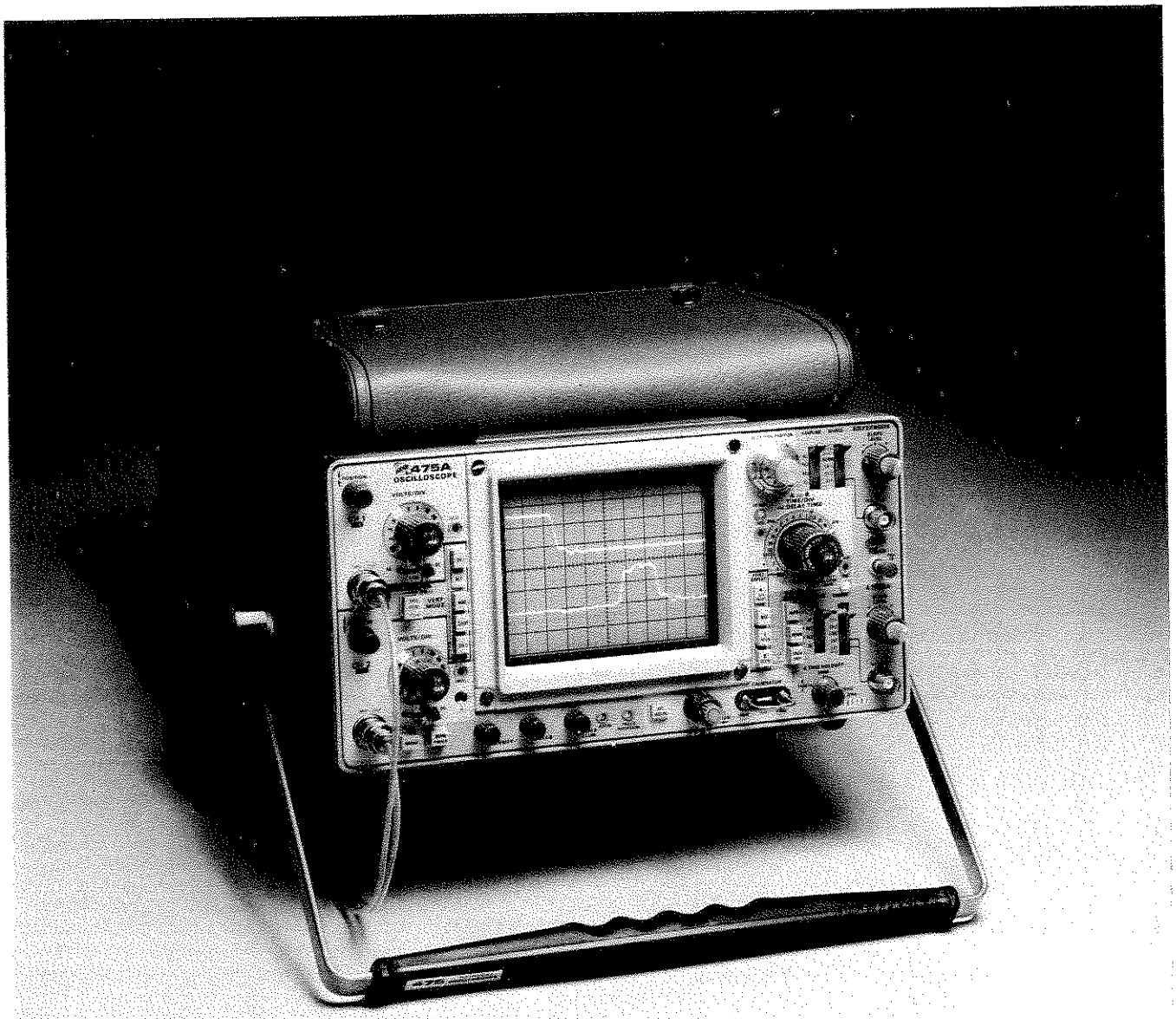


2162-01

Fig. 1-1. 475A Oscilloscope.

SPECIFICATION

Introduction

The 475A Oscilloscope is a 250 megahertz bandwidth portable instrument designed to operate in a wide range of environmental conditions. The lightweight, compact design combines accurate high-frequency measurement capability and ease of transportation.

The dual-channel, DC-to-250 megahertz vertical deflection system provides calibrated deflection factors from 5 millivolts to 10 volts/division. A BW/TRIG VIEW switch permits limiting the bandwidth of the vertical system to reduce interference from high-frequency signals when viewing lower-frequency, low-level signals. The switch also permits displaying of the signal applied to the 'A' Trigger Generator on the CRT.

The trigger circuits provide stable sweep triggering to beyond the 250 megahertz bandwidth of the vertical deflection system. Separate controls are provided to select the desired mode of triggering for the A and B sweeps. The A sweep can be operated in one of three modes; automatic triggering, normal triggering, or single sweep. A variable trigger holdoff control permits the A sweep to trigger in a stable manner on aperiodic signals or complex digital words. The horizontal deflection system has calibrated sweep rates from 0.5 second to 0.01 microsecond/division. A X10 magnifier increases each sweep rate by a factor of 10 to provide a maximum sweep rate of one nanosecond per division in the .01 μs position. The delayed and mixed sweep features allow the start of B sweep to be delayed a selected amount from the start of A sweep to provide accurate relative-time measurements. Calibrated X-Y measurements can be made with Channel 2 providing the vertical deflection and Channel 1 providing the horizontal deflection (TIME/DIV switch fully counterclockwise and VERT MODE switch to CH 2). Regulated DC power supplies provide stable instrument performance over a wide range of line voltages and frequencies. Maximum power consumption of the instrument is approximately 100 watts.

Characteristics

The following instrument specifications apply over an ambient temperature range of −15°C to +55°C unless otherwise specified. Warmup time for specified accuracies is 20 minutes. The calibration procedure given in Section 6, if performed completely, will ensure the instrument meets the electrical characteristics listed in this section.

TABLE 1-1

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
VERTICAL DEFLECTION SYSTEM (CH 1 and CH 2)		
Deflection Factor Calibrated Range	5 mV to 10 V/DIV in 11 steps; 1-2-5 sequence.	
Cascaded Operation (CH 2 VERT SIGNAL OUT Connected to CH 1)	Deflection Factor to approximately 2.5 mV/div into 50 Ω. Bandwidth: DC to ⩾50 MHz.	CH 2 VERT SIGNAL OUT into CH 1 input. DC coupled using a 50 Ω, 42" RG58A/U cable terminated in 50 Ω at CH 1 input.
Uncalibrated (VAR VOLTS/DIV) Range	Provides continuously variable deflection factors between the calibrated steps. Extends maximum uncalibrated deflection factor to at least 25 volts per division in the 10 V/DIV position.	At least 2.5:1.
Low Frequency Linearity		0.1 division or less compression or expansion of 2 division signal at center screen positioned to the upper and lower extremes of the graticule area.
Deflection Factor Accuracy	Within 3% of indicated deflection.	With GAIN set at 10 mV/DIV.
Bandwidth	DC to 250 MHz or greater.	
Risetime	1.4 ns or less (Calculated)[1].	
AC Coupled Lower —3 dB Point	10 Hz or less with 1X probe.	1 Hz or less with 10X probe.
Bandwidth with 100 or 20 MHz BW Switch in 20 MHz Position	Approximately 20 MHz.	—3 dB point between 15 MHz and 20 MHz.
Bandwidth with 100 or 20 MHz BW Switch in 100 MHz Position	Approximately 100 MHz.	—3 dB point between 75 MHz and 125 MHz.
Input Resistance and Capacitance	1 MΩ within 2% paralleled by approximately 20 pF.	

[1]**Risetime is calculated from the formula:** $\frac{0.35}{\text{BW (in megahertz)}}$

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
VERTICAL DEFLECTION SYSTEM (cont)		
Step Response Positive-Going Step Aberrations (0°C to 40°C) At 10 mV/DIV		+4%, −4%, 4% P-P.
Negative-Going Step		Add 3% to positive-going step aberrations.
Added Mode		Add 3% to positive-going step aberrations.
Common-Mode Rejection Ratio (ADD Mode with CH 2 inverted)		20:1 at 1 kHz for common-mode signals of 8 divisions or less.
Trace Shift as VAR is Rotated		Adjusts to 2 divisions or less.
INVERT Trace Shift		Within 1 division from center screen when switching from normal to inverted.
Channel Isolation		At least 100:1 at 50 MHz.
Position Range		At least +12 and −12 divisions from graticule center.
Signal Delay Between CH 1 and CH 2		0.25 ns or less at 5 mV/DIV.
Maximum Input Voltage	DC coupled: 250 V (DC + peak AC) or 500 V P-P AC at 1 kHz or less AC coupled: 500 V (DC + peak AC) or 500 V P-P AC at 1 kHz or less.	
Chopped Mode Repetition Rate	Approximately 1 MHz.	−20%, +30%.

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
TRIGGER SYSTEM		
Sensitivity		
DC Coupled	0.3 div internal or 50 mV external from DC to 40 MHz, increasing to 2.0 div internal or 250 mV external at 250 MHz.	
AC Coupled	0.3 div internal or 50 mV external from 60 Hz to 40 MHz, increasing to 2.0 div internal or 250 mV external at 250 MHz. Attenuates signals below about 60 Hz.	
HF REJ Coupled	0.5 div internal or 100 mV external from 60 Hz to 50 kHz. Attenuates signals below about 60 Hz and above about 50 kHz.	
LF REJ Coupled	0.5 div internal or 100 mV external from 50 kHz to 40 MHz, increasing to 2.0 div internal or 500 mV external at 250 MHz. Attenuates signals below about 50 kHz.	
Trigger Jitter	0.2 ns or less at 250 MHz at 1 ns/DIV sweep rate (X10 MAG on).	
External Trigger Input		
Maximum Input Voltage	250 V DC + peak AC or 250 V P-P AC (1 kHz or less).	
Input Resistance and Capacitance	1 MΩ within 10%, paralleled by approximately 20 pF.	

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
TRIGGER SYSTEM (cont)		
LEVEL Control Range		
EXT	At least + and −2 V, 4 V P-P.	
EXT ÷10	At least + and −20 V, 40 V P-P. Exclude LF REJ coupling mode.	
Trigger View		
Deflection Factor	Approximately 50 mV/DIV.	±20%. Exclude LF REJ and HF REJ trigger coupling modes.
Risetime		≤4.0 ns over the 10% to 90% part of the fast-rise portion.
Delay Difference		≤2.5 ns with a 5 division signal having 1 ns or less risetime from a 25 Ω source, centered vertically with equal cable length from signal source to vertical channel and external trigger inputs, each terminated in 50 Ω.
Centering of Trigger Point		Adjustable to within 1.0 division of center screen.
HORIZONTAL DEFLECTION SYSTEM		
Calibrated Sweep Range		
A Sweep or B DLY'D Sweep	0.5 s/DIV to 0.01 μs/DIV in 24 steps; 1-2-5 sequence. X10 MAG extends maximum sweep rate to 1 ns/DIV.	
A Delaying Sweep (or A INTEN)	0.5 s/DIV to 0.05 μs/DIV in 22 steps; 1-2-5 sequence.	

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements		Supplemental Information
HORIZONTAL DEFLECTION SYSTEM (cont)			
Calibrated Sweep Accuracy	UNMAGNIFIED	MAGNIFIED	Accuracy specification applies over the full 10 divisions of deflection unless otherwise specified. For all sweeps; exclude the first 25 ns when checking 0.01 and 0.02 μs/div unmagnified sweep rates. For all sweeps except B; exclude the first 25 ns or 2 unblanked div (whichever is greater) and all beyond the 100th division of the sweep when checking magnified sweep rates. For B sweep; exclude the first 25 ns or 5 unblanked div (whichever is greater) and all beyond the 100th division of the sweep when checking B magnified sweep rates.
+20°C to +30°C			
A or B DLY'D Sweep			
5 ms/DIV to 0.01 μs/DIV	±1%	±2%	
5 s/DIV to 10 ms/DIV	±2%	±3%	
A INTEN Sweeps (or A Delaying)			
0.5 s/DIV to 0.05 μs/DIV	±2%	±3%	
−15°C to +55°C			
All Sweeps	±3%	±4%	
X10 Magnified Sweep Accuracy	Within 5% over any 2 division interval.		
Mixed Sweep Accuracy	Within 3%		Accuracy applies over 8 divisions of deflection. B sweep must be at least 1 TIME/DIV setting faster than A Sweep on all ranges. When checking A TIME/DIV accuracy, exclude the first 0.5 division after the display start; when checking B TIME/DIV accuracy, exclude the first 0.2 division or 0.1 μs (whichever is greater) after the transition of A to B.
VAR TIME/DIV Control Range	Continuously variable between calibrated settings. Extends the slowest A sweep rate to at least 1.25 seconds per division.		At least 2.5:1.
Sweep Length (A Only)			At least 10.1 divisions.
A Trigger Holdoff	Increases sweep holdoff time to at least 9 times the TIME/DIV switch setting.		

TABLE 1-1 (cont)

ELECTRICAL

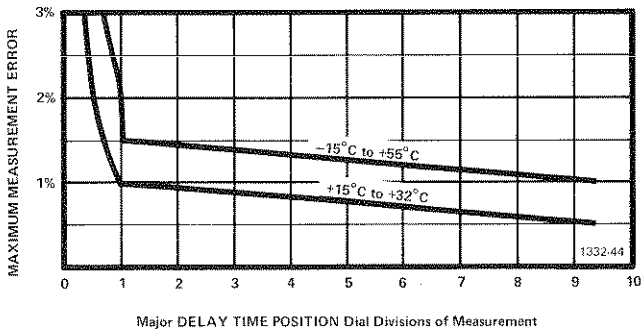
Characteristics	Performance Requirements		Supplemental Information
HORIZONTAL DEFLECTION SYSTEM (cont)			
Magnified Registration			Within 0.5 division from graticule center at 1 ms/DIV when switching X10 magnifier from on to off.
POSITION Control Range			Start of sweep must position to right of graticule center. End of sweep must position to left of graticule center. Check made at 1 ms/DIV.
Delay Time and Differential Time Measurement Accuracy (simplified)	+15°C to +35°C (+60°F to +95°F)	−15°C to +55°C (+5°F to +131°F)	Exclude dial settings of 0.00 thru 0.50 for 0.5 sec through 1 μs/DIV delaying sweep rates. Exclude dial settings of 0.00 thru 1.00 for .5 μs thru .05 μs/DIV delaying sweep rates.
Over One or More Major Dial Divisions	±1%	±1.5%	
Over Less Than One Major Dial Division	±0.01 Major Dial Division	±0.02 Major Dial Division	
Delay Time and Differential Time Measurement Accuracy (see Fig. 1-2)			
Delay Pickoff Jitter	Within 0.002% (less than one part in 50,000) of the maximum available delay time when operating the instrument on power line frequencies above 52 Hz, decreasing to 0.005% (less than one part in 20,000) on power line frequencies of 48 to 52 Hz.		
Delay Range	From 0.05 μs or less to at least 5 seconds after the start of the delaying (A) sweep. Maximum available delay time is ten times the setting of the A TIME/DIV switch.		

Fig. 1-2. Detailed Delay Time and Differential Time Measurement accuracy.

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
X-Y OPERATION		
Sensitivity	Same as vertical deflection system.	Extreme counterclockwise position of TIME/DIV switch. CH 2 OR X-Y button of VERT MODE switch must be pushed.
Deflection Accuracy	Same as vertical deflection system.	
Variable Range	Same as vertical deflection system.	
X-Axis Bandwidth	DC to 3 MHz.	
Input Capacitance	Same as vertical deflection system.	
Input Resistance	Same as vertical deflection system.	
Maximum Input Voltage	Same as vertical deflection system.	
Phase Difference Between X and Y Axis Amplifiers		Within 1° from DC to 1 MHz. Within 3° from 1 MHz to 2 MHz.
X Axis Low Frequency Linearity		0.2 div or less compression or expansion of a 2 div signal at center screen, positioned to horizontal extremes of display area.
CALIBRATOR		
Output Voltage		Adjusted to within 0.5% at 25° C, ±5° C
0° C to +40° C	300 mV within 1.0%.	
−15° C to +55° C		300 mV within 1.5%.
Repetition Rate	Approximately 1 kHz.	Within 25%.
Output Resistance		Approximately 9.4 Ω.
Output Current		
+20° C to +30° C	30 mA within 2%.	
−15° C to +55° C		30 mA within 2.5%
Z AXIS INPUT		
Sensitivity	5 V P-P signal causes noticeable modulation at normal intensity.	Positive-going signal from ground decreases intensity.
Useable Frequency Range	DC to 50 MHz.	
Maximum Input Voltage		100 V (DC plus peak AC). 100 V P-P AC at 1 kHz or less.

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
SIGNAL OUTPUTS		
CH 2 VERT SIGNAL OUT	One division of deflection gives approximately 20 mV into 1 MΩ load.	
Output Voltage	One division of deflection gives approximately 10 mV into 50 Ω load.	
Output Resistance		Approximately 50 Ω.
Bandwidth	DC to at least 50 MHz into 50 Ω.	
Output DC Level	Approximately 0 V.	
A and B + GATE Outputs		
Output Voltage	Approximately 5 V positive-going.	
Output Resistance		Approximately 500 Ω.
POWER SOURCE		
Line Voltage Ranges (AC, RMS)		
115 V		
Low	110 V, ±10%.	99 V to 121 V.
Medium	115 V, ±10%.	103.5 V to 126.5 V.
High	120 V, ±10%.	108 V to 132 V.
230 V		
Low	220 V, ±10%.	198 V to 242 V.
Medium	230 V, ±10%.	207 V to 253 V.
High	240 V, ±10%.	216 V to 264 V.
Line Frequency	48 Hz to 440 Hz.	
Maximum Power Consumption	100 watts at 115 V, 60 Hz.	

TABLE 1-1 (cont)

ELECTRICAL

Characteristics	Performance Requirements	Supplemental Information
CATHODE-RAY TUBE		
Horizontal Resolution		At least 15 lines/division
Vertical Resolution		At least 15 lines/division.
Display Area	8 x 10 cm.	
Geometry		0.1 division or less of tilt or bowing.
Raster Distortion		0.1 division or less.
Normal Accelerating Potential		Approximately 18,000 V.
Trace Rotation Range		Adequate to align trace with horizontal center line.
Standard Phosphor	P31.	
Optional Phosphor	P11.	

TABLE 1-2

ENVIRONMENTAL

Characteristics	Performance Requirements	Supplemental Information
Temperature		
Operating (AC)	−15°C to +55°C.	
Storage	−55°C to +75°C.	
Altitude		
Operating	To 15,000 feet. Maximum operating temperature decreased 1°C/1,000 feet above 5,000 feet.	
Storage	To 50,000 feet.	
Humidity (Operating and Storage)	5 cycles (120 hours) referenced to MIL-E-16400F.	
Vibration (Operating)	15 minutes along each of three major axes at a total displacement of 0.025 inch P-P (4 g's at 55 Hz) with frequency varied from 10 Hz to 55 Hz to 10 Hz in one minute sweeps. After sweep vibration in each axis, hold frequency steady at each major resonance for 3 minutes, or if no such resonances are found, hold at 55 Hz for three minutes.	
Shock (Operating and Non-operating)	30 g's, 1/2 sine, 11 ms duration, 2 shocks per axis each direction for a total of 12 shocks.	
Transportation	Meets the limits of National Safe Transit Committee test procedure 1A with a 30-inch drop.	

TABLE 1-3

PHYSICAL

Characteristics	Information
Construction	
Chassis	Aluminum alloy.
Panel	Aluminum alloy with anodized finish.
Cabinet	Blue vinyl-coated aluminum alloy.
Circuit Boards	Glass laminate etched-wiring.
Overall Dimension	
Height	
With Feet and Pouch	7.5 inches (19.1 cm).
Without Pouch	6.2 inches (15.7 cm).
Width	
With Handle	12.9 inches (32.8 cm).
Without Handle	11.5 inches (29.2 cm).
Depth	
Including Panel Cover	18.1 inches (46 cm).
Handle Extended	20.3 inches (51.5 cm).
Weight	
With Panel Cover, Accessories, and Accessory Pouch	25.3 pounds (11.5 kg).
Without Panel Cover, Accessories, and Accessory Pouch.	22.8 pounds (10.3 kg).
Domestic Shipping Weight	32.7 pounds (14.8 kg).
Export Shipping Weight	Approximately 48.0 pounds (21.8 kg).

Standard Accessories

Standard accessories supplied with the 475A are listed in the Mechanical Parts List, in this Service manual. For optional accessories available for use with the 475A, see the Tektronix, Inc., catalog.

OPERATING INFORMATION

PRELIMINARY INSTRUCTIONS

Introduction

This section of the manual is intended to allow the operator to become familiar with the instrument's power requirements, functions of controls and connectors, and how to obtain a few basic displays. For more complete operating information refer to the 475A Operators Instruction Manual.

Safety Information

WARNING

This instrument may be damaged if operated with the Line Voltage Selector Switch or the Regulating Range Selector set for the wrong applied line voltage. Please read the following instructions before operating to be sure that the requirements for instrument power and user safety are met.

Power Cord Conductor Identification

Conductor	Color	Alternate Color
Ungrounded (Line)	Brown	Black
Grounded (Neutral)	Blue	White
Grounding (Earthing)	Green-Yellow	Green-Yellow

This instrument is designed to operate from a single-phase power source with one of the current-carrying conductors (the neutral conductor) at ground (earth) potential. Operation from power sources where both current-carrying conductors are live with respect to ground (such as phase-to-phase on a 3-wire system) is not recommended, since only the line conductor has over-current (fuse) protection within the instrument.

This instrument has a 3-wire power cord with a 3-terminal polarized plug for connection to the power source and safety-earth. The ground terminal of the plug is directly connected to the instrument frame. For electric-shock protection, insert this plug in a mating outlet with a safety-earth contact. If a 3-to-2 wire adapter is used to connect this instrument to a 2-wire ac power system, be sure to connect the ground lead of the adapter to earth (ground). Failure to complete the ground system may allow the chassis of this instrument to be elevated above ground potential and pose a shock hazard.

Operating Power Sources

This instrument can be operated from either a 115 volt or 230 volt nominal line voltage source, 48 to 440 Hertz. The Line Voltage Selector switch in the instrument converts the instrument from a one nominal operating voltage to the other. The Regulating Range Selector assembly on the instrument rear panel selects 1 of 3 regulating ranges for each nominal line voltage, and also contains the line fuse for overload protection.

Line Voltage and Regulating Range

To select the correct nominal line voltage, regulating range and line fuse, proceed as follows:

1. Disconnect the instrument from the power source.

2. Set the Line Voltage Selector switch (located near the right rear of instrument) to indicate the desired nominal line voltage.

3. Loosen the 2 captive screws that hold the cover on the Regulating Range Selector assembly; then pull on the cover to remove.

4. Check Table 2-1 for the recommended rating of the line fuse to be used with the desired nominal line voltage. Check the fuse in the selector switch cover for the recommended rating or install a fuse with the recommended rating. The instrument Accessory Pouch should contain a spare fuse for each nominal line voltage at any time.

TABLE 2-1
Regulating Ranges

Range Selector Switch Position	Regulating Range	
	115 Volts Nominal	230 Volts Nominal
LO (Switch bar in lower holes)	99 to 121 volts	198 to 242 volts
M (Switch bar in middle holes)	103.5 to 126.5 V	207 to 253 V
HI (Switch bar in upper holes)	108 to 132 volts	216 to 264 volts
Fuse Rating	1.5 A 3AG Fast-blow	0.75 A 3AG Fast-blow

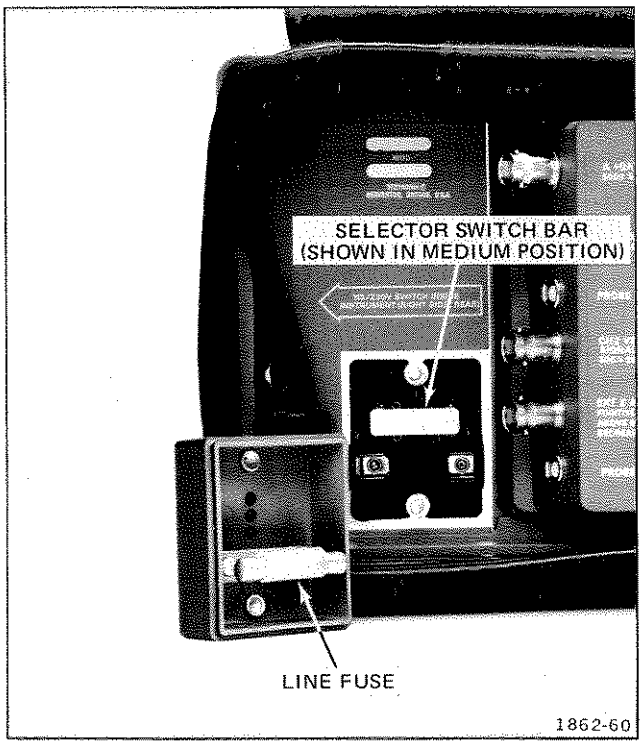


Fig. 2-1. Regulating Range Selector and Line Fuse.

5. Check Table 2-1 for the recommended range position of the Range Selector Switch Bar (see Figure 2-1). Select a range which is centered about the average line voltage to which the instrument is to be connected. The middle position ("M") is a typical setting.

6. If necessary, gently pull out the Range Selector Switch Bar, slide the bar to the desired position and plug it back in.

7. Install the cover on the Regulating Range Selector assembly and gently tighten the 2 captive screws.

8. Connect the instrument to the recommended power source, pull the instrument POWER switch to ON and begin usage of the 475A Oscilloscope.

Options

Options are available to alter oscilloscope performance to meet particular applications. A number in either MOD slot (see instrument rear panel) indicates that the instrument contains an option.

Refer to the Option section in this manual to find any change in operating instructions as a result of the option.

CONTROLS AND CONNECTORS

General

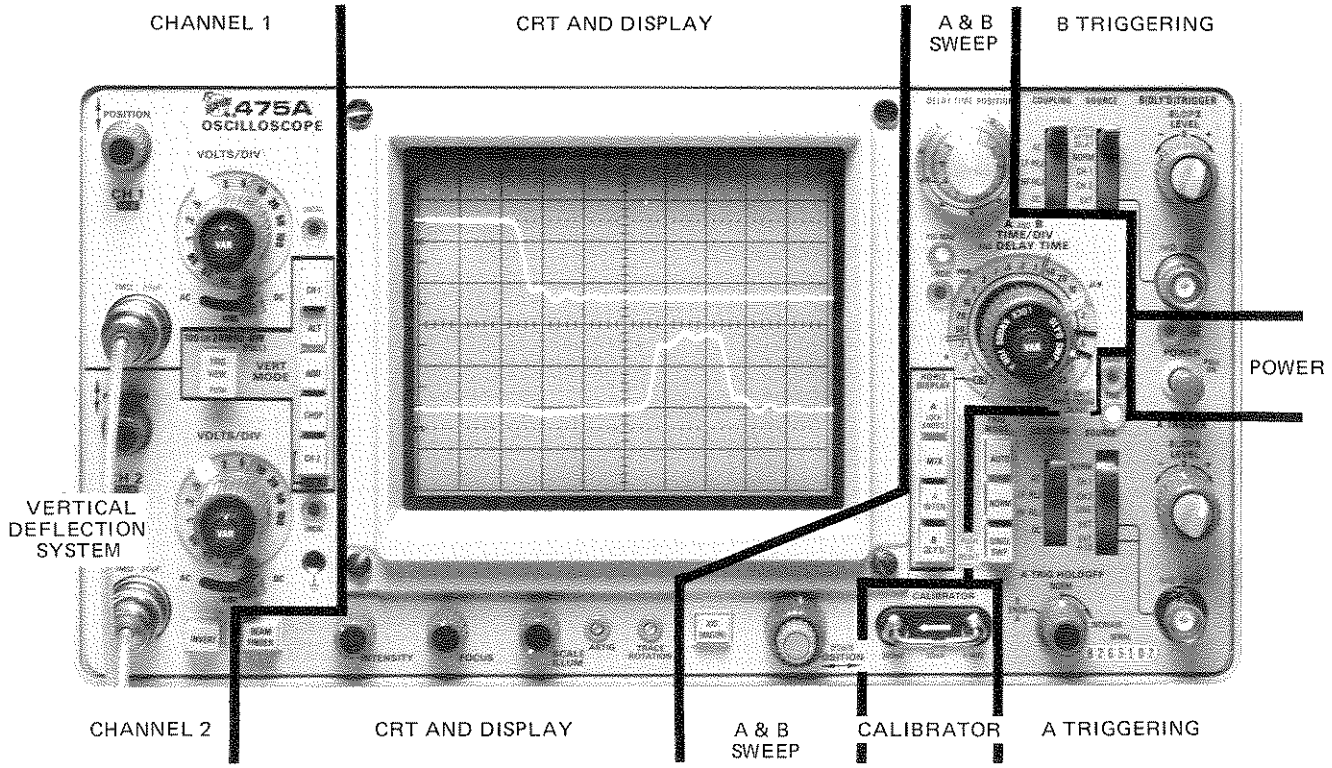
The major controls and connectors for operation of the 475A are located on the front panel of the instrument. A few auxiliary functions are provided on the rear panel. Fig. 2-2 shows the front and rear panels of the 475A. A brief description of each control and connector is given here. More detailed operating information is given in the 475A Oscilloscope Operators Manual.

Cathode-Ray Tube (CRT) and Display

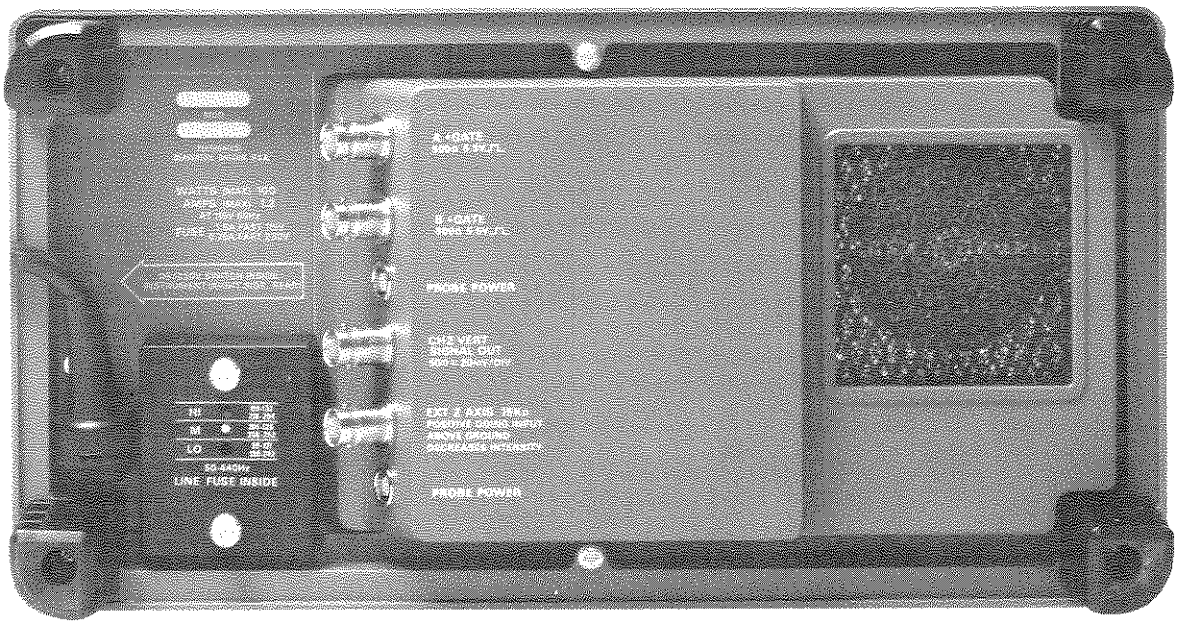
BEAM FINDER	Limits the display to within the graticule area, independently of display position or applied signals and sets the display brightness to a normal viewing level.
INTENSITY	Controls brightness of the display.
FOCUS	Provides adjustment for optimum display definition.
SCALE ILLUM	Controls graticule brightness.
ASTIG	Screwdriver adjustment used in conjunction with the FOCUS control to obtain a well-defined display. Does not require readjustment in normal use.
TRACE ROTATION	Screwdriver adjustment to align the trace with the horizontal graticule lines.

Vertical Deflection System (Channel 1 & Channel 2)

POSITION	Controls the vertical position of the trace. In the X-Y mode of operation, the CH 2 control positions on the Y-axis (vertically) and the CH 1 POSITION control positions on the X-axis (horizontally).
CH 1 OR X	Input connector for Channel 1 deflection signals or X-axis deflection in the X-Y mode of operation.



A. FRONT PANEL



B. REAR PANEL

2162-02

Fig. 2-2. Front panel and rear panel controls and connectors.

CH 2 OR Y

Input connector for Channel 2 deflection signals or Y-axis deflection in the X-Y mode of operation.

GAIN (5 and 10 mV)

Screwdriver adjustments to set the gain of the Vertical Preamp.

VOLTS/DIV

Selects vertical deflection factor in a 1-2-5 sequence (VAR control must be in the calibrated detent for the indicated deflection factor).

VAR

Provides continuously variable uncalibrated deflection factors between the calibrated settings of the VOLTS/DIV switch.

UNCAL

Light indicates that the VAR control is not in the calibrated position.

Input Coupling (AC-GND-DC)

Selects the method of coupling signal to the input of the Vertical Amplifier.

AC: Signal is capacitively coupled to the Vertical Amplifier. DC component of signal is blocked. Low-frequency limit (lower −3 dB point) is about 10 Hertz.

GND: Input signal is removed and the input circuit is grounded. Does not ground the input signal.

DC: All components of the input signal are passed to the Vertical Amplifier.

100 OR 20 MHz BW/ TRIG VIEW

Multi-purpose switch that limits vertical bandwidth or displays an external triggering signal. Full bandwidth of 250 MHz is provided in the switch position obtained when the TRIG VIEW is pushed in, then released. The full bandwidth position serves as the reference for the following settings.

100 (MHz): When TRIG VIEW button is pulled to the first detent (100 indicated on yellow band of TRIG VIEW knob) the upper bandwidth of the complete Vertical Deflection System is limited to approximately 100 MHz.

20 (MHz): When TRIG VIEW button is pulled to the second detent (100 and 20 indicated on yellow band of TRIG VIEW knob) the upper bandwidth of the complete Vertical Deflection System is limited to approximately 20 MHz.

TRIG VIEW: When the TRIG VIEW button is pushed and held, the output of the Vertical Preamplifier is interrupted, and the trigger signal selected by the setting of A TRIGGER SOURCE switch is displayed on the crt.

When the TRIG VIEW button is pushed and held, the crt display available is explained in each of the following settings of the A TRIGGER SOURCE switch.

NOTE

The signals displayed are affected by the coupling characteristics of the A TRIGGER COUPLING switch positions (see A Trigger Coupling information in this section).

The A TRIGGER LEVEL control affects the triggering and the vertical positioning when using a TRIG VIEW display.

NORM: Any signal that is displayed in full bandwidth position is viewed with an increase in signal amplitude.

CH 1: Any signal that is displayed in CH 1 of VERT MODE, in full bandwidth position, is viewed with an increase in signal amplitude.

CH 2: Any signal that is displayed in CH 2 of VERT MODE, in full bandwidth position, is viewed with an increase in signal amplitude.

LINE: The power line signal is displayed at an amplitude approximately equalling full vertical graticule deflection.

EXT: The signal present at the A TRIGGER external input connector will be displayed.

EXT ÷ 10: The signal present at the A TRIGGER external input connector will be displayed, but will be reduced approximately 10 times of that viewed in EXT.

INVERT — Pushbutton switch that inverts the Channel 2 display.

VERT MODE — Selects the vertical mode of operation.

CH 1: Displays Channel 1 only.

ALT: Dual-trace display of signals using both channels. Display is switched between channels at the end of each sweep.

ADD: Signals applied to the CH 1 OR X and the CH 2 OR Y connectors are algebraically added and the sum is displayed on the crt. The INVERT switch in Channel 2 allows the display to be CH 1 + CH 2 or CH 1 − CH 2.

CHOP: Dual-trace display of signals on both channels. Display is switched between channels at an approximate repetition rate of 1 megahertz.

CH 2 OR X-Y: Displays Channel 2 only. Must be pushed when operating in X-Y mode.

A and B Triggering (both where applicable)

COUPLING — Determines the method used to couple signal to input of trigger circuits.

AC: Rejects DC and attenuates signals below about 60 Hz. Accepts signals above about 60 Hz.

LF REJ: Rejects DC and attenuates signals below about 50 kHz. Accepts signals above about 50 kHz.

HF REJ: Accepts signals between 60 Hz and 50 kHz. Rejects DC and attenuates all signals outside the above range.

DC: Accepts all trigger signals between DC and 200 MHz or greater.

SOURCE — Selects source of trigger signal.

NORM: Internal trigger signal obtained from Vertical Deflection System. Actual source is signal(s) displayed on crt.

CH 1: A sample of the signal connected to the CH 1 OR X input connector is used as a trigger signal.

CH 2: A sample of the signal connected to the CH 2 OR Y input connector is used as a trigger signal.

EXT: Trigger signal obtained from signal connected to the External Trigger Input connector.

EXT ÷ 10 (A Trigger circuit only): External trigger signal attenuated by a factor of 10.

STARTS AFTER DELAY (B trigger circuit only): B sweep starts immediately after the delay time selected by the DELAY TIME POSITION dial and the DELAY TIME switch.

LINE (A trigger circuit only): Trigger signal obtained from a sample of the line voltage applied to the instrument.

SLOPE

Selects the slope of the trigger signal which starts the sweep.

+: Sweep can be triggered from the positive-going portion of the trigger signal.

−: Sweep can be triggered from the negative-going portion of the trigger signal.

LEVEL

Selects the amplitude point on the trigger signal at which the sweep is triggered.

A TRIG MODE

Determines the operating mode for the A Trigger Circuit.

AUTO: With the proper trigger control settings, A Sweep can be initiated by signals that have repetition rates above about 20 Hertz and are within the frequency range selected by the COUPLING switch. In the absence of an adequate trigger signal or when the trigger controls are misadjusted, the sweep free-runs to produce a reference trace.

NORM: With the proper trigger control settings, A Sweep can be initiated by signals that are within the frequency range selected by the COUPLING switch. In the absence of an adequate trigger signal or when the trigger controls are misadjusted, there is no trace.

SINGL SWP: After a sweep is displayed, further sweeps cannot be presented until the SINGL SWP pushbutton is pressed again. The display is triggered as for NORM operation using the A Triggering controls.

TRIG Indicator

A light on condition indicates that A Sweep Generator is triggered and will produce a stable display.

A TRIG HOLDOFF

Provides control of holdoff time between sweeps to obtain stable displays when triggering in aperiodic signals (such as complex digital words). Variable can increase hold-off time up to at least 9 times the setting of the TIME/DIV switch. In the B ENDS A position (fully clockwise), the A Sweep is reset at the end of the B Sweep to provide the fastest possible sweep repetition rate for delayed sweep presentations.

External Trigger Input (not labeled)

Input connectors for external trigger signals.

A and B Sweep

DELAY TIME POSITION

Provides variable sweep delay between 0.00 and 10.00 times the delay time indicated by the DELAY TIME switch.

A AND B TIME/DIV AND DELAY TIME

A TIME/DIV switch (clear plastic outer flange) selects the basic delay time to be multiplied by the DELAY TIME POSITION dial setting) for delayed-sweep operation. The B TIME/DIV switch (inner dark knob) selects the sweep rate for A only displays or for the B portion of a delayed sweep display. VAR control must be in the calibrated detent for calibrated sweep rates. Disables sweep for X-Y operation.

VAR

Provides continuously variable (uncalibrated) sweep rates between the calibrated settings of the TIME/DIV switch. Varies the A Time Base sweep rate in the nondelayed mode of horizontal operation and the B Time Base sweep rate in the delayed sweep mode. Extends the slowest sweep rate to at least 1.25 seconds/division. Sweep rate is calibrated when the control is rotated fully clockwise to the calibrated detent.

UNCAL

Light that indicates when the VAR TIME/DIV control is out of the calibrated detent and the horizontal sweep rate is uncalibrated.

X10 MAG Indicator

Light that indicates when the X10 MAG is turned on.

READY

Light that indicates that A Sweep has been prepared to present a single sweep upon receipt of an adequate trigger signal.

HORIZ DISPLAY

Selects the horizontal mode of operation.

A: Horizontal deflection provided by A TIME/DIV switch.

MIX: The first part of the horizontal sweep is displayed at a rate set by the A TIME/DIV switch and the latter part of the sweep at a rate set by the B TIME/DIV switch. Relative amounts of the display allocated to each of the two rates are determined by the setting of the DELAY TIME POSITION dial.

A INTEN: Displayed sweep rate determined by the A TIME/DIV switch. An intensified portion appears on the display during the B sweep time. This switch position provides a check of the duration and position of the B sweep (delayed sweep) with respect to the delaying sweep (A).

B DLYD: Sweep rate determined by the B TIME/DIV switch with the delay time determined by the setting of the DELAY TIME (A TIME/DIV) switch and the DELAY TIME POSITION dial.

Horizontal POSITION

Positions the display horizontally.

Horizontal FINE

Provides more precise horizontal position adjustments.

X10 MAG Pushbutton

Increases the displayed sweep rate by a factor of 10.

Calibrator and Power

CALIBRATOR

A combination current loop/squarewave voltage output device. Provides a 30 mA squarewave current, 300 mV squarewave voltage signal with a repetition rate of approximately 1 kHz.

POWER

Turns instrument power on and off.

LOW LINE Indicator	Light that indicates the applied line voltage is below the lower limit of the regulating range selected by the Regulating Range Selector assembly.

Rear Panel

A + GATE	Output connector providing a positive-going rectangular pulse coincident with the A sweep time.
B + GATE	Output connector providing a positive-going rectangular pulse coincident with the B sweep time.
CH 2 VERT SIGNAL OUT	Output connector providing a sample of the signal applied to the CH 2 input connector.
EXT Z AXIS Input	Input connector for intensity modulation of the crt display.
Regulating Range Selector	Selects the regulating range of the internal power supplies (low, medium, high; determined by specific line voltage applied to the instrument).
PROBE POWER	Connectors that make operating power available for active device probe systems.
Rear Panel Feet	Provide temporary support for the instrument and provide a convenient cord wrap to store power cord when instrument is not in use.

OBTAINING BASIC DISPLAYS

Introduction

The following instructions will allow the operator who is unfamiliar with the operation of the 475A to obtain the basic displays commonly used. Before proceeding with these instructions, preset the instrument controls as follows:

Vertical Controls

VERT MODE Switch	CH 1
VOLTS/DIV Switches	Proper position determined by amplitude of signal to be applied.
VOLTS/DIV VAR Controls	Calibrated detent.
Input Coupling Switches	AC
Vertical POSITION Controls	Midrange
100 or 20 MHz BW Switch	Not limited (Yellow band not visible).
INVERT Switch	Button out
INTENSITY Control	Fully counterclockwise
FOCUS Control	Midrange
SCALE ILLUM Control	Midrange

Trigger Controls (both A and B if applicable)

SLOPE Switch	+
LEVEL Control	0
SOURCE Switch	NORM
COUPLING Switch	AC
TRIG MODE Switch	AUTO
A TRIG HOLDOFF Control	NORM

Horizontal Sweep Controls

TIME/DIV Switches	Locked together at 1 ms
TIME/DIV VAR	Calibrated detent
HORIZ DISPLAY Switch	A
X10 MAG Switch	Off (button out)
POSITION Control	Midrange
FINE Control	Midrange

Normal Sweep Display

1. Pull the POWER switch to on (button out). Allow several minutes for instrument warmup.

2. Connect an external signal to the CH 1 input connector.

3. Advance the INTENSITY control until the display is visible. If the display is not visible with the INTENSITY control at midrange, press the BEAM FINDER pushbutton and adjust the CH 1 VOLTS/DIV switch until the display is reduced in size vertically; then center the compressed display with the vertical and horizontal POSITION controls; release the BEAM FINDER pushbutton. Adjust the FOCUS control for a well-defined display.

4. Set the CH 1 VOLTS/DIV switch and CH 1 POSITION control for a display that remains in the display area vertically.

5. Adjust the A Trigger LEVEL control for a stable display.

6. Set the TIME/DIV switch and the horizontal POSITION control for a display that remains in the display area horizontally.

Magnified Sweep Display

1. Preset the instrument controls and follow steps 1 through 6 for obtaining a Normal Sweep Display.

2. Adjust the horizontal POSITION control to move the area to be magnified to within the center graticule division of the crt. If necessary, change the TIME/DIV switch setting so the complete area to be magnified is within the center division.

3. Set the X10 MAG switch to the on position (button in) and adjust the horizontal POSITION control for precise positioning of the magnified display. Divide the TIME/DIV setting by 10 to determine the magnified sweep rate.

Delayed Sweep Displays

1. Preset the instrument controls and follow steps 1 through 6 for obtaining a Normal Sweep Display.

2. Set the HORIZ DISPLAY switch to A INTEN and the B Trigger SOURCE switch to STARTS AFTER DELAY.

3. Pull out the B TIME/DIV switch knob and turn clockwise so the intensified zone on the display is the desired length. Adjust the INTENSITY control to achieve the desired display brightness.

4. Adjust the DELAY TIME POSITION dial to position the intensified zone to the portion of the display to be delayed.

5. Set the HORIZ DISPLAY switch to B DLYD. The intensified zone on the display noted in step 3 is now being displayed in the delayed form. The delayed sweep rate is indicated by the line on the B TIME/DIV switch knob.

6. For a delayed sweep display that will exhibit less jitter, set the B Trigger SOURCE switch to the same position as the A Trigger SOURCE switch and adjust the B Trigger LEVEL control for a stable display. If the A Trigger SOURCE switch is in the LINE position, a sample of the line voltage will have to be supplied to the B Trigger circuit externally.

Mixed Sweep Display

1. Preset the instrument controls and follow steps 1 through 6 for obtaining a Normal Sweep Display.

2. Pull out the B TIME/DIV switch knob and turn clockwise to the desired sweep rate. Adjust the INTENSITY control to achieve the desired display brightness.

3. Set the HORIZ DISPLAY switch to MIX. The crt display now contains more than one time factor on the horizontal axis. The first portion of the display is at the A Time Base sweep rate and the latter part is at the B Time Base sweep rate. The start of the B Time Base portion of the display can be changed by adjusting the DELAY TIME POSITION control.

X-Y Display

1. Preset the instrument controls and turn the instrument power on. Allow several minutes for instrument warm-up.

2. Set the TIME/DIV switch to X-Y and the VERT MODE to CH 2. Apply the vertical signal to the CH 2 OR Y input connector and the horizontal signal to the CH 1 OR X input connector. The CH 2 POSITION control will provide vertical positioning and the CH 1 POSITION control will provide horizontal positioning.

3. Advance the INTENSITY control until the display is visible. If the display is not visible with the INTENSITY control at midrange, press the BEAM FINDER pushbutton and adjust the CH 1 and CH 2 VOLTS/DIV switches until the display is reduced in size both vertically and horizontally; then center the compressed display with the POSITION controls; release the BEAM FINDER pushbutton. Adjust the FOCUS control for a well-defined display.

CIRCUIT DESCRIPTION

Introduction

This section of the manual describes the circuitry used in the 475A Oscilloscope. The description begins with a discussion of the instrument, using a basic block diagram. Next, each circuit is described in detail, using detailed block diagrams when appropriate, to show the relationships between the stages in each major circuit.

Digital Logic

Digital logic techniques are used to perform many functions within this instrument. The function and operation of the logic circuits are described using logic symbology and terminology. All logic functions are described using the positive logic convention. Positive logic is a system of notation where the more positive of two levels (HI) is called the true or 1 state; the more negative level (LO) is called the false or 0 state. The HI-LO method of notation is used in this logic description. The specific voltages that constitute a HI or LO state vary between individual devices.

NOTE

The HI-LO logic notation can be conveniently converted to 1-0 notation by disregarding the first letter of each step. Thus:

HI = 1
LO = 0

It should be noted that not all of the integrated circuit devices in this instrument are digital logic devices. The function of non-digital devices are described individually, using operating waveforms or other techniques to illustrate their function.

OUTLINE FOR CIRCUIT DESCRIPTION

BLOCK DIAGRAM

General

The following discussion is provided to aid in understanding the overall concept of the 475A Oscilloscope before the individual circuits are discussed in detail. A basic block diagram of the 475A Oscilloscope is shown in Fig. 3-1. Only the basic interconnections between the individual blocks are shown on this diagram. Each block represents a major circuit within the instrument. The numbered diamond in each block refers to the complete circuit diagram of that major circuit and this diagram can be found in the Diagrams Section of this manual.

A complete block diagram is located in the Diagrams Section of this manual. This block diagram shows the overall relationship between all of the circuits. Complete schematics of each circuit are also given in the Diagrams Section. Refer to these diagrams throughout the following circuit description for electrical values, waveforms and relationships of the front panel controls to the individual stages.

Signals to be displayed on the CRT are applied to the CH 1 OR X or CH 2 OR Y connectors. The input signals are then amplified by the Preamplifier circuits. Each Preamplifier circuit includes separate vertical deflection factor, input coupling, balance, gain, and variable attenuation controls. The Channel 2 Preamplifier circuit also contains an INVERT feature to invert the Channel 2 signal as displayed on the CRT.

The output of each Vertical Preamplifier circuit connects to the Vertical Channel Switching circuit. This circuit selects the channel(s) to be displayed. An output signal from this circuit connects to the Z Axis Amplifier circuit to blank out the switching transients between channels when in the chopped mode of operation. The Vertical Channel Switching circuit also provides the Channel 2 VERT SIG OUT signal (available on the instrument rear panel) as well as the signals used for sweep triggering in the NORM, CH 1, and CH 2 positions of the trigger SOURCE switches and the signal used for X-axis deflection in the X-Y mode of horizontal operation.

The output of the Vertical Channel Switching circuit connects to the Vertical Output Amplifier through the Delay Line. The Delay Line provides a fixed amount of signal delay through the vertical deflection system to allow viewing the leading edge of a triggering waveform. The Vertical Output Amplifier circuit provides the final amplification for the signal before it is connected to the vertical deflection plates of the CRT. This circuit includes the BEAM FINDER switch, which limits the vertical and horizontal deflection to within the viewing area, and sets the display brightness to a normal viewing level to aid in locating an off-screen display.

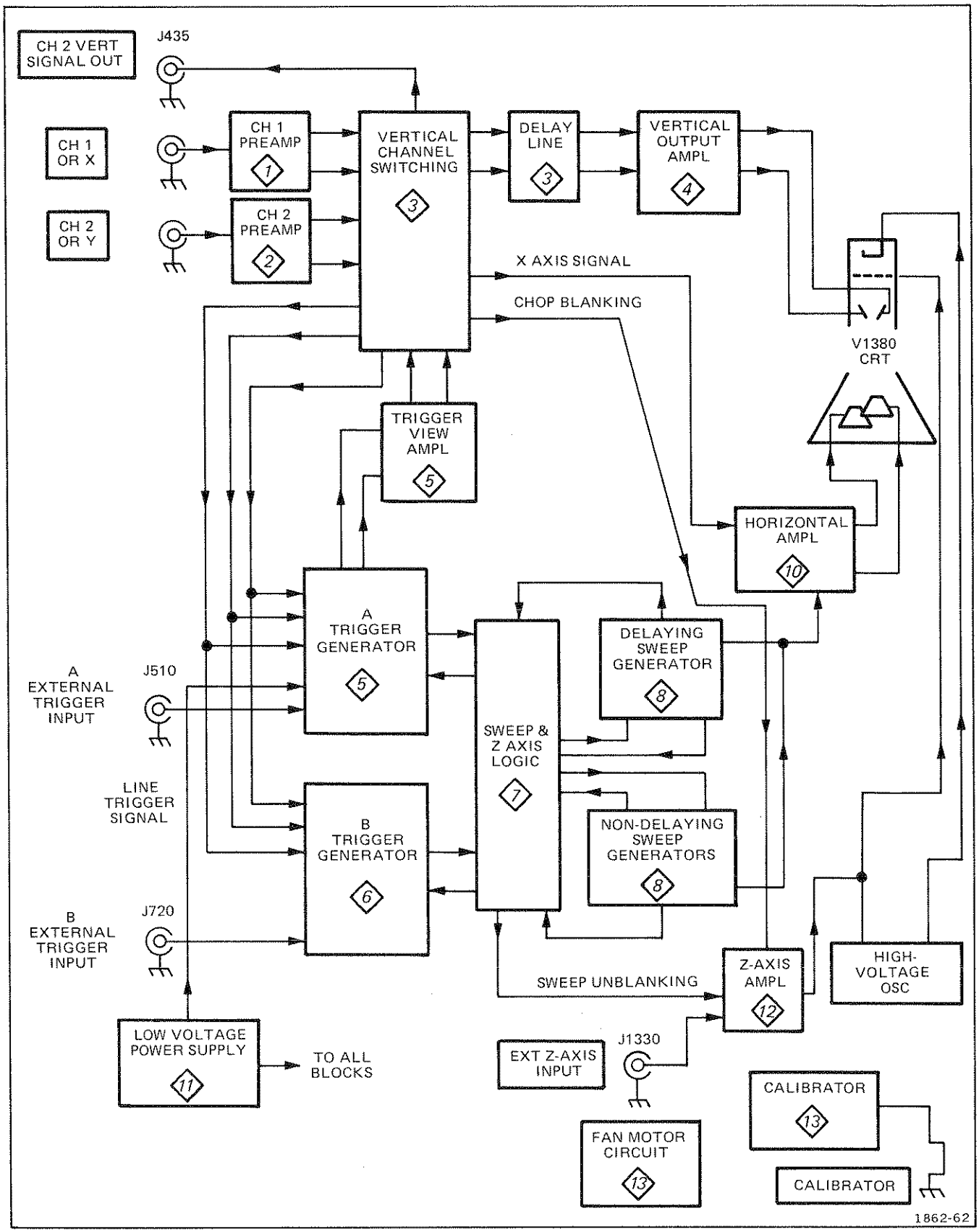


Fig. 3-1. Basic block diagram of the 475A.

The A and B Trigger Generator circuits produce an output pulse that initiates generation of the sawtooth sweep signals produced by the A or B Sweep Generator circuits. The input signal to the Trigger Generator circuits can be individually selected from the Channel 1 signal, Channel 2 signal, the signal(s) displayed on the CRT (NORM), a signal connected to the external trigger input connectors, or a sample of the line voltage applied to the instrument. Each trigger circuit contains separate level, slope, coupling, and source controls.

There are three sweep generator circuits in the 475A. For purposes of explanation, they are called Delaying, Slow Non-Delaying, and Fast Non-Delaying. The Delaying Sweep generates a range of sweep rates from 0.5 second to 0.05 microsecond/division. The Slow Non-Delaying Sweep generator provides the 0.5 second through 1 microsecond/division sweep rates and the Fast Non-Delaying Sweep Generator provides the sweep rates of 0.5 through 0.01 microsecond/division.

The Delaying Sweep runs when the instrument is operated in a delayed-sweep mode (MIX, A INTEN or B DLY'D) and is displayed as the A portion of a MIX or A INTEN display. In B DLY'D mode the Delaying Sweep is used to delay the Non-Delaying Sweep, which is displayed on the CRT. The sweep rate for the Delaying-Sweep Generator is selected by the A TIME/DIV switch (skirt knob). One of the Non-Delaying Sweeps (depending on the sweep rate selected) will run and may be displayed in all modes of the HORIZ DISPLAY switch. In the A mode (knobs locked) the Non-Delaying Sweep is displayed as the A Sweep and in the MIX mode, displayed as the B DLY'D Sweep. In the A INTEN mode, the Non-Delaying Sweep is displayed as the intensified portion and in the B DLY'D mode is displayed as the B DLY'D Sweep. The sweep rate for the Non-Delaying Sweep Generator is selected by the B TIME/DIV switch (DLY'D SWEEP knob). It may be helpful to see Table 3-2, found later in this section.

The TRIG MODE switch controls the mode of operation of the sweep generator deriving the A portion of a display. In the AUTO position, the absence of an adequate trigger signal causes the sweep to free run. In the NORM position, a horizontal sweep is presented only when correctly triggered by an adequate trigger signal. Pushing the SINGL SWP pushbutton allows one (and only one) sweep to be presented. The Z Axis Logic circuit produces an unblanking gate signal to unblank the CRT so that the display can be presented. This gate signal is coincident with the sawtooth produced by the sweep generator. The Z Axis Logic Circuit also produces, at the end of each sweep, a gate signal that is supplied to the Vertical Channel Switching circuit. This pulse switches the display between channels at the end of each sweep when the Vertical Deflection System is operating in the ALT mode.

The outputs of the sweep generators are amplified by the Horizontal Amplifier to produce horizontal deflection for the CRT except in the fully counterclockwise (X-Y) position of the TIME/DIV switch. The Horizontal Amplifier contains a 10X magnifier to increase the sweep rate by a factor of 10 in any A or B TIME/DIV switch position. Other horizontal deflection signals can be connected to the Horizontal Amplifier by using the X-Y mode of operation. When the TIME/DIV switch is set to X-Y, the X-axis signal is connected to the Horizontal Amplifier circuit through the Channel 1 Vertical Preamplifier circuit.

The Z Axis Amplifier circuit determines the CRT intensity and blanking. The Z Axis Amplifier circuit sums the current inputs from the INTENSITY control, the Vertical Channel Switching circuit (chopped blanking), the Z Axis Logic circuit (unblanking), and the external Z AXIS INPUT connector. The output level of the Z Axis Amplifier circuit controls the trace intensity through the CRT circuit. The CRT circuit provides the voltages and contains the controls necessary for operation of the cathode-ray tube.

The Power Supply circuit provides the low voltage power necessary for operation of this instrument. This voltage is distributed to all of the circuits in the instrument.

The Calibrator circuit provides a square-wave output with accurate voltage and current amplitudes, which can be used to check the calibration of the instrument and the compensation of probes. The CALIBRATOR current loop provides an accurate current source for calibration of current measuring probe systems.

CHANNEL 1 PREAMP ◇1

General

Input signals for vertical deflection on the CRT can be connected to the CH 1 OR X input connector. In the X-Y mode of operation, the input signal connected to the CH 1 OR X connector provides the horizontal (X-axis) deflection (TIME/DIV switch set to X-Y, VERT MODE switch set to CH 2 OR X-Y). The Channel 1 Preamp circuit provides control of input coupling, vertical deflection factor, gain, and DC balance. Fig. 3-2 shows a detailed block diagram of the Channel 1 Preamp circuit. A schematic of this circuit is shown on Diagram 1 at the rear of this manual.

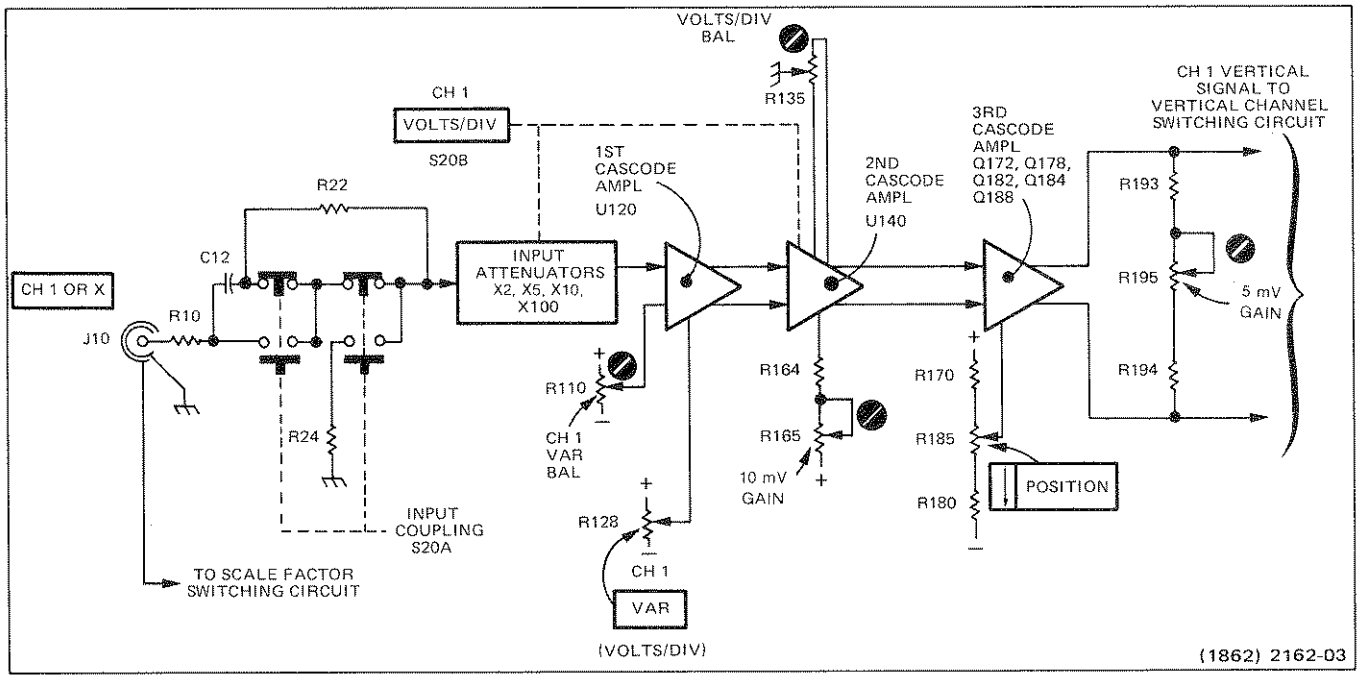


Fig. 3-2. Detailed block diagram of the Channel 1 Vertical Preamplifier circuit.

Input Coupling

Signals applied to the input connector can be AC coupled, DC coupled, or internally disconnected from the input to the Vertical Input Amplifier circuit. When Input Coupling switch S20A is set for DC coupling, the input signal is coupled directly to the Input Attenuator stage. When AC coupled, the input signal passes through capacitor C12. This capacitor prevents the DC component of the signal from passing to the amplifier. In the GND position, S20A opens the signal path and connects the input of the amplifier to ground through R24. This provides a ground reference without the need to disconnect the applied signal from the input connector. Resistor R22, connected across the input coupling switch, allows C12 to be pre-charged in the ground position, which prevents generation of large voltage transients at the input to the amplifier and allows the trace to remain on screen when switched to the AC position.

Input Attenuator

The effective overall deflection factor of each channel of the 475A is determined by the appropriate VOLTS/DIV switch setting. The basic deflection factor of the Vertical Deflection System is 10 millivolts/division of CRT deflection. To achieve the deflection factor values indicated on the front panel, precision attenuators are switched into the circuit and, in the 5 mV position, the gain of the Second Cascode Amplifier stage is increased.

For the VOLTS/DIV switch positions above 10 mV, attenuators are switched into the circuit singly or in pairs to help produce the vertical deflection factors indicated. These attenuators are frequency-compensated voltage dividers. In addition to providing constant attenuation at all frequencies within the bandwidth of the instrument, the Input Attenuators are designed to maintain the same input RC characteristics for each setting of the VOLTS/DIV switch. Each attenuator contains an adjustable series capacitor to provide correct attenuation at high frequencies and an adjustable shunt capacitor to provide correct input capacitance.

NOTE

Each attenuator is a hybrid encapsulated plug-in assembly; therefore, replacement of individual components within the attenuator are not possible. Should defects occur, the attenuator must be replaced as a unit.

First Cascode Amplifier

The first amplifier stage in the Channel 1 Preamplifier circuit is hybrid circuit U120. U120 basically consists of an integrated emitter-coupled, push-pull, cascode amplifier and two discrete field-effect transistors (FET) mounted on a ceramic substrate with the thick-film resistors. The stage is a paraphase amplifier and converts the single-ended input signal to push-pull output signals. CR104 and CR107 provide protection for the input to U120 if large negative-going signals or DC levels are applied to the CH 1 OR X input connector.

Circuit Description—475A Service

This input amplifier stage contains the CH 1 VAR VOLTS/DIV control. This control provides continuously variable (uncalibrated) vertical deflection factors between the calibrated positions of the VOLTS/DIV switch. With the VAR control in its calibrated detent (wiper at ground), the output transistors of U120, whose collectors connect to pins 5 and 9, are conducting; the output transistors whose collectors connect to pins 6 and 8 are biased off. Thus, the current available to the following amplifier stage is that flowing from pins 5 and 9.

When the VAR control is rotated out of its calibrated detent, the transistors whose collectors connect to pins 6 and 8 begin to conduct. The current they conduct is robbed from the other output transistors. This causes two things to occur:

1. The current flowing in the collectors of the transistors connected to pins 5 and 9 is less now than when the VAR control was in its calibrated detent.

2. The current available to the following amplifier stage is the algebraic sum of the currents in the collectors tied together (i.e., pins 8 and 9 and pins 5 and 6). Since the two collectors tied together have signals of opposite polarity, the signal available to the following amplifier stage is less than that when the VAR control was in its calibrated detent. The component values selected for the variable function provide a variable attenuation ratio of approximately 2.5 to 1. The Channel 1 Variable Balance adjustment R110 adjusts for no trace shift in the display when rotating the VAR control. The Channel 1 UNCAL light indicates when the Channel 1 VAR control is out of its calibrated detent. The components connected between pins 2 and 3 of U120 provide high-frequency compensation for the stage.

Second Cascode Amplifier

The second amplifier stage in the Channel 1 Preamplifier circuit is U140. U140 is an integrated emitter-coupled, push-pull, cascode amplifier similar to that used in U120. It is used as a push-pull amplifier and has 5 mV and 10 mV gain adjustments that determine the overall gain of the Channel 1 Preamplifier circuit. The output signals available to the next stage for amplification are taken from pins 5 and 9 of U140.

The gain of U140 is determined by biasing the output transistors connected to pins 6 and 8 to conduct more or less current. As more current is conducted through the transistors connected to pins 6 and 8, that much less is conducted through the transistors connected to pins 5 and 9. The current conducted by the transistors connected to pins 5 and 9 in the 5 mV position of the VOLTS/DIV switch is approximately 2.5 times the current conducted by the same transistors in all of the other VOLTS/DIV switch positions. This results in increased gain and a DC level shift at the signal output terminals of U140. The VOLTS/DIV switch compensates for a shift in the DC level by shorting out part of the common-mode resistance (R157) when operating with 5 mV sensitivity. Gain Switch Balance adjustment R135 adjusts the DC balance of the stage, so there is no baseline shift in the CRT display when switching between the 5 mV and 10 mV positions of the CH 1 VOLTS/DIV switch. The remainder of the components connected between pins 2 and 3 of U140 provide high-frequency compensation for the stage.

Third Cascode Amplifier

The third amplifier stage in the Channel 1 Preamplifier circuit is a discrete component cascode amplifier made up of Q172, Q178, Q182, Q184, and Q188. Q184 is a relatively constant current source for Q172 and Q182. Q172 and Q182 convert the input voltage signals into current signals which are in turn converted back to voltage signals by Q178 and Q188 respectively. R172 and R182 provide thermal compensation and C172 and C182 AC-couple the signal around R172 and R182 to reduce Miller effect. C175 and R175 are variable high-frequency compensation adjustments while CR170, CR174, and RT170 offset compensation changes associated with variations in ambient temperature. As temperature increases, the value of RT170 decreases. This results in a decrease in voltage across CR170 and CR174. CR170 and CR174 are voltage-variable capacitance semiconductors whose capacitance increases with a decrease in reverse voltage across them. Thus, CR170 and CR174 will provide more peaking at higher temperatures. T178 is a toroid inductor that cancels high-frequency common-mode signals generated by the previous stages. The Channel 1 Vertical Position Centering adjustment centers the range of control of the Channel 1 POSITION control.

CHANNEL 2 PREAMP 

General

The Channel 2 Preamp circuit is virtually the same as the Channel 1 Preamp circuit. Only the differences between the two circuits are described here. Portions of this circuit not described in the following description operate in the same manner as for the Channel 1 Preamp circuit. Fig. 3-3 shows a detailed block diagram of the Channel 2 Preamp circuit. A schematic of this circuit is shown on Diagram 2, at the rear of this manual.

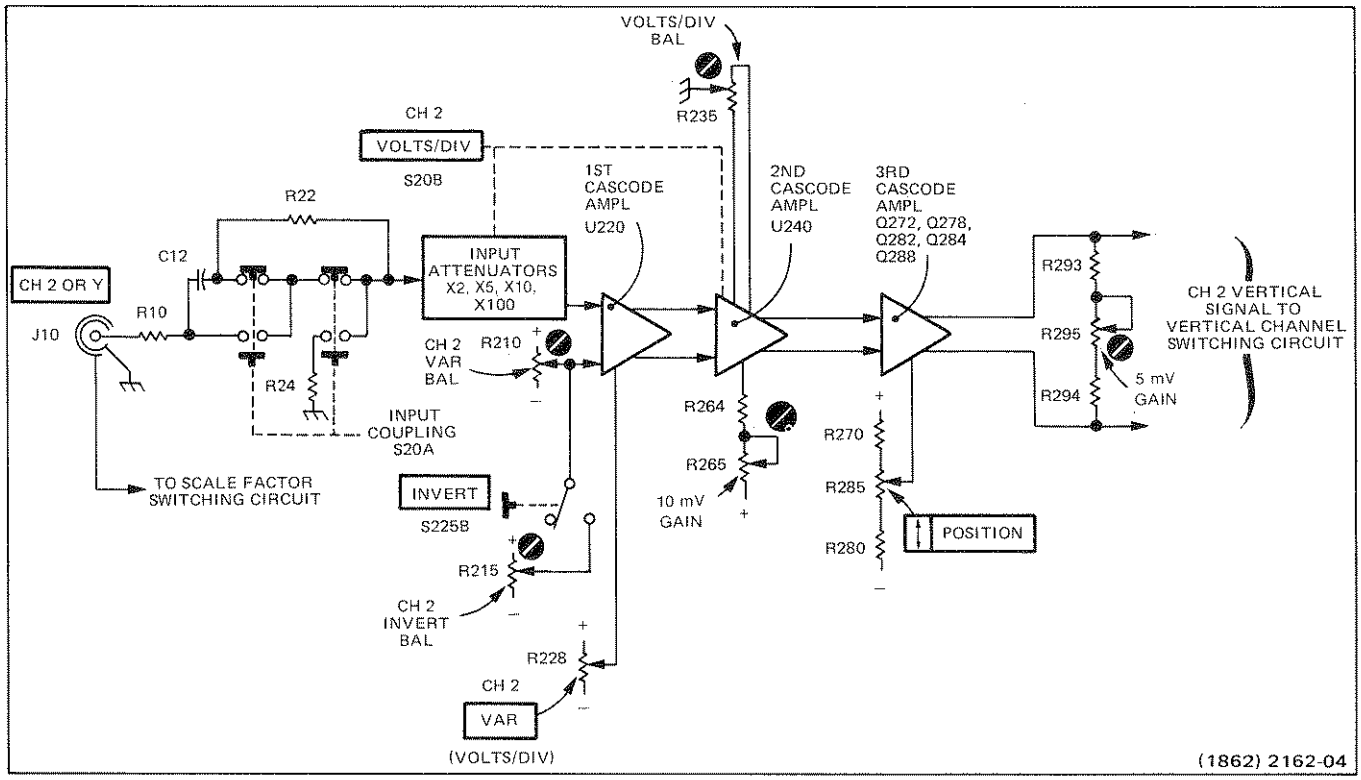


Fig. 3-3. Detailed block diagram of the Channel 2 Vertical Preamplifier circuit.

First Cascode Amplifier

Basically, the First Cascode Amplifier stage in Channel 2 operates as described for the First Cascode Amplifier stage in Channel 1. However, the Channel 2 First Cascode Amplifier also contains the INVERT switching function. This allows the Channel 2 signal to be inverted as displayed on the CRT. The INVERT switch, when pushed, changes the biasing on the output transistors of U220 so that the normally inactive transistors are now carrying the signal. Since their outputs are cross-coupled from side to side the output signal is of opposite polarity to that available in the normal (button out) position of the INVERT switch. The Channel 2 Invert Balance adjustment R215 adjusts the DC balance of the stage to eliminate baseline shift in the display when switching from a normal to an inverted display.

VERTICAL CHANNEL SWITCHING

General

The Vertical Channel Switching circuit determines whether the Channel 1 or the Channel 2 Preamp signal or both will be connected to the Vertical Output Amplifier circuit. In the ALT and CHOP modes of operation, both channels are alternately displayed on a shared-time basis. The Vertical Channel Switching circuit also provides several internal trigger signals to the Trigger Generator circuits, the Channel 2 VERT SIGNAL OUT signal to a connector on the rear panel, and the chopped blanking signal to the Z Axis Amplifier. Fig. 3-4 shows a detailed block diagram of the Vertical Channel Switching circuit. A schematic of this circuit is shown on Diagram 3 at the rear of this manual.

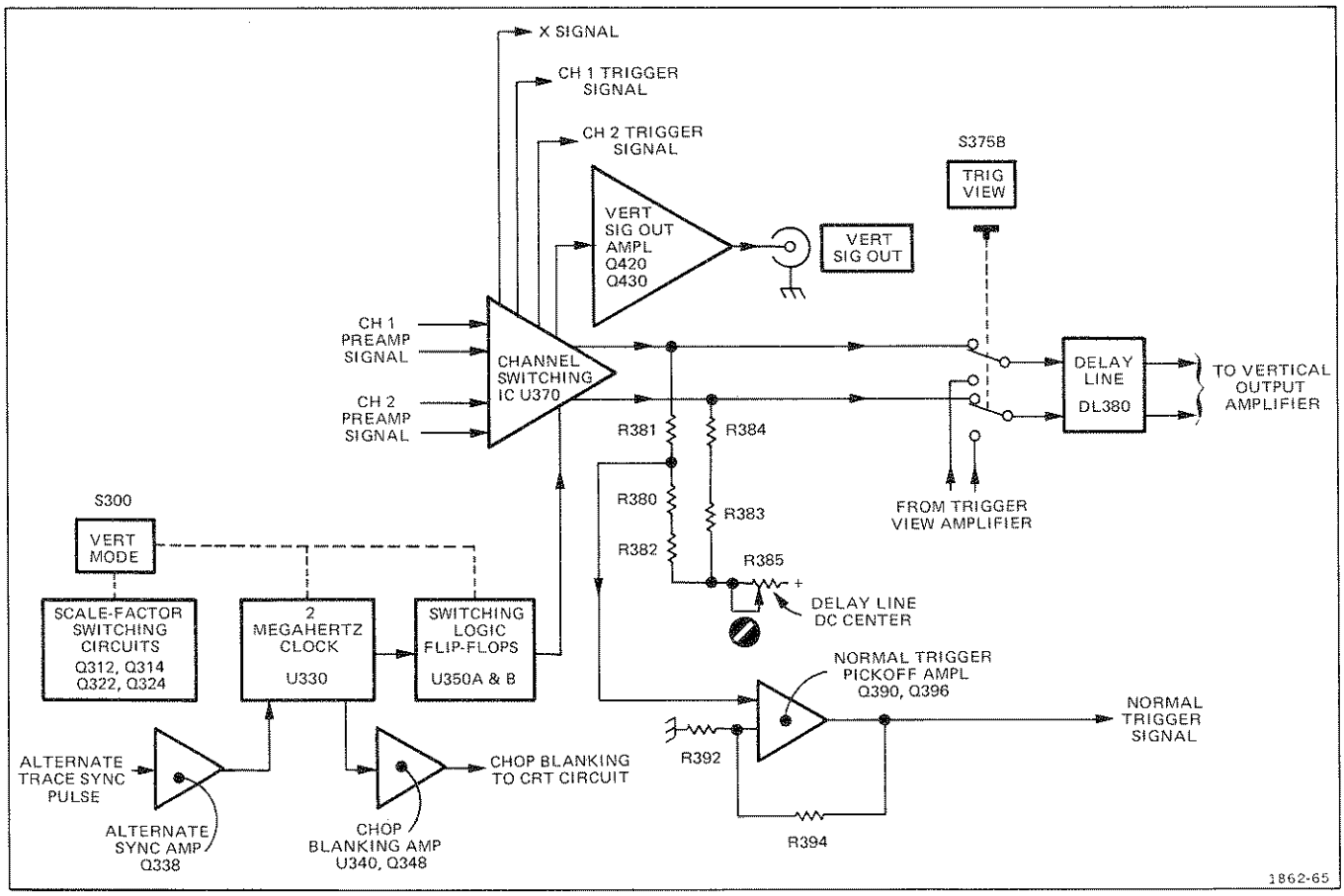


Fig. 3-4. Detailed block diagram of the Vertical Channel Switching circuit.

Channel Switch IC

The Channel Switch IC U370 determines which of the Preamp signals will be passed to the Vertical Output Amplifier. The push-pull Preamp signals connect between pins 2 and 3 (Channel 2) and between pins 10 and 11 (Channel 1) of U370. The logic levels connected to pins 1, 12, 13, and 16 determine what signals are presented at output pins 14 and 15. The following logic truth table (Table 3-1) defines the switching function of U370.

TABLE 3-1 1862-85

Input/Output Logic for U370

Pin 1	Pin 12	Pin 13	Pin 16	Output Signal Pins 14, 15
1	0	1	0	Channel 2
0	1	0	1	Channel 1
1	1	0	0	Add (Algebraic sum of Channel 1 and 2)

U370 also makes available samples of the Channel 1 signal at pins 8 and 9 and samples of the Channel 2 signal at pins 4 and 5. The output signals at pins 4, 5, 8, and 9 are always present when signals are applied to the channel inputs regardless of the switching logic levels applied to U370. The Channel 1 signal present at pin 9 provides drive to the Horizontal Amplifier in the X-Y mode of horizontal operation. The Channel 1 signal at pin 8 and the Channel 2 signal at pin 4 are used by the Trigger Generator circuits in the appropriate positions of the Trigger SOURCE switches. The Channel 2 signal at pin 5 connects to the Channel 2 Vertical Signal Out Amplifier.

Switching Logic Flip-Flops

U350A and U350B are edge-triggered flip-flops that derive the switching logic for the Channel Switch IC U370. In the CH 1, CH 2, and ADD positions of the VERT MODE switch the output logic from U350A and U350B is determined by the voltage levels applied to the clear (pins 1 and 13) and preset (pins 4 and 10) inputs. In the ALT mode of operation the flip-flops are switched by the alternate-trace sync pulse applied to their clock inputs through Q338 and U330B. In the CHOP mode, the clock pulse generated by U330C and U330D switch the flip-flops at a one-megahertz rate.

Two Megahertz Clock

U330C and U330D form an astable multivibrator having a repetition rate of two megahertz. The rectangular output waveform connects to the Switching Logic Flip-Flops through nand gate U330B. Only in the CHOP position of the VERT MODE switch is a LO level applied to the input of inverter U330A. This puts a logical HI in pin 13 of U330D, which permits the astable multivibrator to free-run. At the same time, Q338 is biased on, which puts a logical HI on pin 5 of U330B. Thus, the signal present at pin 6 of U330B will be the two-megahertz clock signal.

Chop Blanking Amplifier

The Chop Blanking Amplifier Q348 provides an output pulse to the Z Axis Amplifier circuit, which blanks out the transitions between the Channel 1 and Channel 2 traces when operating in the CHOP mode. The inherent propogation delay of inverters U340A, U340B, and U340C are used to provide some signal delay to the chop blanking signal. This allows the blanking signal and the channel switching transient to arrive in the CRT simultaneously.

Channel 2 Signal Output Amplifier

Q420 and Q430 compose the Channel 2 Vertical Signal Output Amplifier. A sample of the Channel 2 signal from pin 5 of Channel Switch IC U370 is amplified and inverted by Q420. CR422 provides thermal compensation for the base-emitter junction of Q420. Common-base amplifier Q430 provides the final amplification and isolates the output from the internal amplifier circuitry. Output impedance of the amplifier is equal to the parallel combination of R431 and R432 (approximately 50 ohms).

Normal Trigger Pickoff Amplifier

The trigger signal for NORM trigger operation is obtained from a sample of the vertical deflection signal that is available from pin 15 of U370. Normal Trigger DC Center Adjustment R425 sets the DC level of the normal trigger output signal so that the sweep is triggered at the 0 level of the displayed signal when the Triggering LEVEL control is set to 0. Q390 and Q396 are connected as a non-inverting feedback amplifier. Gain of the stage is approximately 2.75.

Scale-Factor Switching Circuits

The vertical deflection factor for each channel is indicated by back-lighting the appropriate figures imprinted on the flange of each VOLTS/DIV knob. For purposes of explanation, only the circuit action of the Channel 1 Scale-Factor Switching circuit is discussed.

With a cable or an X1 probe connected to the CH 1 OR X input connector, the probe coding ring terminal on the connector is not contacted, and therefore presents an open to the base of Q312. This causes Q312 to be biased off and the X10 display factor bulb to be off. The base level of Q314 is held low by this action, thus Q314 is biased on and conducts current to light the X1 display factor bulb.

When an X10 probe with a scale-factor switching connector is attached to the CH 1 OR X input connector, the probe coding ring terminal on the connector is contacted; the base of Q312 is connected through R311, R310 and an 11,000-ohm resistor (within the probe) to ground. Now, Q312 conducts through X10 display-factor bulb DS312. The positive level at the collector of Q312 turns Q314 off, the X10 display factor bulb is on, and the X1 display factor bulb is off.

VERTICAL OUTPUT AMPLIFIER ◇4

General

The Vertical Output Amplifier provides the final amplification for the vertical deflection signal. This circuit includes the BEAM FINDER function. The BEAM FINDER pushbutton, when pressed, limits the vertical and horizontal deflection to within the viewing area and sets the trace intensity to a normal viewing level to aid in locating an off-screen display. A schematic of the Vertical Output Amplifier is shown on Diagram 4 at the rear of this manual.

First IC Amplifier

The first amplifier stage in the Vertical Output Amplifier is integrated circuit U450. U450 is basically an emitter-coupled, push-pull, cascode amplifier cell. Biasing is arranged so that there is no phase-inversion through the stage. The signal from the delay line is applied to the amplifier through C441, L441, L442, C445, and L444. These inductances and capacitances are part of the etched runs of the circuit board and provide some high-frequency peaking by forming a T-coil circuit without mutual coupling. Most of the remaining external components connected between pins 2 and 3 of U450 provide high-frequency compensation for the delay line. Connected between pins 2 and 3 of U450, internally, a resistor (approximately 33 ohms) has a large effect on the gain of the stage.

RT452 changes in value with variations in ambient temperature to compensate for temperature-associated changes in amplifier gain. The BEAM FINDER pushbutton, when pressed, removes −8 volts from the top of R459. This reduces the dynamic swing capabilities of the stage to limit the display on the CRT to within the viewing area. The gain of the Vertical Output Amplifier section is adjusted in this stage by adjusting Vertical Output Gain R449.

Second IC Amplifier

The second amplifier stage in the Vertical Output Amplifier is integrated circuit U470. U470 is a multi-stage cascode amplifier cell. The input signal is applied to pins 1 and 5 with the inverted output signal taken from pins 9 and 12. Pins 2 and 4 are emitter connections. Some of the components connected between pins 2 and 4 provide slower time constants to compensate for signal rolloff that occurs in the delay line, while the remaining components compensate for thermal considerations in the stage. The Output Bias adjust (R487) sets the DC levels within the stage to optimize the operating performance of U470. The output signal from U470 connects directly to the deflection plates of the CRT.

A TRIGGER GENERATOR ◇5

General

The A Trigger Generator circuit produces the trigger pulse used to start the Sweep Generator circuit that provides the A portion of the CRT display. The trigger pulse is derived from the internal trigger signal from the vertical deflection system, an external signal connected to the external trigger input connector, or a sample of the line voltage connected to the instrument. Controls are provided to select trigger level, slope, coupling, and source. Fig. 3-5 shows a detailed block diagram of the A Trigger Generator circuit. A schematic of this circuit is shown on Diagram 5 at the rear of this manual.

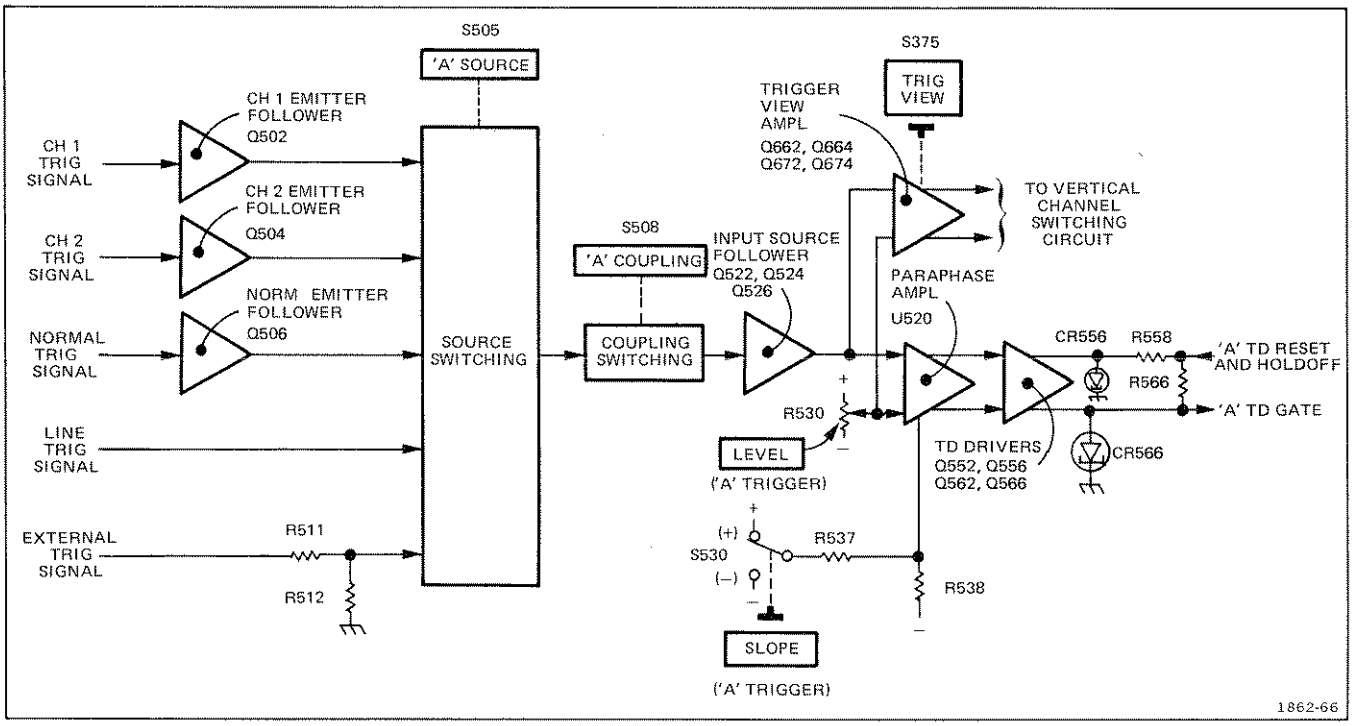


Fig. 3-5. Detailed block diagram of the A Trigger Generator circuit.

Trigger Source

Trigger SOURCE switch S505 selects the source of the trigger signal. The sources available to the A Trigger Generator circuit are the signal being displayed (NORM), Channel 1 (CH 1), Channel 2 (CH 2), the instrument line voltage (LINE), and external signals (EXT and EXT ÷10). Emitter followers Q502, Q504, and Q506 provide isolation between the input to the A Trigger Circuit and the output of the Vertical Channel Switching Circuit.

In the LINE mode of triggering, a sample of the power line frequency is obtained from the secondary of the power transformer T1400 in the Low Voltage Power Supply circuit. The Trigger COUPLING switches should not be in the LF REJ mode when using the instrument line voltage as a trigger signal source.

Trigger Coupling

The Trigger COUPLING switches offer a means of accepting or rejecting certain components of the trigger signal. In the AC, LF REJ, and HF REJ mode of trigger coupling, the DC component of the trigger signal is blocked by coupling capacitors C515 or C516. Frequency components below about 60 Hz are attenuated when using AC or HF REJ coupling and below about 50 kHz when using LF REJ coupling. The higher frequency components of the trigger signal are passed without attenuation. In the HF REJ mode of trigger coupling, the high frequency components of the trigger signal (above about 50 kHz) are attenuated, while the lower frequency components (between about 60 Hz and 50 kHz) are passed without attenuation. The DC mode of trigger coupling passes unattenuated all signals from DC to 250 MHz and above.

Input Source Follower

Transistor Q522 is a FET (field-effect transistor) connected as a source follower. It provides a high input impedance (set primarily by R517) for the trigger signal; it also provides isolation between the Trigger Generator circuit and the trigger signal sources. CR519 provides input protection for Q522 if excessively high amplitude negative-going input signals are present. Q524 is a high-impedance, relatively constant current source for Q522 and provides a measure of temperature compensation for Q522. The output signal from the Source Follower is taken from Emitter Follower Q526.

Paraphase Amplifier

U520 is a paraphase amplifier stage that converts the single-ended input from Emitter Follower Q526 into a dual-ended push-pull output, which is applied to one of the Tunnel Diode Driver stages. Trigger Centering adjustment R534 sets the level at pin 14 of U520 (through emitter follower Q532) so that the display is correctly triggered when the LEVEL control is centered. The LEVEL control varies the level at pin 14 of U520 to select the point on a trigger signal where triggering occurs.

The slope of the input signal that triggers the Sweep Generator circuit is determined by the setting of the SLOPE switch S530. When the SLOPE switch is set to the + position, the output signal at pin 8 of U520 is inverted with respect to the input signal, and the output signal at pin 9 is in phase with respect to the input signal. When the SLOPE switch is set to the − position, the output signal at pin 8 is in phase with respect to the input signal, and the output signal at pin 9 is inverted with respect to the input signal.

Tunnel Diode Driver

Q552, Q556, Q562 and Q566 are common-emitter amplifier stages that provide the signal currents necessary to switch the triggering tunnel diodes. CR556 and CR566 are ten-milliampere tunnel diodes. Quiescently, CR556 and CR566 are biased into their low voltage states and Q566 cannot provide sufficient current to switch CR566 to its high voltage state. When the input signal increases the current in Q556 slightly above its quiescent state, this current and the current through R555 is sufficient to bias CR556 into its high voltage state. The anode of CR556 steps positive to an approximately +0.5 volt level. Since less current is required to maintain a tunnel diode in its high voltage state than is required to switch it to its high voltage state, approximately 6 mA of current is additionally available to switch CR566 to its high voltage state. Thus, the next time Q566 conducts signal current, CR566 steps to its high voltage state sending a positive pulse to the logic circuit to initiate sweep action. The A Trig Sensitivity adjustment, R565, adjusts the tunnel diode bias to the proper level that will not allow CR566 to be switched to his high voltage state until CR556 has been switched to its high voltage state. At the end of the sweep time and during holdoff, a negative level is applied to the junction of R558 and R566, thereby resetting both CR556 and CR566 to their low voltage states. The reset level remains during holdoff time to ensure that a sweep gating signal is not generated until the sweep circuit has returned to its quiescent state.

Trigger View Amplifier

The Trigger View Amplifier circuit amplifies a sample of the signal present in the A Trigger Generator circuit and passes it on to the Vertical Output Amplifier for display on the CRT when the TRIG VIEW pushbutton is pressed. This provides a method of making a quick and convenient check of the signal being used to trigger the oscilloscope and is intended primarily to be used to check the timing difference between the trigger signal and the vertical deflection signal.

The amplifier consists of two emitter-coupled push-pull amplifier stages. The emitter source voltage for Q662 and Q672 is switched on and off by the TRIG VIEW pushbutton. With the TRIG VIEW bushbutton not pushed, the emitters of Q662 and Q672 are returned to ground through R665. This reverse-biases the base-emitter junctions of the transistors, preventing any loading of the A Trigger Generator circuit. When the TRIG VIEW pushbutton is pushed, the emitters are now returned to +15 volts through R663 and R679. This forward biases Q662 and Q672 to allow signal amplification. Trigger View Centering adjustment R673 adjusts for correct DC balance in the circuit.

Normally, the output of the Vertical Channel Switching circuit is applied to the input of the Delay Line. When the TRIG VIEW pushbutton is pushed, the signal from the Vertical Channel Switching circuit is removed and the output from the Trigger View Amplifier is applied in its place.

B TRIGGER GENERATOR 6

General

The B Trigger Generator circuit produces the trigger pulse used to start the Sweep Generator circuit that provides the B portion of the CRT display. The B Trigger Generator circuit is virtually the same as the A Trigger Generator circuit and only the differences between the two are discribed here. A schematic of this circuit is shown on Diagram 6 at the rear of this manual.

Trigger Source

The B Trigger Generator circuit has no LINE or EXT ÷10 positions on its Trigger SOURCE switch. If the Generator is to be triggered from a line voltage signal or the external trigger signal is to be attenuated, it must be accomplished in some other manner. The B Trigger SOURCE switch does have a STARTS AFTER DELAY position, however, the A Trigger SOURCE switch does not. This position allows the B portion of a display to start immediately after the selected delay time without waiting for a triggering signal.

SWEEP AND Z-AXIS LOGIC 7

General

The Sweep and Z Axis Logic Circuit derives the logic levels necessary to control the sequence of events associated with sweep generation and CRT unblanking. The +A and +B GATE signals are also generated in this circuit. Positive logic terminologies and symbologies are used in the following explanation of circuit operation. Fig. 3-6 shows a detailed block diagram of the Sweep and Z-Axis Logic circuits. A schematic of this circuit is shown on Diagram 7 at the rear of this manual.

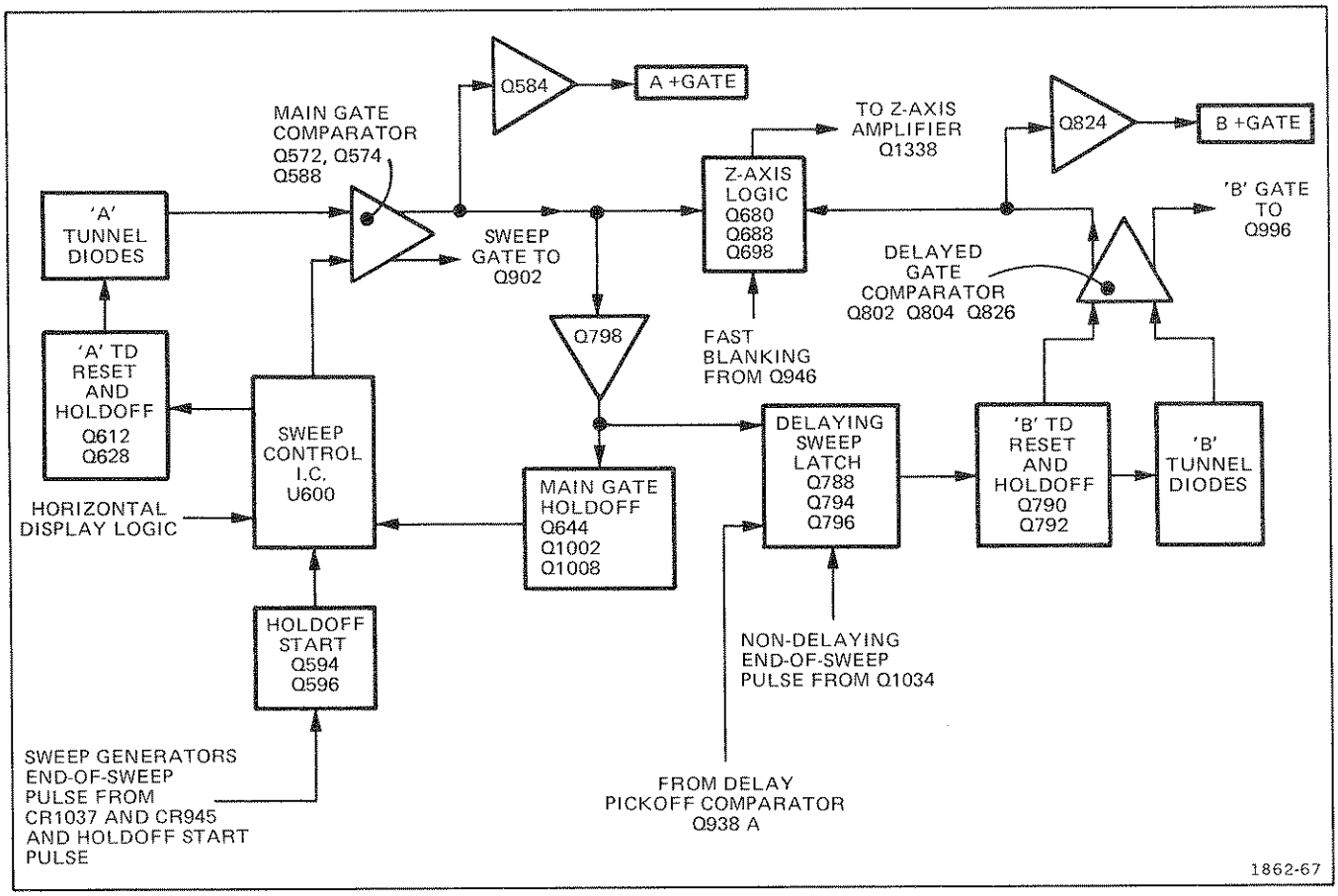


Fig. 3-6. Detailed block diagram of the Sweep and Z-Axis Logic circuits.

Sweep Control Integrated Circuit

U600 is the Sweep Control Integrated Circuit. Several functions are performed in this stage, depending on the mode of operation of the instrument sweep generators. The following is a brief explanation of the function associated with each pin of the IC.

Pin 1. This is the positive tunnel diode input. The signal connected here comes from the A Firing TD in the A Trigger Generator circuit. The voltage level switches from 0 to +0.5 volts and is compared with pin 2 internally.

Pin 2. This is the negative tunnel diode input. A fixed DC level established by R602 and R603 provides the reference for comparison with pin 1.

Pin 3. This is the positive tunnel diode output terminal. In the AUTO mode of operation (TRIG MODE set to AUTO) at the end of the holdoff time period, pin 1, pin 16 and pin 19 are LO, and pin 8 is HI. This causes the gate level at pin 3 to step LO to turn Q574 on, which initiates a sweep.

Pin 4. This is the negative tunnel diode output terminal; connected to +5 volts in this application.

Pin 5. Input terminal for a negative 5 volts through VR608 from the −8-volt supply.

Pin 6. This is the auto RC timing terminal. R609 and C609 determine the amount of time between loss of trigger signal and the generation of an auto gate at pin 3 when TRIG MODE is set to AUTO.

Pin 7. This terminal lights the TRIG light when a triggering gate has occurred, causing pin 1 to go HI.

Pin 8. This is the holdoff timing terminal. The time between the end of an individual sweep and the start of the next sweep is determined by RC components that affect the time constant of voltage of pin 8. The TIME/DIV control selects fixed components in the holdoff timing circuit and the A TRIG HOLDOFF control allows a variable holdoff setting in each position of the TIME/DIV control. When pin 8 goes HI, pin 17 will go LO and allow the trigger tunnel diodes to fire on an incoming signal or generate an auto gate in the Auto mode if pin 6 is HI.

Pin 9. Ground terminal.

Pin 10. This is the holdoff output; connected to ground in this application.

Pin 11. This terminal lights the READY light when operating in the single sweep mode.

Pin 12. This is the single sweep mode terminal. When +5 volts is connected to this terminal, the sweep operates in the single sweep mode; when the terminal is left open or grounded, the sweep operates in the repetitive mode.

Pin 13. Connected to ground in this application.

Pins 14 and 15. Single Sweep reset terminals. Pressing the SINGL SWP pushbutton prepares the single sweep circuitry to respond to the next triggering event. Also, this action causes the READY light to be lit.

Pin 16. This is the holdoff start input terminal. A HI on this pin resets the sweep and starts the holdoff period. This sets pin 17 HI to reset and hold the trigger tunnel diodes LO and allows pin 3 to go HI.

Pin 17. This is the sweep disable output terminal. The gate level at this terminal is HI during holdoff and LO otherwise.

Pin 18. This is the lockout input terminal; +5 volts applied to this terminal disables all sweep action.

Pin 19. This is the auto mode terminal. Grounding this terminal enables auto sweep operation.

Pin 20. Input terminal for the +5-volt supply.

Main Gate Comparator

Q572 and Q574 form the Main Gate Comparator and are connected as a voltage comparator, where both transistors do not conduct at the same time. The input signal to the stage is the positive-going trigger signal from the A Firing Trigger TD in the A Trigger Generator circuit. The signal at the collector of Q574 is inverted by Q588, is connected to the Z Axis Logic Multivibrator to control CRT blanking, and to Q584 to generate the A + GATE output signal. The signal at the collector of Q572 connects to the base of the Main Gate Amplifier stage (Q902) in the Sweep Generators circuit to initiate sweep generation.

Delayed Gate Comparator

Q802 and Q804 form the Delayed Gate Comparator and are connected as a voltage comparator where both transistors do not conduct at the same time. The input signal to the stage is the positive-going trigger signal from the B Firing Trigger TD in the B Trigger Generator circuit. The signal at the collector of Q804 is inverted by Q826 and is connected to the Z Axis Logic Multivibrator to control CRT blanking and to Q824 to generate the B + GATE output signal. The signal at the collector of Q802 connects to the base of the Delayed Gate Amplifier stage (Q996) in the Sweep Generators circuit to initiate sweep generation.

A Trigger TD Reset Circuit

Transistors Q612 and Q628 are connected as a Schmitt Trigger circuit and form the A Trigger TD Reset Circuit. (A Schmitt Trigger circuit is a bistable pulse generator in which an output pulse of constant amplitude exists only as long as the input voltage exceeds a certain dc value.)

At the start of holdoff, pin 17 of U600 steps HI. This turns on Q612 and turns Q628 off. The collector signal of Q612 connects to the Trigger Tunnel Diodes in the A Trigger Generator circuit and resets them to their LO state. At the end of holdoff pin 17 steps LO, Q612 turns off, and Q628 turns on to allow the tunnel diodes to fire on the next trigger signal.

Holdoff Start Circuit

Q594 and Q596 form the Holdoff Start Circuit. The input signal to the stage is a momentary positive-going end-of-sweep signal from the Sweep Generators circuit or from the Delayed Latch circuit. The positive-going signal turns Q594 on which in turn turns on Q596. The positive-going signal at the collector of Q596 is connected to pin 16 of U600 to reset the sweep and start the holdoff period. This signal is also used in the Vertical Switching Circuit to switch between channels in the ALT mode of operation.

Z Axis Logic Multivibrator

Q688 and Q698 are basically a Schmitt Trigger circuit and form the Z Axis Logic Multivibrator. Quiescently, with the CRT display blanked, Q688 is on and Q698 is off. The signal to switch states of the multivibrator (and thereby unblank the CRT) can come from the Main Gate Comparator (via Q588 and CR681) or from the Delayed Gate Comparator (via Q826 and C684). The negative going signals turn off Q688 and cause Q698 to turn on. The positive going signals that return the multivibrator to its original state (thereby blanking the CRT display) come from Q588 via CR682 and CR683, or from Q680 via CR680 and CR683. Q680 is used primarily to ensure proper early turn-off of the CRT display at faster sweep rates. In the

MIX or A INTEN positions of the HORIZ DISPLAY switch, some additive unblanking is accomplished to slightly increase the intensity of the B portion of the display. In these positions of the switch, −8 volts is connected to the cathodes of CR693 and CR694 through R692. Now, when the Z-Axis signal from the collector of Q826 steps negative at the beginning of the B portion of the display, CR693 is made to conduct less current, which makes a slight amount of additional unblanking current available to the Z-Axis Amplifier through CR694 and R692.

Delaying Sweep Latch Circuit

Q788, Q794, and Q796 form the Delaying Sweep Latch Circuit. The circuit function is used during the three delayed sweep modes of operation that the instrument is capable of (MIX, A INTEN, and B DLY'D). Q938A, in the Delay Pickoff Comparator of the Delaying Sweep Generator, is the current source for the emitters of Q794 and Q796. Prior to the end of the delay time selected by the A TIME/DIV switch and DELAY TIME POSITION control, Q938A is off, thereby causing both Q794 and Q796 to be off also. The base level of Q794 sits at a more negative level than does the base of Q796 so that when Q938A turns on, at the delay pickoff point, Q794 will turn on and Q796 will remain off. The resultant positive movement at the collector of Q794 is connected to the B Trigger TD Reset Circuit.

The end-of-sweep pulse from the Non-Delaying Sweep Generators connects to the emitter of Q788. When this pulse steps positive at the end of a delayed sweep, Q788 turns off and the current through R788 pulls the base of Q794 positive. This turns off Q794 and causes Q796 to turn on. The circuit remains in this state until the Delaying Sweep Generator ends its sweep and resets the Delay Pickoff Comparator. In the B ENDS A position of the A TRIG HOLDOFF control, +5 volts is connected to R798. This enables the diode gate composed of CR799 and CR592. Now, when the end-of-sweep pulse signals the end of a delayed sweep, the positive movement at the collector of Q796 is connected to the base of Q594 and ends the delayed sweep instead of waiting until the end of the delaying sweep. This mode of operation gives the fastest possible sweep repetition rate when operating in the delayed sweep mode.

B Trigger TD Reset Circuit

Q790 and Q792 are connected as a Schmitt Trigger and form the B Trigger TD Reset Circuit. At all times other than when the Non-Delaying Sweep Generators are running, Q790 is on, which holds the trigger tunnel diodes in the B Trigger Generator circuit in their LO states. At the end of the delay time selected by the A TIME/DIV switch and DELAY TIME POSITION control, the positive movement at the collector of Q794 turns on Q792 and causes Q790 to turn off. The tunnel diodes in the B Trigger Generator are capable of being biased into their HI states. Also, if the B Triggering SOURCE switch is in the STARTS AFTER DELAY TIME position, the negative movement at the collector of Q792 reverse biases CR811, letting the −8 volt supply pull down on the base of Q804 in the Delayed Gate Comparator. This turns on Q804 and causes Q802 to turn off, which initiates a delayed sweep.

Main Sweep Holdoff Gate and Delayed Sweep Override Amplifier

During the interval of the main gate, Q798 functions as a holdoff gate and is biased off to provide a forward bias on Q1002 (Q1002 is located on diagram 9). This turns on Q1002, discharges the holdoff capacitors and maintains a current path to keep the capacitors discharged.

During the delayed sweep, Q798 functions as an override amplifier. It is possible, with the right combination of control settings, to achieve a delayed sweep presentation where the delayed sweep would normally want to continue running after the end of the delaying sweep. For instance, if the TIME/DIV controls are set only 1 or 2 ranges apart and the DELAY TIME POSITION control is set to a 8.50 setting. Under these conditions the delaying sweep end-of-sweep pulse occurs before the delayed sweep end-of-pulse. The positive movement on the collector of Q588 at the time of the delaying sweep end-of-sweep pulse turns Q798 on. The negative movement on the collector of Q798 pulls down on the collectors of Q794 and Q796, through CR793 and CR792 respectively, which in turn pulls down on the base of Q792. This turns off Q792 and causes Q790 to turn on, which resets the B Trigger Tunnel Diodes to their LO states, thereby terminating the delayed sweep.

A +GATE And B +GATE Amplifiers

Q584 and Q824 are the A +GATE and B +GATE amplifiers respectively. They provide the +GATE output signals available at the instrument rear panel. These output gate signals are positive-going rectangular waveforms, approximately 5 volts in amplitude, coincident with their respective sweep waveforms.

LOW LINE Indicator Circuit

Q1492, Q1498, and their associated circuitry monitor the unregulated voltage in the +50 volt supply and provide a visual indication (via the LOW LINE indicator on the front panel) when the applied line voltage falls below the lower regulating limit selected by the Regulating Range Selector assembly. Q1482 provides operating power to the CRT graticule lights that is adjustable via the SCALE ILLUM control R1480.

SWEEP GENERATORS 8 TIMING AND HORIZONTAL DISPLAY SWITCHING 9

General

The Sweep Generators provide several sweep display modes, dependent upon the horizontal mode selected by the HORIZ DISPLAY switch. One sweep generator may be employed as a delay circuit for a second sweep generator, permitting a variety of useful display modes. Before the discussion of sweep generation, it is helpful to become familiar with each principle mode of horizontal display and its associated sweep generator, sweep gate and sweep display labeling. See Table 3-2 for a list of sweep generator, sweep gate and sweep display terminology whenever needed throughout the following sweep generators discussion.

The Sweep Generators produce the sawtooth voltages that are amplified by the Horizontal Amplifier to provide horizontal deflection on the CRT. These sawtooth voltages are produced on command (trigger pulses) from the Trigger Generator circuits. The Sweep Generator circuits also produce gate waveforms that are used by the Z Axis Logic circuit to unblank the CRT during sweep time, and by the Sweep Logic circuit to terminate sweep generation. There are three Sweep Generator circuits in the instrument. Operation of all three is very similar; therefore only the operation of the Delaying Sweep Generator and the differences in operation of the three generators is discussed. Fig. 3-7 shows a detailed block diagram of the Sweep Generators. A schematic of the Sweep Generators is shown on Diagram 8 and a schematic of the Timing And Horizontal Display Switching is shown on Diagram 9 at the rear of this manual.

TABLE 3-2 1862-86
Horizontal Display Sweep Generator Terminology

HORIZ DISPLAY Switch Setting	CRT Display		Gate that Initiates Sweep
	Portion of Sweep Displayed on CRT	Sweep Generator Used for Display	
A (TIME/DIV Knobs Locked)	A	Non-Delaying	Main
A (TIME/DIV Knobs Unlocked)	A	Delaying	Main
MIX	A (First Portion)	Delaying	Main
	B (Last Portion)	Non-Delaying	Delayed
A INTEN	A	Delaying	Main
	B (Intensified Portion)	Non-Delaying	Delayed
B DLY'D	B	Non-Delaying (After being delayed by Delaying Sweep)	Delayed

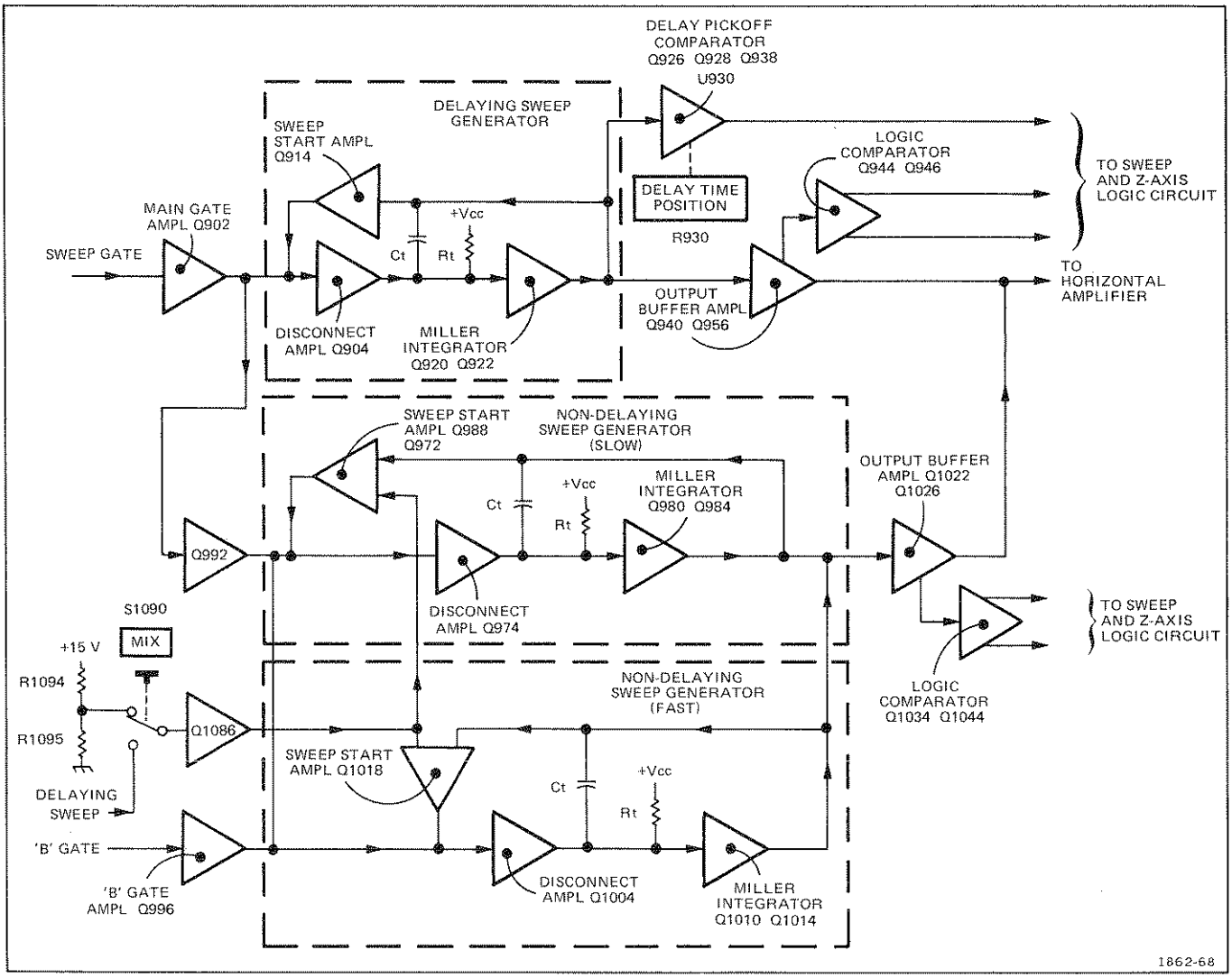


Fig. 3-7. Detailed block diagram of the Sweep Generator circuits.

Delaying Sweep Generator

Basically the Delaying Sweep Generator is composed of Q904, Q920, Q922, and Q914. This generator runs in the A INTEN, MIX, and B DLY'D positions of the HORIZ DISPLAY switch and generates the A portion of the display. In these modes the sweep rate is selected by the A TIME/DIV switch (skirt knob).

Main Gate Amplifier

Q902 is the Main Gate Amplifier stage. The negative-going Main Gate waveform from the Sweep Logic circuit is applied to the base of Q902. The amplified and inverted waveform at the collector of Q902 is applied to the Delaying Sweep Generator (through CR903), or to both of the Non-Delaying Sweep Generators (through Q992) in the A sweep mode. This initiates sweep generation.

Sweep Disconnect Amplifier

Q904 is the Sweep Disconnect Amplifier. The biasing on the base of this stage determines whether the Delaying Sweep Generator will run. In the A position of the HORIZ DISPLAY switch, the anode of CR907 is connected to +5 volts through R908 and the HORIZ DISPLAY switch circuit. This biases the base of Q904 far enough positive that the positive-going gates on the emitter cannot turn off Q904. Q904 therefore conducts all of the timing current through R905, R904, and timing resistor R_t, charging timing capacitance C_t. When the HORIZ DISPLAY switch is in any position other than A, CR907 is reverse-biased, which lets the base of Q904 be biased at a level that will allow the positive-going gates on the emitter of Q904 to interrupt the current flow through Q904. When Q904 turns off, the timing current starts to discharge timing capacitance C_t.

Sawtooth Sweep Generator

Q920 and Q922 form a Miller Integrator circuit. When the current through the Sweep Disconnect Amplifier Q904 is interrupted, timing capacitance C_t begins to discharge through timing resistor R_t. The timing resistor and capacitance are selected by the A TIME/DIV switch to provide the various sweep rates listed on the instrument front panel. The output signal at the collector of Q922 is a negative-going sawtooth voltage waveform.

Sweep Start Amplifier

Just before the sweep starts to run down, the levels at the bases of Q914 are approximately equal. When the sweep starts to run down, the base of Q914B goes negative, which increases the forward bias on CR914B. This in turn decreases the forward bias on CR914A, which very shortly after the start of the sweep, becomes reverse biased to interrupt the current through Q914A. The circuit remains in this condition until after the sweep retrace is complete. When the circuit returns to quiescence, Q914A begins to conduct through R904. This sets the current through Q904 which in turn establishes the DC level starting point for the sweep.

Output Buffer Amplifier

Q940 and Q956 form the Output Buffer Amplifier. Q940 is an emitter follower and Q956 is a common-base amplifier whose emitter is current-driven by the signal. The Output Buffer Amplifier provides the output sawtooth signal current to the Horizontal Amplifier and provides a measure of isolation between the Sawtooth Generator and the Horizontal Amplifier. Intensified Gain adjustment R950 adjusts the gain of the stage to match the output signal amplitude with that of the Non-Delaying Sweep Generators.

The Delaying Sweep Output Buffer Amplifier passes the signal to the Horizontal Amplifier when the HORIZ DISPLAY switch is in the A INTEN position and the TIME/DIV switches are not in the X-Y position. When the TIME/DIV switches are in the X-Y position the anode of CR956 is connected to +5 volts. This sets the base of Q956 at a positive enough level to reverse bias Q956 and prevent passage of the Delaying Sweep signal to the Horizontal Amplifier. With the TIME/DIV switches not in the X-Y position and the HORIZ DISPLAY switch in the A INTEN position, R955 is connected to −8 volts (through Q1099 in the Horizontal Display Switching circuit) and the anode of CR956 is not connected to any voltage. This forward biases CR955 and sets the base of Q956 at a DC level of approximately +4.3 volts. Now Q956 is forward biased and the Delaying Sweep signal is passed to the Horizontal Amplifier.

Delaying Sweep End Difference Amplifier

Q944 and Q946 are connected as a voltage comparator and generate the logic pulses that signal the end of sweep and blank the CRT display at the end of the sweep. Prior to the generation of a sawtooth voltage waveform by the Delaying Sweep Generator, the base of Q944 is at an approximate −1.6 volt level. The base of Q946 is held at about −3 volts by the divider made up of R948 and R949. Therefore, Q946 is reversed biased and not conducting and Q944 is forward biased and is conducting. When the sweep voltage at the emitter of Q940 begins to go in a negative direction, the base of Q944 follows until the base of Q944 goes more negative than the base of Q946. Q944 turns off and Q946 turns on, generating a positive pulse at the collector of Q944 and a negative pulse at the collector of Q946. The positive pulse at the collector of Q944 signals the end of sweep and starts the holdoff period. The negative pulse at the collector of Q946 signals the Z-Axis Logic circuit to blank the CRT and prevent any further display.

Delay Pickoff Comparator

The Delay Pickoff Comparator stage allows selection of the amount of delay from the start of the Delaying Sweep Generator before one of the Non-Delaying Sweep Generators is turned on. The amount of delay available is variable from 0.00 to 10.00 times the setting of the A TIME/DIV switch. The sweep rate of the Delayed (non-delaying) Sweep Generator is determined by the setting of the B TIME/DIV switch.

Q926A and Q926B are connected as a voltage comparator. Q928 is a relatively constant current source for Q926. Q938 is also connected as a voltage comparator circuit and is used to improve the switching capabilities of the stage. The reference voltage for the Delay Pickoff Comparator stage is provided by DELAY TIME POSITION control R930. U930 is an integrated circuit containing two high-gain amplifier cells used in a feedback amplifier configuration. They provide accurate fixed voltages (determined by settings of Delay Start, R938, and Delay Stop, R936) connected to the DELAY TIME POSITION control to allow precise delay pickoff. The instrument is calibrated so that the major dial divisions of the DELAY TIME POSITION control correspond to major divisions of horizontal deflection on the CRT graticule. For example, if the DELAY TIME POSITION control is set to 5.00, the Non-Delaying Sweep Generator is delayed five divisions of the Delaying Sweep time before it can produce a sweep.

The sawtooth voltage waveform from the Delaying Sweep Generator is connected to the gate of Q926B. The quiescent level of the delaying sawtooth biases Q926B on and its drain is negative enough to bias Q938B on. Q926A and Q938A are off and not conducting. As the Delaying Sweep sawtooth voltage goes down, the gate of Q926B also goes down. When it goes more negative than the level at the gate of Q926A (established by the DELAY TIME POSITION control), Q926A conducts and Q926B turns off. This also switches the states of Q938A and B and produces a positive-going rectangular current pulse at the collector of Q938A. This initiates the B sweep when B TRIG SOURCE is set to STARTS AFTER DELAY or enables the B Trigger Tunnel Diodes in all other positions of B TRIG SOURCE switch. When the Delaying Sweep resets, Q926B again conducts and Q926A is turned off. This switches Q938A and B back to their original states.

Non-Delaying Sweep Generators

There are two Non-Delaying Sweep Generators. In any position of the HORIZ DISPLAY switch, one of these generators will be running. They generate the displayed sweep in the A position of the HORIZ DISPLAY switch and the B portion of a display in the remaining positions. The B TIME/DIV switch (DLY'D SWEEP knob) selects the sweep rate for these generators. One generator provides the 0.5 second through 1 microsecond sweep rates, while the other generator provides the 0.5 microsecond through 0.01 microsecond sweep rates.

Either the "Main" Gate or the Delayed Gate can initiate sweep generation by the Non-Delaying Sweep Generators. When the HORIZ DISPLAY switch is in the A position and the TIME/DIV knobs are locked, a positive voltage is applied to the emitter of Q992, through R922 and Q1062. Q992 is forward biased, and the "Main" Gate is passed on to the Non-Delaying Sweep Generators through CR922 and CR971 or CR1001. In all the other positions of the HORIZ DISPLAY switch and when the TIME/DIV knobs are unlocked, a negative voltage is applied to the emitter of Q922 to reverse bias Q992 and prevent the "Main" Gate from reaching the generators. Now, only the "B" Gate can initiate sweep action in the Non-Delaying Sweep Generators.

"B" Gate Amplifier

Q996 is the "B" Gate Amplifier stage. The negative-going waveform from the Sweep Logic circuit is applied to the base of Q996. The amplified and inverted waveform at the collector of Q996 is applied to the Non-Delaying Sweep Generators through CR996 and CR971 or CR1001 to initiate sweep generation.

Non-Delaying Sweep Generator Differences

Basically the Non-Delaying Sweep Generators operate in the same manner as the Delaying Sweep Generator. The "fast" generator (Q1004, Q1010, Q1014, and Q1018) has only one timing capacitance (the parallel combination of C1008 and C1009). The capacitance is variable to achieve precise timing accuracy. Timing resistors are selected by the B TIME/DIV switch to provide the fastest six sweep speeds listed on the front panel.

Q988 and Q1018 are Sweep Start Amplifiers and establish the DC level starting points for the sweeps. The "slow" generator (Q974, Q980, Q984, Q988, and Q972) has an additional emitter follower (Q972). This emitter follower increases the current-gain of the loop to speed up the retrace time of the generator (determined by the time required to discharge the timing capacitor).

Mixed Mode Operation

Normally, Q1086 is an emitter follower with a fixed dc level at its base established by R1094 and R1095. The fixed level at the emitter of Q1086, in turn, is applied to the bases of Q1018 and Q988 through CR1017 and CR987 respectively. This sets the quiescent current flow through Q988 and Q1018 to establish the dc level starting points for the sweeps as previously explained. However, when the HORIZ DISPLAY switch is in the MIX position, the fixed level at the base of Q1086 is replaced by the sawtooth voltage waveform being generated by the Delaying Sweep Generator. Now, the dc level starting point of the Non-Delaying Generator that is running is constantly being changed by the Delaying Sweep sawtooth until the Delaying Sweep runs down to a voltage determined by the setting of the DELAY TIME POSITION control. At this time, one of the disconnect transistors (Q974 in the "slow" Non-Delaying Generator, or Q1004 in the "fast" Non-Delaying Generator, depending on the settings of the TIME/DIV controls) is turned off, allowing the appropriate Non-Delaying Generator to begin a ramp waveform determined by the setting of B DLY'D control. The output waveform from the Non-Delaying Sweep Generator that is running will be a composite sawtooth waveform with the first and last parts occurring at a rate determined by the Delaying Sweep Generator (last part blanked out of CRT display) and the middle part occurring at a rate determined by one of the Non-Delaying Sweep Generators.

Non-Delaying Sweep End Difference Amplifier

Q1044 and Q1034 are connected as a voltage comparator, and generate the same sort of logic pulses as the Logic Comparator in the Delaying Sweep Generator circuit. The positive-going pulse at the collector of Q1034 signals the end of the Non-Delaying Sweep, and the negative-going pulse at the collector of Q1044 blanks the display at the end of the Non-Delaying Sweep. However, the logic pulses from this comparator are not always allowed to pass to the Sweep and Z-Axis Logic circuits.

In the A INTEN position of the HORIZ DISPLAY switch, +5 volts is connected to the anode of CR1049. This forward biases CR1044, which sets the collector of Q1044 at approximately +0.7 volts. This keeps CR1046 reversed biased and prevents completely blanking the CRT at the end of the Non-Delaying Sweep portion of the display. In the A INTEN, MIX, and B DLY'D positions of the HORIZ DISPLAY switch, −8 volts is connected to the anode of CR1036 through R1090. This turns off the diode gate (CR1034 and CR1037) preventing a Non-Delaying Sweep end-of-sweep pulse output from Q1034 collector which would terminate the Delaying Sweep. This pulse is allowed to reset the Non-Delaying Sweep through Q788. In the A position of the HORIZ DISPLAY switch (knobs locked), a more positive voltage is connected to the anode of CR1036. This enables CR1034 and CR1037, thus allowing the Main Sweep end-of-sweep pulse to pass to the Sweep Logic circuit. The logic levels are generated by the HORIZ DISPLAY switch, Q1062, Q1066 and Q1099.

TIME/DIV Functions (Knobs Unlocked)

Normally, when the HORIZ DISPLAY switch is set to A, the Non-Delaying Sweep Generator is being used to display A Sweep. When the DLY'D SWEEP control (inner knob of TIME/DIV) is unlocked and set to a faster sweep rate, the Non-Delaying Sweep Generator is then being used to display A Sweep. In this mode, the A TIME/DIV (skirt knob) must be used to control A Sweep rates.

HORIZONTAL AMPLIFIER 

General

The Horizontal Amplifier circuit provides the output signals to the CRT horizontal deflection plates. The signal applied to the input of the Horizontal Amplifier is determined by the TIME/DIV switch. The signal can be a sawtooth waveform generated within the instrument, or some external signal applied to the CH 1 OR X input connector (X-Y mode of operation). The Horizontal Amplifier also contains the X10 magnifier, horizontal positioning controls, and some beam finder circuitry. Fig. 3-8 shows a detailed block diagram of the Horizontal Amplifier circuit. A schematic of this circuit is shown on Diagram 10 at the rear of this manual.

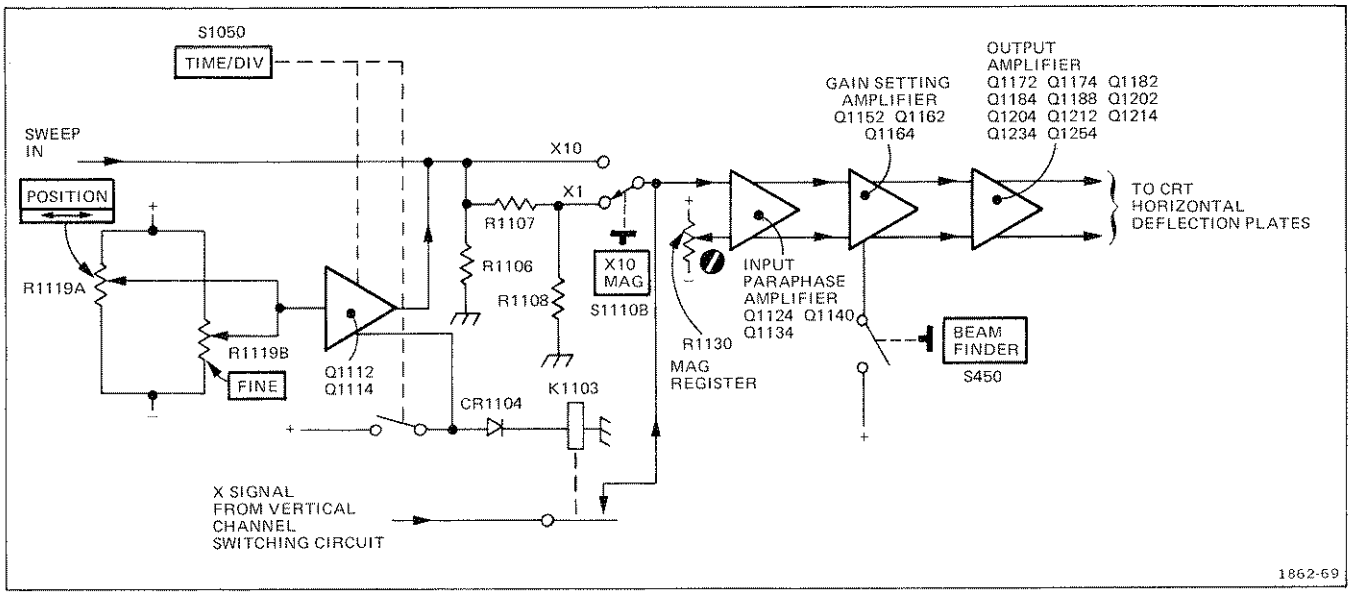


Fig. 3-8. Detailed block diagram of the Horizontal Amplifier circuit.

Input Paraphase Amplifier

Q1124 and Q1134 form the Input Paraphase Amplifier. This is an emitter-coupled amplifier stage that converts the single-ended input signal to a push-pull output signal. The X10 Magnifier circuitry is in this stage and consists of a divide-by-ten attenuator R1106-R1107-R1108. When the X10 Magnifier is on, the input signal is applied unattenuated to the Input Paraphase Amplifier. When the X10 Magnifier is off, the input signal is applied to the Input Paraphase Amplifier through the attenuator. X10 MAG indicator DS1110 lights when the X10 Magnifier is being used. CR1121 and CR1122 limit signal amplitudes at the input to the amplifier to prevent amplifier overdrive. Q1140 is a relatively constant current source for Q1124 and Q1134. CR1140 provides temperature compensation for the base-emitter junction of Q1140. Magnifier Registration adjustment R1130 balances quiescent DC current in Q1124 and Q1134 so that a center screen display does not change position when the X10 Magnifier is turned on.

Q1112 and Q1114 together form a temperature compensated current source that is an interruptable path for the horizontal positioning currents. When the TIME/DIV switch is in any position other than X-Y, the anodes of CR1103, CR1104, and CR1111 are connected to −8 volts through R1104, which reverse-biases them. In the X-Y position of the TIME/DIV switch, +5 volts is connected directly to the anodes of CR1103, CR1104, and CR1111. This accomplishes three things. First, the emitter-base junction of Q1114 is reverse biased, which prevents the Horizontal POSITION and FINE controls from having any effect on the display. Second, relay K1103 is energized, which connects the X-axis signal from the Channel 1 Preamplifier to the input to the Horizontal Amplifier. Third, +5 volts is connected to the Channel 1 Scale Factor Switching circuit so that both deflection factor indicators are operating. When operating in the X-Y mode, R1102 adjusts for correct X-axis gain and L1103 adjusts to reduce the phase differences between the horizontal (X) and vertical (Y) signal paths.

Gain Setting Amplifier

Q1152 and Q1162 are an emitter-coupled push-pull amplifier stage. The gain of this stage is adjusted to match the CRT sensitivity. When the BEAM FINDER pushbutton is pushed, R1168 is switched into the circuit. This reduces the current through this stage, thereby limiting horizontal deflection to within the limits of the CRT viewing area. Q1152 and Q1162 operate in an overdriven mode. This means at the extremes of signal amplitude, one side will be turned off while the other side is still conducting. This condition generates some common-mode signal differences between Q1152 and Q1162. Q1164 monitors any common-mode signal differences (through R1165 and R1167) and conducts to minimize them.

Output Amplifier

The push-pull signal from the Gain Setting Amplifier is connected to the Output Amplifier. Each half of the Output Amplifier can be considered as a single-ended feedback amplifier, which amplifies the signal at its input to produce a voltage output to drive one of the horizontal deflection plates of the CRT. Both halves of the Output Amplifier are basically the same with only minor differences; therefore, only the upper amplifier (drives the + horizontal deflection plate) and the differences will be explained.

Q1172 and Q1174 are connected in a Darlington configuration. Q1234 is a feedback amplifier in the feedback path for the output amplifier. Q1234 sets DC levels and reduces the impedance of the feedback path. Q1202 and Q1204 form a complementary amplifier that provides the output signal to drive the + deflection plate of the CRT. CR1173 clips excessive signal amplitudes and sets a sweep start voltage level for the positive deflection plate. R1175, C1233, and C1179 are high-frequency compensation adjustments. R1256 centers the output signal swing within the dynamic swing capabilities of the output amplifier.

There are two signal paths through each half of the Output Amplifiers. Slow signal transitions are applied to the CRT through Q1172, Q1174, and Q1204 with feedback via R1233 and R1235. C1235, C1233, and C1178-C1179 compensate the amplifier and provide a fast AC signal path from one side of the amplifier to the other. The lower amplifier (drives the − horizontal deflection plate) is basically the same as the upper except for two things. Q1188 is a relatively constant current source for Q1182 and Q1184. VR1216 shifts the DC level of the signal from the collectors of Q1182 and Q1184 to the emitter level of Q1214.

LOW-VOLTAGE POWER SUPPLY

General

The Low-Voltage Power Supply circuit provides the operating power for this instrument from six regulated power supplies and one unregulated power supply. Electronic regulation is used to provide stable, low-ripple output voltages. Fig. 3-9 shows a detailed block diagram of the Power Supply circuit. A schematic of this circuit is shown on Diagram 11 at the rear of this manual.

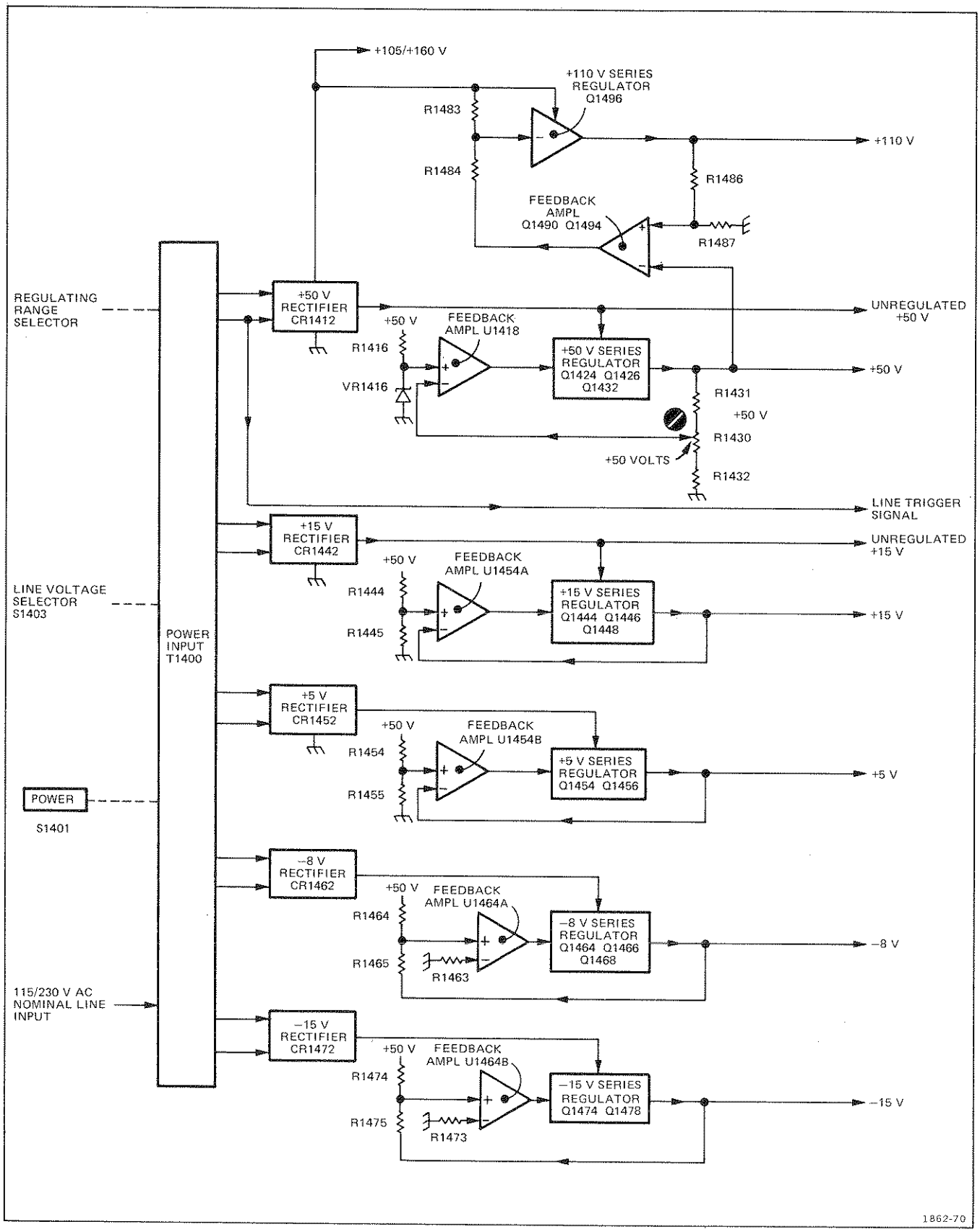


Fig. 3-9. Detailed block diagram of the Power Supply circuit.

Power Input

Power is applied to the primary of transformer T1400 through Line Fuse F1401, POWER switch S1401, Thermal Cutout S1402, Line Voltage Selector switch S1403, and the Regulating Range Selector. Line Voltage Selector switch S1403 connects the split primaries of T1400 in parallel for 115-volt nominal operation, or in series for 230-volt nominal operation. Line Fuse F1401 should be changed for each nominal line voltage (current rating of fuse for 230-volt operation must be 0.75A fast; for 115-volt operation current rating of fuse must be 1.5A fast).

Thermal cutout S1402 provides thermal protection for this instrument. If the internal temperature of the instrument exceeds a safe operating level, S1402 opens to interrupt the applied power. When the temperature returns to a safe level, S1402 automatically closes to reapply the power.

The vacant windings between pins 10, 10A, 11, 12, and 12A of T1400 are intended for use with the optional Inverter Circuit Board (Option 7) or for use with a 475A Oscilloscope modification, a Power Supply Board (475A DM44).

Secondary Circuit

The −8 volt, −15 volt, +5 volt, +15 volt, +50 volt, and +110 volt supplies are series-regulated supplies. U1418, U1454A and B, and U1464A and B are high-gain amplifier cells with differential inputs. These amplifiers monitor variations in the output voltages and generate error signals to maintain relatively constant output levels. Each regulated supply contains a current-limiting circuit that provides short circuit protection to prevent instrument damage if a supply is inadvertently shorted to ground. Additionally, unregulated voltages are used from the +15 volt and +50 volt supplies.

+50-Volt Supply. The +50-Volt Power Supply provides the reference voltage for all remaining regulated supplies in the instrument. The following discussion includes the description of the +50-Volt Series Regulator, +50-Volt Feedback Amplifier, +50-Volt Reference, and +50-Volt Current Limiting stages. Since these stages are closely related in the production of the +50-volt regulated output voltage, their operation is most easily understood when discussed as a unit.

CR1412 functions as a full-wave, center-tapped, bridge rectifier and provides an unregulated output voltage (approximately +65 volts) for the +50-Volt Power Supply. This voltage is filtered by C1414 and is connected to the +50-Volt Series Regulator, Q1426, to provide a sufficient collector supply for stable regulation over a wide range of ac power line voltages. Zener diode VR1416 sets a reference level of about +9 volts at the positive input of Feedback Amplifier U1418. A sample of the output voltage from the +50-Volt Supply is connected to the negative input of U1418 through divider R1430-R1431-R1432. R1430 in this divider is adjustable to set the output level of the +50-Volt Supply. The 2 input voltages at Feedback Amplifier U1418 are compared and any error between the 2 inputs is amplified. The amplified error output from U1418 drives Q1424 and Q1426 and controls the output voltage of the power supply.

Regulation occurs as follows: If the output level of this supply decreases (due to an increase in load, for example) the voltage across divider R1430-R1431-R1432 decreases also. This results in a more negative feedback level at pin 2 of U1418 than that established by the reference voltage at pin 3. The difference in voltage levels is amplified and polarity is inverted by U1418. The result is that voltage increases at pin 1 of U1418. This increase in voltage causes a more positive voltage at the base of Q1424. More current is allowed to flow through Q1424 to result in increased conduction of the +50-volt Series Regulator Q1426. The output voltage increases, thereby achieving regulation of the +50-volt power supply.

The +50-volt Current Limiting stage, Q1432, protects the +50-Volt Series Regulator if excess current is demanded from this supply. Since the load is connected to this supply through R1426, all current must flow through this resistor. When excess current is demanded from the +50-Volt Series Regulator, due to a short circuit or similar malfunction at the output of this supply, the voltage drop across R1426 increases, causing a higher positive voltage at the emitter of Q1426 than the supply output voltage. This increased voltage is coupled through the emitter-to-base junction of Q1426 to voltage divider R1424 and R1425. Under normal conditions, this divider sets the base level of Q1432 for a biased-off condition. However, when the power supply load increases beyond preset limits, or the supply output becomes short circuited, the positive going change across the divider R1424-R1425 causes Q1432 to become biased on. The collector current of Q1432 reduces the voltage at the base of Q1424 to limit the conduction of current through Q1426 and R1426 to a preset value. This mode of operation is called foldback because both the supply voltage and current are reduced during overload. The supply automatically returns to normal operation when the overload is removed.

+110-Volt Supply. CR1412 functions as a full-wave center-tapped rectifier and provides an unregulated output voltage (approximately +136 volts) for the +110-Volt Power Supply. This voltage is filtered by C1412 and is connected to the +110-Volt Series Regulator, Q1496, to provide sufficient collector supply for stable regulation over a wide range of ac power line voltages. Transistors Q1490 and Q1494 are connected as a comparator. A sample of the output voltage from the +110-Volt Supply, through divider R1486, R1487, is connected to the base of Q1490. The base of Q1494 is connected to the +50-Volt Supply to provide a reference voltage. The error output at the collector of Q1494 reflects the difference, if any, between these 2 inputs. This error output drives Q1496 and controls the output voltage of the power supply.

Regulation occurs as follows: If the output level of this supply decreases (due to an increase in load, for example) the voltage at the base of Q1490 decreases also. This decreased voltage when compared to the reference voltage at the base of Q1494 results in a decreased voltage at the collector of Q1494. A portion of this decreased voltage is connected to the base of Q1496 causing increased conduction. The output voltage increases, thereby achieving regulation of the +110-volt power supply.

A current limiting stage, Q1497, protects the +110-Volt Supply if excess current is demanded from this supply. All output current from the +110-Volt Supply must flow through R1489. Transistor Q1497 senses the voltage drop across R1489. Under normal operating conditions, Q1497 is biased off. However, when excess current is demanded from the +110-Volt Series Regulator due to a short circuit or similar malfunction at the output of this supply, the voltage drop across R1489 increases until it is sufficient to forward bias Q1497. The collector current of Q1497 pulls the base of Series Regulator Q1496 positive and turns it off. The output current from the supply is then limited by R1488 and the +110-Volt Supply is thereby protected.

+15-Volt Supply. Basic operation of all stages in the +15-Volt Supply is the same as for the +50-Volt Supply. The +15 volt reference for this supply is established by divider R1444-R1445 between +50 volts and ground. Any change in the output level of the supply is compared at Feedback Amplifier U1454A, which produces a signal of inverted polarity at its output (pin 1). This change is coupled to +15-Volt Series Regulator Q1448 through Q1446 to correct the change in output voltage. Transistor Q1444 provides current limiting (foldback operation) if the supply load increases beyond preset limits or becomes shorted to ground.

+5-Volt Supply. Basic operation of all stages in the +5-Volt Supply is the same as described in the +50-Volt Supply and the +15-Volt Supply. The +5 volt reference for this supply is established by divider R1454-R1455 between +50 volts and ground. Any change in the output level of the supply is compared at Feedback Amplifier U1454B which produces a signal of inverted polarity at its output (pin 7). This change is coupled to +5-Volt Series Regulator Q1456 to correct the change in the output voltage. Transistor Q1454 provides current limiting (foldback operation) if the supply load increases beyond preset limits or becomes shorted to ground.

−8-Volt Supply. Basic operation of all stages in the −8-Volt Supply is the same as described in previous supplies. The reference level for this supply (0 volt) is established by the ground connection through R1463 to pin 2 of Feedback Amplifier U1464A. Feedback voltage to pin 3 of U1464A is provided by divider R1464-R1465 between +50 volts and the −8-Volt Supply output. The divider ratio of R1464-R1465 is 10:1 so the level at pin 3 is 0 volt when the supply is operating properly. Any change in the output level of the supply is compared at U1464A, which produces a correction signal of the same polarity as its output (pin 1). This change is coupled to the −8-volt Series Regulator, Q1468, through Q1466 to correct the change in output voltage. Transistor Q1464 provides current limiting (foldback operation) if the supply load increases beyond preset limits or becomes shorted to ground.

−15-Volt Supply. Basic operation of all stages in the −15-Volt Supply is the same as described in the −8-Volt Supply. The reference level for this supply (0 volt) is established by the ground connection through R1473 to pin 6 of Feedback Amplifier U1464B. The feedback voltage (0 volt) to pin 5 of U1464B is provided by divider R1474-R1475 between +50 volts and the −15-Volt Supply output. Any change in the output voltage of the supply is compared at U1464B, which produces a correction signal of the same polarity at its output (pin 7). This change is coupled to the base of −15-Volt Series Regulator Q1478 to correct the change in output voltage. Transistor Q1474 provides current limiting (foldback operation) if the supply load increases beyond preset limits or becomes shorted to ground.

CRT CIRCUIT 

General

The CRT Circuit provides the voltage levels and control circuits necessary for operation of the cathode-ray tube (CRT). Fig. 3-10 shows a detailed block diagram of the CRT Circuit. A schematic of this circuit is shown on Diagram 12 at the rear of this manual.

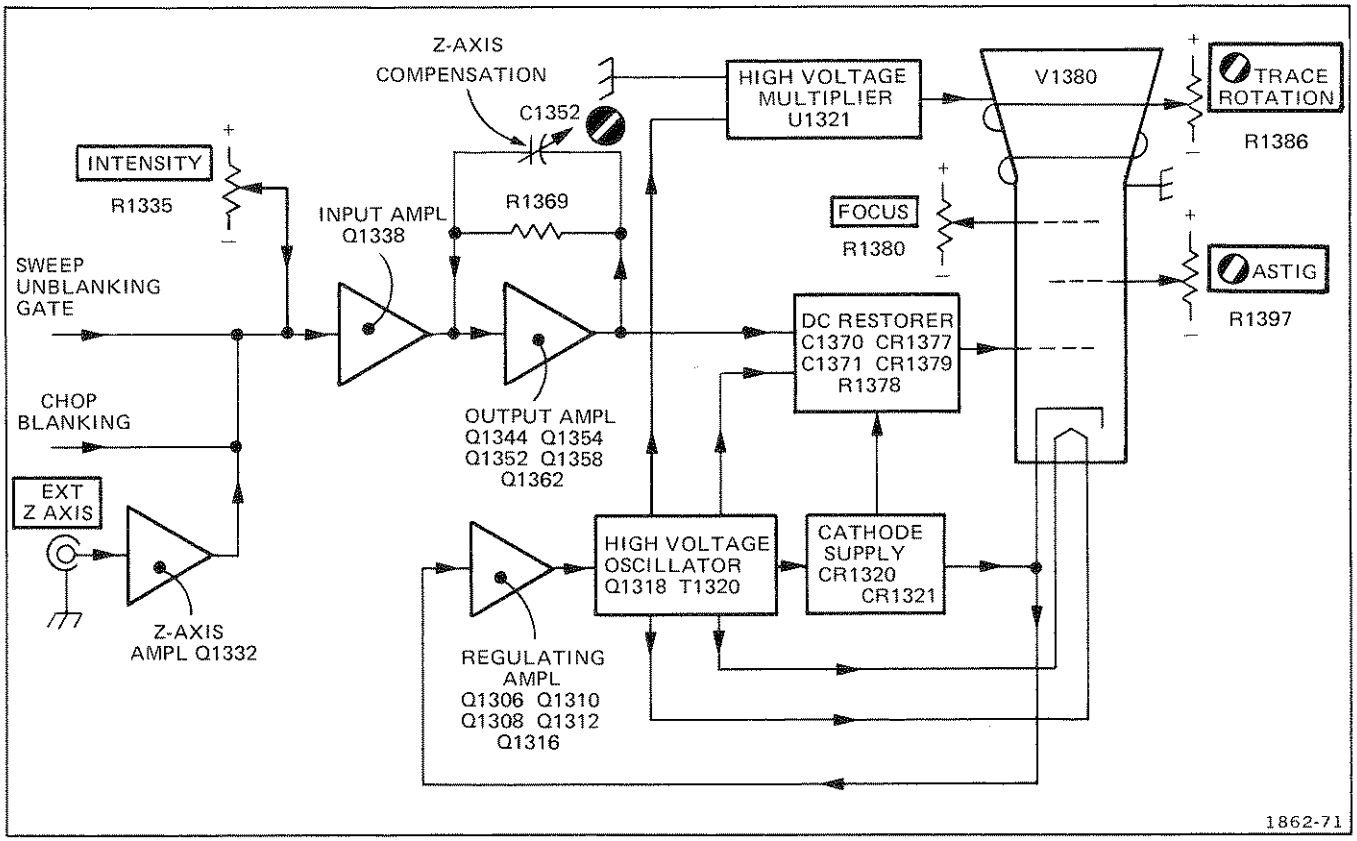


Fig. 3-10. Detailed block diagram of the CRT circuit.

High-Voltage Oscillator

Q1318 and associated circuitry compose the high-voltage oscillator that produces the drive for high-voltage transformer T1320. When the instrument is turned on, current through Q1316 provides forward bias for Q1318. Q1318 conducts and the collector current increases, which develops a voltage across the collector winding of T1320. This produces a corresponding voltage increase in the feedback winding of T1320, which is connected to the base of Q1318, and Q1318 conducts even harder. Eventually the rate of collector current increase in Q1318 becomes less than that required to maintain the voltage across the collector winding and the output voltage drops. This turns Q1318 off by way of the feedback voltage to the base. The voltage waveform at the collector of Q1318 is a sine wave at the resonant frequency of T1320. Q1318 remains off during the negative half cycle while the field collapses in the primary of T1320. When the field is collapsed sufficiently, the base of Q1318 becomes forward biased into conduction again and the cycle begins anew. The amplitude of sustained oscillation depends upon the average current delivered to the base of Q1318. The frequency of oscillation is approximately 50 kilohertz. Fuse F1318 protects the unregulated +15-volts supply in the event the High-Voltage Oscillator stage becomes shorted. C1318 and L1318 decouple the +15-volt supply line and prevent the current changes present in the circuit from affecting the +15-volt regulated supply.

High-Voltage Regulator

Feedback from the CRT cathode −2450 volt supply is applied to the base of Q1306 through R1303A. Any change in the level at the base of Q1306 produces an error signal at the collector of Q1306, which is amplified by Q1308 and Q1316 and applied to the base of Q1318 through the feedback winding of T1320. Regulation occurs as follows.

If the output voltage at the −2450 volt test point starts to go positive (less negative), this positive-going change is applied to the base of Q1306. Q1306 conducts harder, which in turn causes Q1308 and Q1316 to conduct harder. This results in greater bias current to the base of Q1318 through the feedback winding of T1320. Now, Q1318 is biased closer to its conduction level so that it comes into conduction sooner to produce a larger induced voltage in the secondary winding or T1320. This increased voltage appears as a more negative voltage at the −2450 volt test point to correct the original positive-going change. By sampling the output from the CRT cathode supply in this manner, the total output of the High-Voltage Supply is held relatively constant.

Q1312 and Q1310 compose an overvoltage protection circuit. In the event the regulating action of the circuit should cause the CRT cathode supply to approach approximately −3000 volts, the voltage level at the emitter of Q1316 will be very close to −6 volts. Normally Q1312 and Q1310 are biased off and do not conduct. When the voltage level at the emitter of Q1316 reaches approximately −6 volts, Q1312 is biased into conduction, which in turn biases Q1310 on. Q1310 now starts to reduce the base drive applied to Q1318 and prevents the amplitude of oscillations from increasing. This prevents the CRT cathode supply from going more negative than approximately −3300 volts.

High-Voltage Rectifiers and Output

The high-voltage transformer T1320 has two output windings. One winding provides filament voltage for the cathode-ray tube. The filament voltage can be supplied from the High-Voltage Supply, since the cathode-ray tube has a very low filament current drain. The filament of the cathode-ray tube is elevated to the cathode level to prevent cathode-to-filament arcing. The other winding of T1320 is used to derive both the negative cathode potential and the positive anode accelerating potential.

The positive accelerating potential is supplied by High Voltage Multiplier U1321. Regulated output voltage is approximately +15,500 volts. The negative cathode potential is supplied by a voltage doubler circuit, C1320, CR1320 and CR1321. Voltage output is −2450 volts. Variations in supply voltage are monitored by the High-Voltage Regulator circuit to provide a regulated high-voltage output.

Control-Grid DC Restorer

The Control-Grid DC Restorer couples dc and low frequency components of the Z-Axis Amplifier signal to the CRT control grid. This allows the Z-Axis Amplifier to control the CRT beam current (intensity). The potential difference between the Z-Axis Amplifier output and the control grid (about 2450 volts) prohibits direct coupling.

The dc restorer is actually a cathode-referenced bias supply for the CRT control grid. Quiescently, its output voltage is more negative than the CRT cathode by an amount set by the voltage level across VR1374, the setting of Grid Bias adjustment R1375, and the voltage at the output of the Z-Axis Amplifier.

When the secondary-winding output of T1320 swings positive, C1372 charges through C1326, R1326, R1372, CR1379, and R1379 to a voltage level that equals the voltage determined by VR1374 and the setting of Grid Bias adjustment R1375. At this voltage level, (approximately +15 volts) CR1373 turns on, preventing any additional increase in positive voltage. When the secondary-winding output swings negative, CR1373 turns off, then CR1371 turns on and clamps the less positive voltage swing at C1372 to the voltage level of the Z-Axis Amplifier. During this less positive voltage swing, C1372 discharges through CR1377 into C1371. Capacitor C1371 holds the voltage constant at the CRT control grid; it also provides a path for the fast rising and falling portions of the Z-Axis Amplifier output to be coupled to the CRT control grid for blanking and unblanking.

CRT Control Circuits

Focus of the CRT display is controlled by FOCUS control R1380. The Focus Tracking control, R1335B, located in a series resistor network with the FOCUS control, is ganged with the INTENSITY control to reduce focus variations when changing the INTENSITY setting. The ASTIG adjustment R1397 which is used in conjunction with the FOCUS control to provide a well-defined display, varies the positive level on the astigmatism grid. Geometry adjustment R1390 varies the positive level on the horizontal deflection plate shields to control the overall geometry of the display.

Two adjustments control the trace alignment by varying the magnetic field around the CRT. Y Align adjustment R1385 controls the current through L1385, which affects the CRT beam after vertical deflection but before horizontal deflection. Therefore, it affects only the vertical (Y) components of the display. TRACE ROTATION adjustment R1386 controls the current through L1386 and affects both vertical and horizontal rotation of the beam.

Z-Axis Amplifier

The Z-Axis Amplifier circuit controls the CRT intensity level from several inputs. The effect of these input signals is to either increase or decrease the trace intensity, or to completely blank portions of the display. The input transistor, Q1338, is a current-driven, low input impedance amplifier. It provides termination for the input signals as well as isolation between the input signals and the following stages. The current signals from the various control sources are connected to the emitter of Q1338 and the algebraic sum of the signals determines the collector conduction level.

Q1344, Q1352, Q1354, Q1358, and Q1362 compose a feedback amplifier stage. R1369 is the feedback resistor and C1352 provides high-frequency compensation. Q1344 is an emitter follower that provides drive to the output complementary amplifier made up of Q1352, Q1354, and Q1358. Q1358 is a device with higher frequency characteristics than Q1354 and is used to improve the overall frequency capabilities of the Z-Axis Amplifier. On the fast positive-going output signal peaks, Q1358 depletes the charge on C1358. Then, on the negative-

going signal peaks, Q1362 is pulsed on to renew the charge on C1358. CR1367 provides protection to the Z-Axis Amplifier circuitry in the event of short duration arcing in the CRT High-Voltage Power Supplies.

In the 0.1 s, 0.2 s, 0.5 s, and X-Y positions of the TIME/DIV switch, the anode of CR1337 is connected to ground. This limits how negative the operating level at the emitter of Q1338 can go to reduce the unblanking capabilities of the amplifier, thereby reducing the possibility of inadvertently burning the CRT phosphor. When the BEAM FINDER pushbutton is pressed, −8 volts is connected to the junction of R1342 and R1346. This biases Q1338 off which in turn causes CR1343 to be reverse biased. Now the output of the Z-Axis Amplifier is isolated from all of the circuit's normal signal inputs. The output level of the amplifier is set at a nearly fixed level (approximately +25 volts) determined by the parallel value of R1343 and R1346 divided into the feedback resistance of the amplifier. This sets the sweep intensity to a normal viewing level.

CALIBRATOR 13

General

The Calibrator circuit produces a square-wave output signal with accurate voltage and current amplitudes. This output is available as a voltage or current at the CALIBRATOR current loop on the instrument front panel. Fig. 3-11 shows a detailed block diagram of the Calibrator circuit. A schematic of this circuit is shown on Diagram 13 at the rear of this manual.

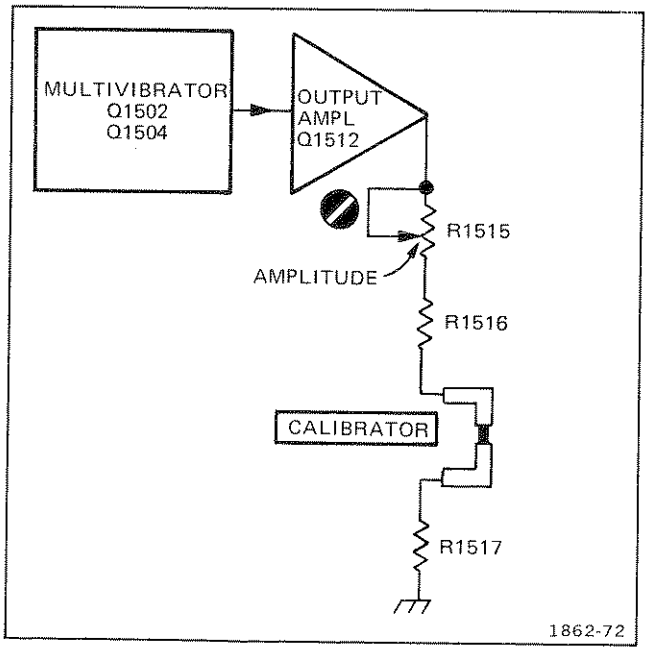


Fig. 3-11. Detailed block diagram of the Calibrator circuit.

Multivibrator

Q1502 and Q1504 along with their associated circuitry compose an astable multivibrator. The basic frequency of the multivibrator is approximately one kilohertz and is essentially determined by the RC combination of C1505, R1502, and R1504. Q1502 and Q1504 alternately conduct, producing a square-wave signal that is taken from the collector of Q1504.

Output Amplifier

The output signal from the Multivibrator overdrives Output Amplifier Q1512 to produce a square wave at the output. When the base of Q1512 goes positive, Q1512 is cut off and the collector level drops down to ground. When the base goes negative, Q1512 biased into saturation and the collector of Q1512 rises positive to about +5 volts. Amplitude adjustment R1515 adjusts the resistance between the collector of Q1512 and ground to determine the amount of current allowed to flow, which in turn determines the voltage developed across R1517.

FAN MOTOR CIRCUIT 13

General

The fan motor used in the 475A is a brushless DC motor using Hall Effect devices. The fan motor control circuitry varies the rotational speed of the fan as the operating temperature changes.

Two Hall Effect devices inside the motor, and 4 transistors U1690A, B, C, and D compose a sine-wave generator to drive the motor windings. Each of the 4 transistors is controlled by 1/2 of a Hall element to generate 1/4 of the sine-wave cycle.

As the ambient temperature increases, the value of thermistor RT1696 decreases. This biases Q1698 on harder to conduct more current through the Hall devices and turn the motor winding control transistor on harder. The harder the transistor is conducting, the faster the fan rotates.

Typical fan speed variation with ambient temperature is:

−15° C, approx. 800 RPM
+25° C, approx. 2000 RPM
+55° C, approx. 3100 RPM

MAINTENANCE

This section of the manual contains directions for cabinet removal, preventive maintenance, troubleshooting and corrective maintenance of the 475A.

MAINTENANCE SECTION OUTLINE

Corrective Maintenance

CABINET AND RACK ADAPTER REMOVAL

Standard Cabinet Removal

The standard instrument cabinet can be removed in the following manner:

1. Disconnect the instrument power cord from the power source.

2. Install the front-panel cover and set the instrument face on a flat surface.

3. Unwrap the power cord from the instrument feet.

4. Remove the 6 screws indicated in Fig. 4-1 and remove the rear cabinet frame with feet and screws from the instrument as an intact assembly.

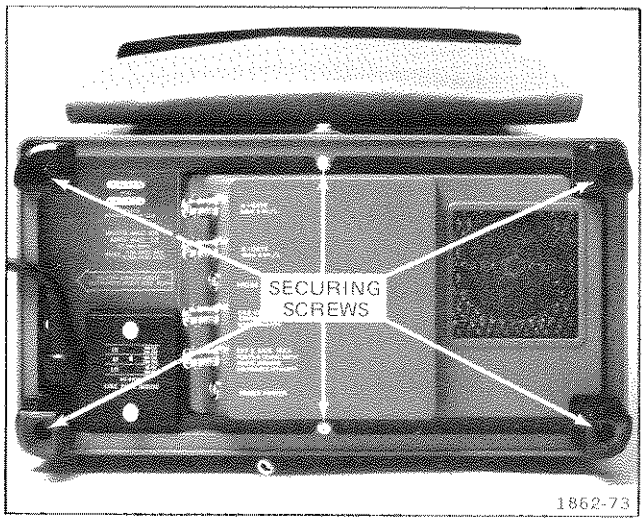


Fig. 4-1. Removing the standard cabinet.

5. Lift the cabinet up until it is separated from the instrument and power cord.

WARNING

Dangerous potentials exist at several points throughout this instrument. When the instrument is operated with the cabinent removed, do not touch exposed connections or components. Some transistors may have elevated cases. Disconnect power before cleaning the instrument or replacing parts.

Standard Cabinet Installation

The standard instrument cabinet should be installed in the following manner:

1. Disconnect the instrument power cord from the power source.

2. If the Vertical Output circuit-board cover is not in place, install the cover on the top of main chassis. Where parts were removed or replaced check all sections of the instrument for proper assembly. It may by helpful to use the diagrams in Section 9, Mechanical Parts List, for the locations of parts.

3. 475A DM44—If the DM44 main circuit-board is not in place, install the board on the main chassis.

4. Install the front-panel cover and set the instrument face on a flat surface.

5. Place the cabinet handle against the bottom of the cabinet (bottom of cabinet is nearest the carrying handle pivot points).

6. Pull the power cable through the cabinet and slide the cabinet over the instrument using care to avoid pinching cables or damaging components that protrude from circuit boards.

7. Using both hands, press lightly on the top and bottom sides of the cabinet until the front edge of the cabinet is inserted into the braided gasket groove around the full periphery of the front cabinet frame.

8. Pull the power cord through the rear cabinet frame, align a cutout portion in the frame for proper fit at the regulating-range selector cover and work the frame into place.

9. Set the feet and screws in place and exert a light downward pressure on the rear cabinet frame with 1 hand and arm. Press lightly on the top and bottom sides of cabinet with the other hand, checking that cabinet edge is properly seated in the gasket groove of both front and rear frames. Continue to exert a downward pressure and tighten the 6 screws of the rear frame to a snug fit. Do not over-tighten these screws.

The standard cabinet protects this instrument from dust in the interior and also provides protection to personnel from the operating potentials present. In addition, the cabinet reduces the emi (electromagnetic interference) radiation from the instrument and interference to the display due to other equipment.

The front-panel cover provides a dust-tight seal around the front panel and protects the front panel when storing or transporting the instrument.

Rack Adapter Removal

The Rack Adapter can be removed from the instrument in the following manner:

1. Remove the hardware that fastens the Rack Adapter to the rack and pull the adapter partially out. Disconnect the instrument power cord from the power source and remove any interconnecting cables.

NOTE

If it is desired to tilt the Rack Adapter and instrument, remove a screw from the rear of each slide section mounted to the Rack Adapter. These securing screws are an important part of the mounting and should be installed when tilt operation is not necessary.

2. Remove the Rack Adapter, with instrument, from the rack and set the bottom of the complete assembly on a flat surface.

3. Remove 2 setscrews from the top, front of Rack Adapter chassis, (A 0.125-inch Allen wrench is required to remove the setscrews.) It may be helpful to use the diagrams in Section 9, Mechanical Parts List for the locations of parts.

4. Remove 10 screws that hold the rear support plate to an angle bracket on one side, to the Rack Adapter chassis on the opposite side, and to the rear of the instrument. Remove the rear support-plate and blue-plastic rear frame.

5. Slide the instrument forward through the adapter cabinet, using both hands (front and rear) to lift and guide the instrument until separated from the Rack Adapter.

WARNING

Dangerous potentials exist at several points throughout this instrument. When the instrument is operated with the Rack Adapter removed, do not touch exposed connections or components. Some transistors may have elevated cases. Disconnect power before cleaning the instrument or replacing parts.

Rack Adapter Installation

The Rack Adapter should be installed in the following manner:

1. Disconnect the instrument power cord from the power source.

2. If the Vertical Output circuit-board cover is not in place, install the cover on the top of the 475A main chassis. Check all sections of the instrument where parts were removed or replaced for proper assembly. It may be helpful to use the diagrams in Section 9, Replaceable Mechanical Parts for the locations of parts.

3. Set the bottom of the Rack Adapter on a flat surface, pull the power cord through the cabinet portion of the Rack Adapter and slide the instrument rearward using both hands (front and rear) to lift and guide the instrument until fully inserted. Use care to avoid pinching cables or damaging components that protrude from circuit boards.

4. Check that the front edge of the cabinet portion of the Rack Adapter is inserted into the braided gasket groove around the full periphery of the instrument front-frame. Pull the power cord through the blue-plastic rear frame, align a cutout portion in the plastic frame for proper fit at the regulating-range selector cover, and work the frame into place.

5. Apply the rear support bracket to the rear of the Rack Adapter. Install, without tightening, 6 screws that secure the rear support bracket through the blue-plastic frame to the rear of the instrument and 4 screws that secure the rear support bracket to an angle bracket and to the Rack Adapter chassis.

6. Check that all parts of the complete assembly are properly seated, then tighten to a snug fit the screws at the rear of the instrument and the screws at the adapter chassis. Do not overtighten these screws.

7. Install 2 setscrews at the top-front of the Rack Adapter chassis. (A 0.125-inch Allen wrench is requred to install the setscrews.)

8. Mount the Rack Adapter slide sections to the rack slide assemblies, connect the power cord, connect any interconnecting cables, push the Rack Adapter into final operating position, and install the adapter-to-rack hardware.

The Rack Adapter cabinet (Part No. 016-0556-00) for the 475A provides the proper electrical environment for the instrument, reduces dust collection, reduces handling damage to a minimum, and provides a means for mounting the instrument solidly to a surface such as a rack or console.

PREVENTIVE MAINTENANCE

Introduction

Preventive maintenance consists primarily of cleaning and visual inspection. When performed on a regular basis, preventive maintenace can prevent instrument breakdown and improves the reliability of this instrument. The severity of the environment to which the 475A is subjected will determine the frequency of maintenance. A convenient time to perform preventive maintenance is just prior to recalibration of the instrument.

Cleaning

The cabinet provides protection against dust in the interior of the instrument. Operation without the cabinet in place necessitates more frequent cleaning. The front cover provides a measure of dust protection for the front panel and the crt face. The front-panel cover should be installed when storing or transporting the instrument.

CAUTION

The volts/division attenuators use a plastic material (polyphenylene oxide) that is easily damaged by the use of carbon-based solvents. Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Do not use chemicals that contain acetone, benzene, toluene, xylene, petroleum ether, white kerosene, carbon tetrachloride, methylene chloride, trichloroethane, trichlorotrifluoroethane (freon 113, -tf, -ta, -tmc) and trichlorethylene. Recommended cleaning agents for general interior cleaning, except switch contacts, are isopropyl alcohol, kelite (1 part kelite, 20 parts water), and a solution of 1% mild detergent and 99% water. (Read the information under Cleaning, Switch Contacts, before attempting to clean in the area of the volts/division attenuators). As a second choice, in the absence of these cleaners, it is safe to use ethyl alcohol (fotocol, ethanol) and methyl alcohol (methanol).

Most spray circuit-coolants contain freon 12 as a propellant. Because many freons adversely affect switch contacts, check the contents and brand name before using a spray coolant. Use the following brand names for an acceptable coolant in areas other than the volts/division attenuators: Arctic Freeze, Quik-Freeze, and Can-O-Gas. Do not use Zero Mist brand of circuit coolant. The recommended circuit coolants for the volts/division attenuators are dry ice (CO_2) or isopropyl alcohol.

Switch Contacts. Most of the switching in the 475A is accomplished with circuit-board mounted, cam-actuated contacts. Care must be exercised to preserve the high-frequency characteristics of these switches. Seldom is switch cleaning necessary, but if it is required, observe the following precautions.

For cleaning the switch contacts, isopropyl alcohol is the recommended solvent to use. Apply the isopropyl alcohol with a camel-hair brush. Do not use cotton swabs as they tend to snag on contacts, possibly causing damage, and leave strands of cotton, causing intermittant electrical contact.

General Interior. Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high-humidity conditions. Accumulations of dirt should be removed as often as operating conditions require because dirt can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path that can result in instrument failure. The best way to clean the interior is to blow off the accumulated dust with dry, low-pressure air (approximately 9 lb/in^2). Remove any dirt that remains with a soft brush or a cloth damped with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning ceramic terminal strips and circuit boards.

Exterior. Loose dust accumulated on the outside of the 475A can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt that remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

CRT Face, Filter and Shields. Clean the individual blue or clear plastic implosion shields and the crt face with a soft, lint-free cloth dampened with denatured alcohol (ethyl alcohol) or a mild detergent and water solution. Install only one implosion shield between the bezel and crt face. The optional crt mesh filter can be cleaned in the following manner:

1. Hold the filter in a vertical position and brush lightly with a soft watercolor brush to remove light coatings of dust and lint.

2. Greasy residues or dried-on dirt can be removed with a solution of warm water and a neutral pH liquid detergent. Use the brush to lightly scrub the filter.

3. Rinse the filter thoroughly in clean water and allow to air dry.

4. If any lint or dirt remains, use clean low-pressure air (approximately 9 lb/in^2) to remove. Do not use tweezers or other hard cleaning tools on the filter as the special finish may be damaged.

5. When not in use, store the mesh filter in a lint-free, dust proof container such as a plastic bag.

Air Filter. The air filter should be visually checked every few weeks and cleaned or replaced if dirty. More frequent inspections are required under severe operating conditions. The following procedure is suggested for cleaning the filter. If the filter is to be replaced, order new air filters from your local Tektronix Field Office or representative; order by Tektronix Part No. 378-0044-01.

1. Remove the filter by pulling it out of the retaining frame on the rear panel. Be careful not to drop any of the accumulated dirt into the instrument.

2. Flush the loose dirt from the filter with a stream of hot water.

3. Place the filter in a solution of mild detergent and hot water and let it soak for several minutes.

4. Squeeze the filter to wash out any dirt which remains.

5. Rinse the filter in clear water and allow it to dry.

6. Coat the dry filter with an air-filter adhesive (available from air conditioner suppliers, or order Tektronix Part No. 006-0580-00).

7. Let the adhesive dry thoroughly.

8. Install the filter in the retaining frame.

Visual Inspection

The instrument should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated semiconductors, damaged or improperly installed circuit boards, and heat-damaged parts.

The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

Lubrication

The fan motor and most of the potentiometers used in the 475A are permanently sealed and generally do not require periodic lubrication. The switches used in the 475A, both cam- and lever-type, are installed with proper lubrication applied where necessary and will only rarely require any additional lubrication. It is recommended that a regular periodic lubrication program not be performed on any of the components used in the 475A.

Semiconductor Checks

Periodic checks of the transistors and other semiconductors in the 475A are not recommended. The best check of semiconductor performance is actual operation in the instrument.

Recalibration

To ensure accurate measurements, check the calibration of this instrument after each 1000 hours of operation or every six months if used infrequently. In addition, replacement of component may necessitate recalibration of the affected circuits. The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by recalibration. Complete calibration instructions are given in the Calibration section.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the 475A. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is helpful in locating troubles, particularly where integrated circuits are used. See the Circuit Description section for this information.

Troubleshooting Aids

Diagrams. Complete circuit diagrams are given on foldout pages in the Diagram section. The component number and electrical value of each component in this instrument are shown on the diagrams (see first page of the Diagrams section for definition of the reference designators and symbols used to identify components in this instrument). Each main circuit is assigned a series of component numbers. Table 4-1 lists the main circuits in the 475A and the series of component numbers assigned to each. Important voltages and waveforms are also shown on the diagrams. The portions of the circuit mounted on circuit boards are enclosed with blue lines.

Circuit Board Illustrations. To aid in locating circuit boards in the instrument, a circuit board location illustration is placed on the back of the pullout page preceding the circuit diagram. An illustration of the circuit board, with circuit components of the following circuit diagram identified, is also included on this page. Each circuit board illustration is arranged to facilitate rapid physical location of components listed on the schematic diagrams.

Adjustment Locations Illustrations. To aid in locating test points and adjustable components, the Adjustment Locations pullout pages (normally used with the calibration procedure) permit very rapid location of test points and adjustments because only these components are identified. The Adjustment Location illustrations will be found following the Calibration Procedure (Section 6 of this manual).

Resistor Color-Code. In addition to the brown composition resistors, some metal-film resistors and some wire-wound resistors are used in the 475A. The resistance values of wire-wound resistors are usually printed on the body of the component. The resistance values of composition resistors and metal-film resistors are color-coded on the components with EIA color-code (some metal-film resistors may have the value printed on the body). The color-code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes, which consist of two significant figures, a multiplier, and a tolerance value (see Fig. 4-2). Metal-film resistors have five stripes consisting of three significant figures, a multiplier, and a tolerance value.

Capacitor Color-Code. The capacitance values of common disc capacitors and small electrolytics are marked on the side of the component body. The white ceramic and epoxy-coated tantalum capacitors used in the 475A are color-coded, using a modified EIA code (see Fig. 4-2).

TABLE 4-1

Circuit Number-to-Diagram Locator

Circuit Number Series	Name of Circuit	Diagram Number
10 — 49 100 — 199	CH 1 ATTENUATORS CH 1 VERTICAL PREAMP	1
10 — 69 200 — 299	CH 2 ATTENUATORS CH 2 VERTICAL PREAMP	2
300 — 439	VERTICAL CHANNEL SWITCHING	3
440 — 499	VERTICAL OUTPUT AMPLIFIER	4
500 — 570, R579 (See LV POWER SUPPLY for more 500-series numbers) 660 — 679 700 — 709	A TRIGGER GENERATOR	5
710 — 786, R789	B TRIGGER GENERATOR	6
571 — 629 640 — 649 680 — 699 787 — 829 1492 — 1499 (See LV POWER SUPPLY for more 1490-series numbers)	SWEEP AND Z AXIS LOGIC	7
900 — 1049	SWEEP GENERATORS	8
1050 — 1099	TIMING AND HORIZONTAL DISPLAY SWITCHING	9
1100 — 1269	HORIZONTAL AMPLIFIER	10
C507, R507, C508, R508, R529 C1335, LR1335, C1336, LR1336 1400 — 1490 R1495, Q1494, Q1496, Q1497	LV POWER SUPPLY	11
1300 — 1399	CRT CIRCUIT	12
1500 — 1519 1690 — 1699	CALIBRATOR FAN CIRCUIT	13

Diode Color-Code. The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes, or a dot. For most silicon or germanium diodes with a series of stripes, the color-code identifies the three significant digits of the Tektronix Part Number using the resistor color-code system (e.g., a diode color-coded pink — or — blue —, brown — gray — green indicates Tektronix Part No. 152-0185-00). The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

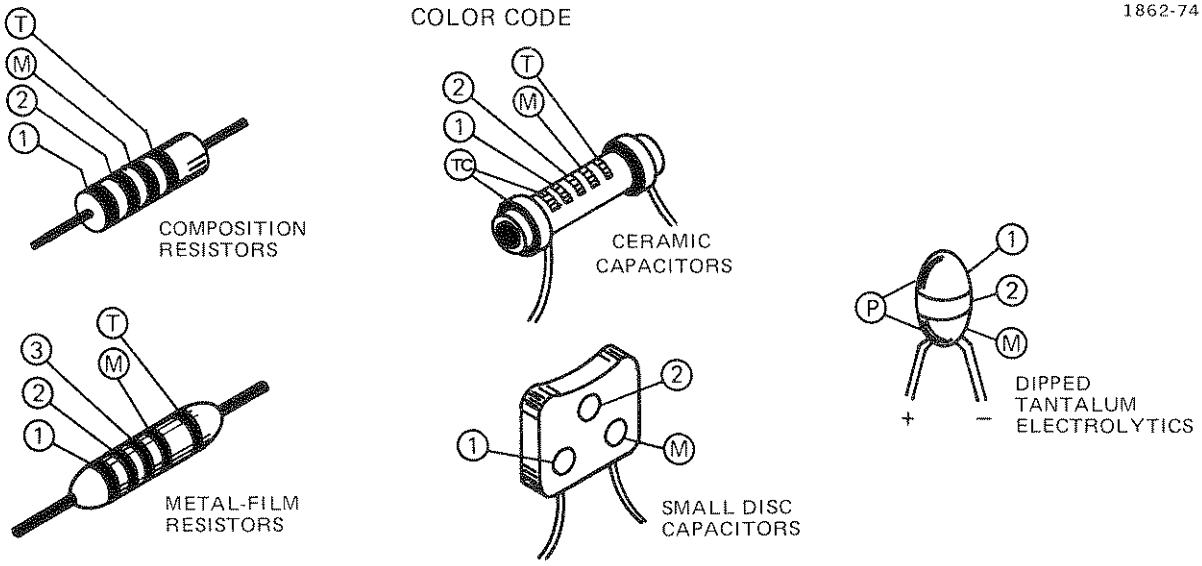
Semiconductor Lead Configuration. Fig. 4-3 shows the lead configuration for the semiconductors used in this instrument, as viewed from the bottom of the semiconductors.

Troubleshooting Equipment

The following equipment is useful for troubleshooting in the 475A.

COLOR CODE

1862-74



(1) (2) and (3) - 1ST, 2ND, AND 3RD SIGNIFICANT FIGS. (T) AND/OR (TC) COLOR CODE MAY NOT BE PRESENT ON SOME CAPACITORS;

(M) - MULTIPLIER (T) - TOLERANCE; (TC) - TEMPERATURE COEFFICIENT. (P) - POLARITY AND VOLTAGE RATING

COLOR	SIGNIFICANT FIGURES	RESISTORS		CAPACITORS			DIPPED TANTALUM VOLTAGE RATING
		MULTIPLIER (OHMS)	TOLERANCE	MULTIPLIER (pF)	TOLERANCE		
					OVER 10pF	UNDER 10pF	
BLACK	0	1	—	1	±20%	±2pF	4VDC
BROWN	1	10	±1%	10	±1%	±0.1pF	6VDC
RED	2	10^2 or 100	±2%	10^2 or 100	±2%	—	10VDC
ORANGE	3	10^3 or 1 K	±3%	10^3 or 1000	±3%	—	15VDC
YELLOW	4	10^4 or 10K	±4%	10^4 or 10,000	+100% –0%	—	20VDC
GREEN	5	10^5 or 100 K	±1/2%	10^5 or 100,000	±5%	±0.5pF	25VDC
BLUE	6	10^6 or 1 M	±1/4%	10^6 or 1,000,000	—	—	35VDC
VIOLET	7	—	±1/10%	10^7 or 10,000,000	—	—	50VDC
GRAY	8	—	—	10^{-2} or 0.01	+80% –20%	±0.25pF	—
WHITE	9	—	—	10^{-1} or 0.1	±10%	±1pF	3VDC
GOLD	—	10^{-1} or 0.1	±5%	—	—	—	—
SILVER	—	10^{-2} or 0.01	±10%	—	—	—	—
NONE	—	—	±20%	—	±10%	±1pF	—

Fig. 4-2. Color codes for resistors and capacitors.

@

1862-75

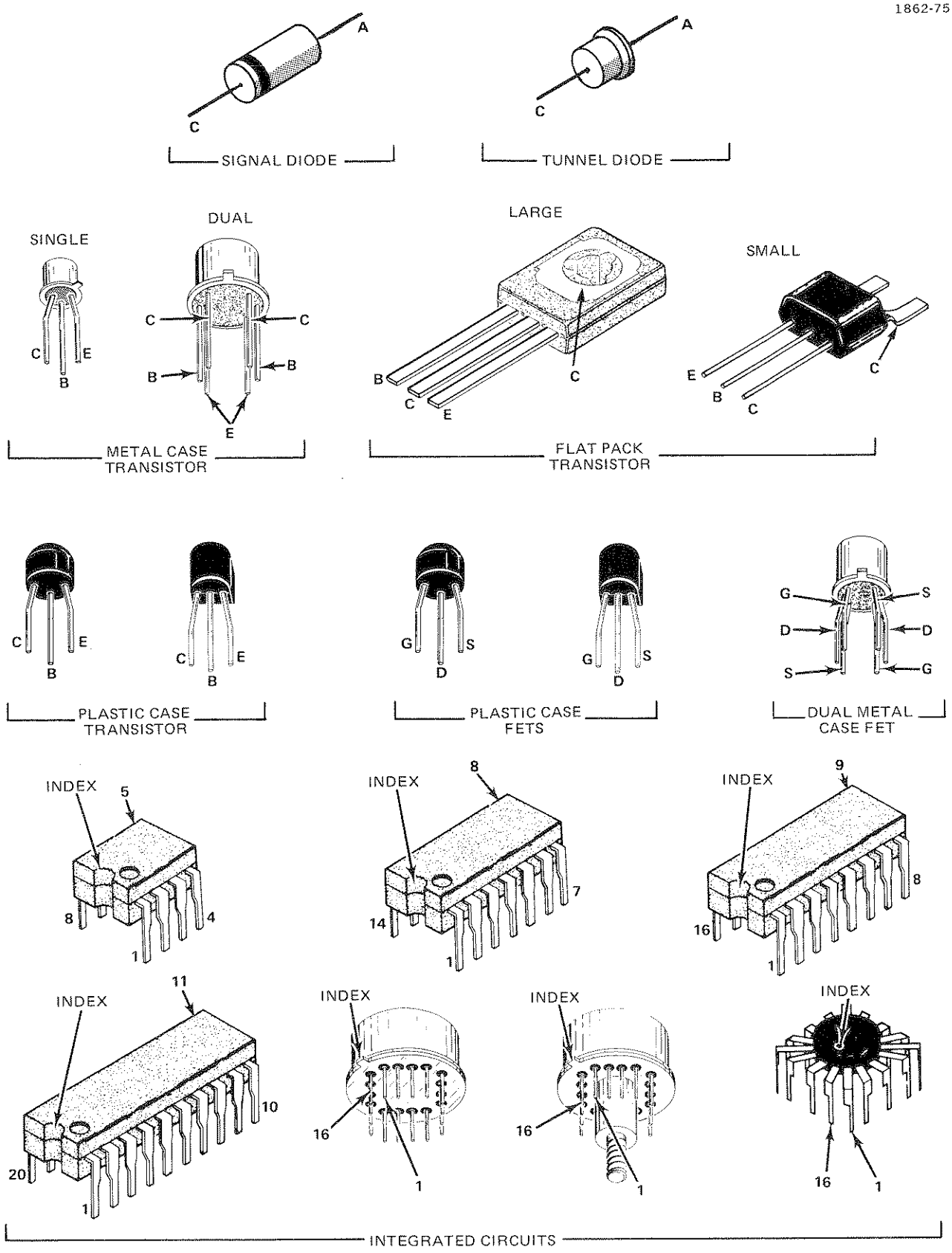


Fig. 4-3. Lead configurations of semiconductors used in this instrument.

1. Semiconductor Tester

Description: Dynamic — type tester. Must be capable of measuring reverse breakdown voltages of at least 400 volts.

Purpose: To test the semiconductors used in this instrument.

Recommended type: Tektronix 576 Curve Tracer or Tektronix 577 (D1 or D2) Curve Tracer with 177 Test Fixture.

2. Test Oscilloscope

Description: Frequency response, dc to 75 megahertz or greater; deflection factor, 1 millivolt to 5 volts/division; Input impedance, 1 megohm, 20 picofarads; sweep rate, 0.5 second/division to 50 nanoseconds/division. A 10X, 10-megohm voltage probe should be used to reduce circuit loading for waveform measurements. A 1X, 1-megohm voltage probe should be used for power supply ripple checks.

Purpose: To check operating waveforms in this instrument.

Recommended type: Tektronix 7603 Oscilloscope with 7A13 Amplifier and 7B50 Time-Base units. Use a P6053 10X probe and a P6011 1X probe.

3. Multimeter

Description: Non-loading Digital Multimeter. Voltmeter, 10 megohm input impedance and 0 to 150 volts range; dc voltage accuracy, within 0.15%; display, 4-1/2 digits. Ohmmeter, 0 to 20 megohms.

Purpose: To check voltages and for general troubleshooting in this instrument.

Recommended type: Tektronix DM 501 Digital Multimeter (requires a TM 500-series power module).

4. Variable Autotransformer

Description: Output variable from 0 to 140 volts, 1.2 amperes minimum rating. Must have 3-wire power cord, plug, and receptacle.

Purpose: To vary the input line voltage when troubleshooting in the power supply.

Recommended type: General Radio W8MT3VM or W10MT3W Metered Variac Autotransformer.

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks ensure proper connection, operation and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedure given under Corrective Maintenance.

1. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operating Instructions section of this manual.

2. Check Associated Equipment. Before proceeding with troubleshooting of the 475A, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source.

3. Check Instrument Calibration. Check the calibration of this instrument, or the affected circuit if the trouble exists in only one circuit. The apparent trouble may only be a result of misadjustment and may be corrected by calibration. Complete calibration instructions are given in the Calibration section of this manual.

4. Visual Check. Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged circuit boards, damaged components, etc.

5. Isolate Trouble to a Circuit. To isolate trouble to a particular circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. When trouble symptoms appear in more than one circuit, check affected circuits by taking voltage and waveform readings. Typical voltages and waveforms are given on the schematics in the Diagrams section.

6. Circuit Troubleshooting Sequence. If the instrument is found to have inoperative functions in more than one area of the main oscilloscope circuits, repair the circuits in the order specified in the following list:

a. L.V. POWER SUPPLY (Check +50 V, +110 V, +15 V, +5 V, −15 V and −8 V supplies.)

b. HIGH VOLTAGE (Check oscillator and regulator, over-voltage protection circuit and secondary load.)

c. A SWEEP (Set TRIG MODE to AUTO; repair until sweep is repetitive.)

d. HORIZONTAL AMPLIFIER (Turn horizontal POSITION; repair until each deflection plate output has proper voltage swing.)

e. VERTICAL OUTPUT AMPLIFIER (Turn vertical POSITION; repair until each deflection plate output has proper voltage swing.)

f. Z AXIS (set TRIG MODE to SINGL SWP; repair until spot display is controlled by INTENSITY.)

g. All remaining inoperative functions.

The preceding recommended troubleshooting sequence is intended to be a quick approach to circuit troubleshooting. See Special Troubleshooting Information listing in this section for detailed troubleshooting instructions.

Fig. 4-4 provides a guide in locating a defective circuit. This chart may not include checks for all possible defects; use steps 7 through 9 in such cases. Start from the top of the chart and perform the given checks on the left side of the page until a step is found which does not produce the indicated results. Further checks and/or the circuit in which the trouble is probably located are listed to the right of this step.

After the defective circuit has been located, it may be helpful to read the applicable part of the Circuit Description section and Special Troubleshooting Information part of this section to aid in locating defective components. After doing this, see steps 7 through 9 for additional information.

7. Check Circuit Board Interconnections. After the trouble has been isolated to a particular circuit, check for loose or broken connections at circuit-board interconnecting pins, plugs and end-lead connectors.

8. Check Voltages and Waveforms. Often the defective component can be located by checking for the correct voltage or waveform in the circuit. Typical voltages and waveforms are given on the diagrams.

NOTE

Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the voltage and waveforms page with each schematic diagram. On this page, note the recommended test equipment, front-panel control settings, voltage and waveform conditions, and test equipment cable connection instructions. Voltages and waveforms given on the schematics should be checked against each instrument while it is operating properly. Deviations should be noted on the schematics for later reference.

9. Check Individual Components. The following procedures describe methods of checking individual components. Components which are soldered in place should be checked after disconnecting one end from the circuit. This isolates the measurement from the effects of surrounding circuitry.

a. SEMICONDUCTORS.

WARNING

Power switch must be turned off before removing or replacing components.

A good check of transistor operation is actual in-circuit performance under operating conditions and most transistors in the 475A can be checked this way. A transistor can be most effectively checked by substituting a new component for it (or one which has been checked previously). However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester. Static-type testers are not recommended, since they do not check operation under simulated operating conditions.

When troubleshooting transistors with a voltmeter, measure the emitter-to-base and emitter-to-collector voltages to determine if the voltages are consistent with normal circuit voltage. Voltages across a transistor vary with the type of device and its circuit function. Some of these voltages are predictable. The emitter-to-base voltage of a conducting silicon transistor will normally be 0.6 to 0.8 volts. The emitter-to-collector voltage of saturated transistors is approximately 0.2 volts. Because these values are small, the best way to check them is by connecting the voltmeter across the junction and using a sensitive voltmeter setting, rather than by comparing 2 voltages taken with respect to ground (both leads of the voltmeter must be isolated from ground if this method is used.

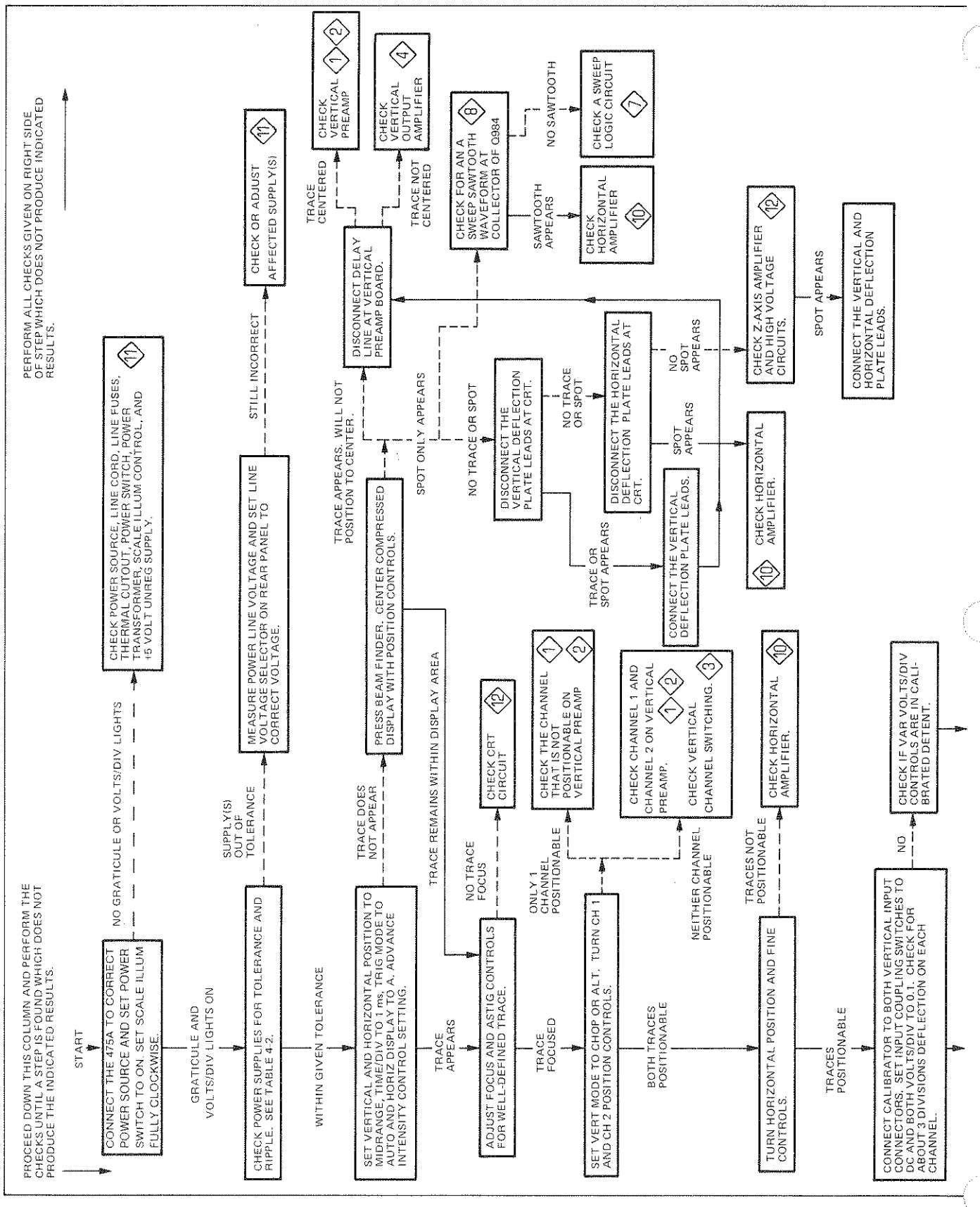


Fig. 4-4. Troubleshooting chart for the 475A Oscilloscope.

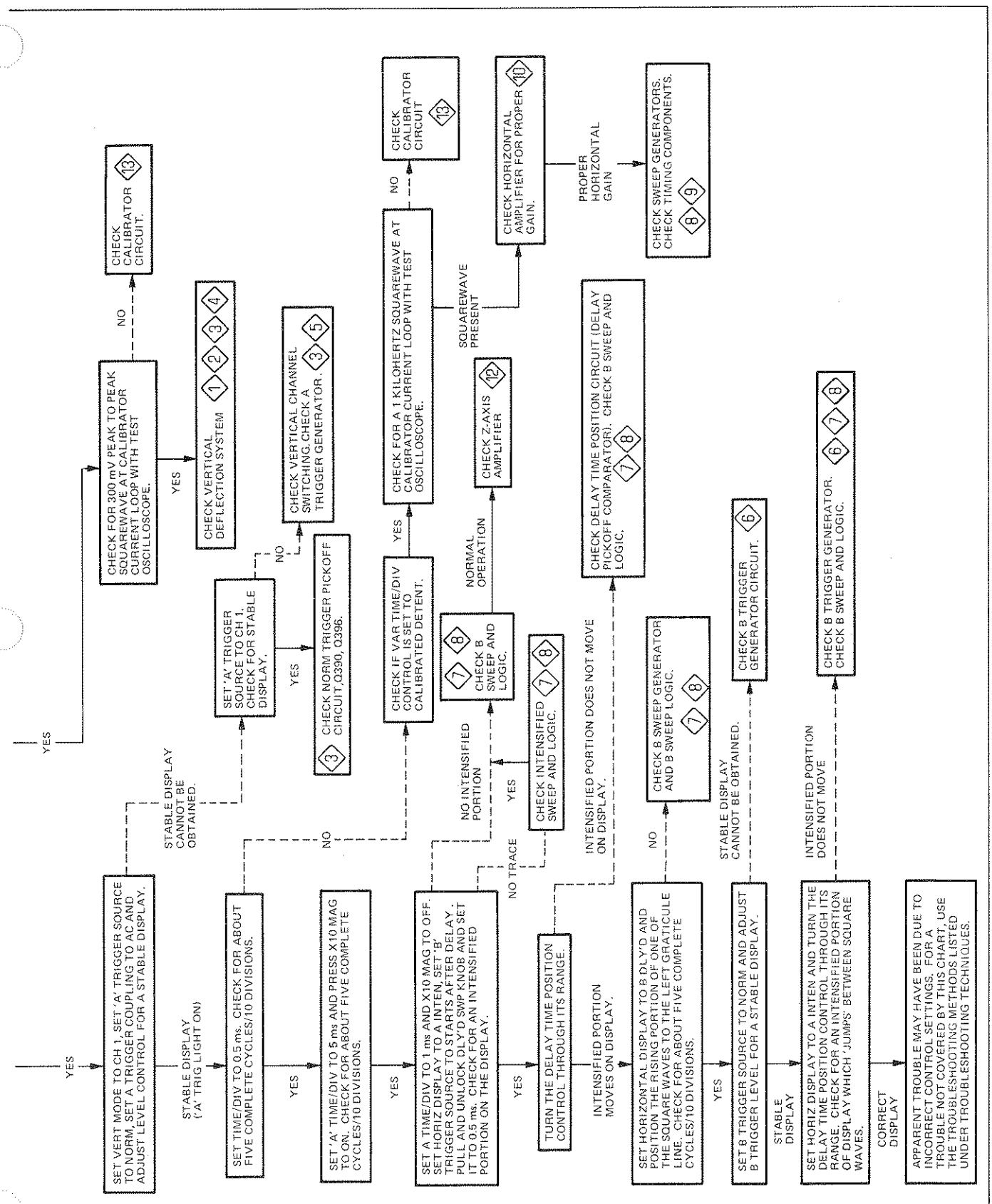


Fig. 4-4. Troubleshooting chart for the 475A Oscilloscope (cont).

If values less than these are obtained, either the device is short-circuited or no current is flowing in the circuit. If values are in excess of the base-emitter values given, the junction is back-biased or the device is defective. Values in excess of those given for emitter-collector could indicate either a non-saturated device operating normally, or a defective (open-circuited) transistor. If the device is conducting, voltage will be developed across resistances in series with it; if it is open, no voltage will be developed across resistances in series with it unless current is being supplied by a parallel path.

When troubleshooting field-effect transistors, the voltage across its elements can be checked in the same manner as transistors. However, it should be remembered that usual operation has the gate-to-source junction reverse biased, or 0 biased, as is used in many circuits in the 475A.

IC's (integrated circuits) can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of circuit operation is essential to troubleshooting circuits using IC's. Use care when checking voltages and waveforms around the IC's so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin IC's is with an IC test clip. This device also doubles as an extraction tool. The lead configuration for the semiconductors used in this instrument are shown on Fig. 4-3.

b. DIODES. A diode can be checked for an open or shorted condition by measuring the resistance between terminals after disconnecting one end from the circuit. With an ohmmeter set to the R X 1k scale, the resistance should be very high in one direction and very low when the leads are reversed.

CAUTION

Do not measure tunnel diodes with an ohmmeter; use a dynamic tester (such as a Tektronix Type 576 Transistor-Curve Tracer).

Voltmeter checks on diodes can be performed in much the same manner as on transistor emitter-to-base junctions. Silicon diodes should have 0.6 to 0.8 volts across the junction when conducting. Higher readings indicate that they are either back biased or defective, depending on polarity.

c. RESISTORS. Check the resistors with an ohmmeter after disconnecting one end from the circuit. Check the Electrical Parts List for the tolerance of the resistors used in this instrument. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

d. INDUCTORS. Check for open inductors by checking continuity with an ohmmeter. (It may be helpful to disconnect one end of the inductor when checking continuity.) Shorted or partially shorted inductors can also be found by checking the waveform response when high-frequency signals are passed through the circuit. Partial shorting often reduces high-frequency response (increases roll-off).

e. CAPACITORS. A leaky or shorted capacitor can be detected by checking resistance with an ohmmeter, on the highest scale, after disconnecting one end from the circuit. Do not exceed the voltage rating of the capacitor (some ohmmeters use 30 volts as source voltage). The resistance reading should be high after initial charge of the capacitor. An open capacitor can also be detected with a capacitance meter or by checking whether the capacitor passes ac signals.

f. ATTENUATORS. The thick film attenuators are best checked by substitution. If only one channel of the 475A is not operating properly, and there is reason to believe an attenuator is defective, replace the suspected attenuator with the same attenuator from the other channel and check instrument operation. If proper operation results, order a new attenuator. (See Component Replacement for replacement instructions.)

10. Repair and Readjust the Circuit. If any defective parts are located, follow the replacement procedures given in this section. Be sure to check the performance of any circuit that has been repaired or that has had any electrical components replaced. Recalibration of the affected circuit may be necessary.

Special Troubleshooting Information

General. The following information provides a procedure for troubleshooting some of the more complex circuits in the 475A. A thorough understanding of the circuit operation is essential before troubleshooting in these areas. Read the applicable portions of the Circuit Description in Section 3 before proceeding. This troubleshooting procedure refers to the diagrams, operating voltages, and waveforms given in Section 8. Specifications for the equipment necessary to troubleshoot in these procedures are given earlier in this section under Troubleshooting Equipment.

Troubleshooting the L.V. Power Supplies. Incorrect operation of all circuits often indicates trouble in the power supply. Check first for correct voltage of the individual supplies. A defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits. Table 4-2 lists the tolerances of the power supplies in this instrument. Check or repair the power supplies in the sequence specified in Table 4-2. These voltages are measured between the power-supply test points and ground. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the +50-volt supply may be misadjusted or other supplies may by operating incorrectly. Use the procedure given in the Calibration section to adjust the +50-volt supply if adjustment is necessary. Use Adjustment Locations 1 pullout page in the Calibration section to locate power-supply test points.

TABLE 4-2

Power Supply Tolerance and Ripple

Power Supply	Tolerance	Typical Ripple (peak-to-peak)
+50 V	0.5% (250 mV)	2 mV
+110 V	3% (3.3 V)	1 V
+15 V	1.5% (225 mV)	2 mV
+5 V	1.5% (75 mV)	2 mV
−15 V	1.5% (225 mV)	2 mV
−8 V	1.5% (120 mV)	2 mV

Connect the 475A to a variable autotransformer. Then, check each power supply for correct ripple with a test oscilloscope, while varying the autotransformer throughout the regulating range of this instrument (see rear panel regulating range selector cover for regulating range). Table 4-2 lists the typical ripple of the power supplies in this instrument. Measure the ripple between the power supply test points and ground.

A malfunction in the power supply can be caused by one or more supplies being shorted to ground. Check the resistance of the individual supplies to ground against the typical resistances listed in Table 4-3. Be sure the instrument is not connected to a power source when making these measurements to prevent error in resistance readings and to prevent possible meter damage.

TABLE 4-3

Power Supply Resistance Check[1]

Supply	Ohmmeter Scale[2]	Typical Resistance To Ground[3]	
		+ Lead At Supply	− Lead At Supply
+110 V	20 K	11 kΩ	9.3 kΩ
+50 V	20 K	2.7 kΩ	2.7 kΩ
+15 V	2 K	63 Ω	63 Ω
+5 V	2 K	46 Ω	46 Ω
−15 V	2 K	480 Ω	-----
	20 K	-----	10 kΩ
−8 V	2 K	32 Ω	32 Ω
UNREG	20 K	14 kΩ	-----
+50 V	2 K	-----	500 Ω
+105/	20 K	12 kΩ	-----
160 V	2 K	-----	1 kΩ

If any of the supplies are shorted to ground, repair them until normal resistance readings are obtained. Connect the instrument to the correct power source and check the supplies for proper voltages listed in Table 4-2. If two or more of the individual supplies have incorrect voltages, repair them in the order listed in Table 4-2.

The +50 volt supply is the reference for all other supplies and must be repaired first. The +15 volt supply and the +5 volt supply should be working properly before repair on the −8 volt supply or the −15 volt supply is attempted.

When repairing a power supply in the 475A the following information may be helpful. The +50-volt supply is used as an example to identify component functions.

1. Check for proper voltage and ripple from the diode bridge rectifier (CR1412 in the +50-volt supply; check at collector of the series regulator for any supply).

[1] **Instrument power cord should be removed from power source.**

[2] **Readings taken with a digital ohmmeter (see item 3 under Troubleshooting Equipment in this section).**

[3] **Readings are normal if within 50% of listed value.**

2. Check that the current-limiting transistor is off (Q1432 in the +50 volt supply) by measuring base-to-emitter voltage. If the supply is current limiting, remove the power from circuit boards, individually, until the supply voltage returns to normal and the circuit board drawing excess power is identified. To remove power to circuit boards, disconnect plugs, or desolder and lift one end of decoupling networks, or move circuit boards enough to clear interconnecting pins.

3. Measure the reference voltage at the supply operational amplifier and check for proper voltage (pin 3 of U1418 of +50 volt supply; negative input of the operational amplifier of any supply).

Troubleshooting the High-Voltage Circuit. There are 3 major areas of concern when troubleshooting this circuitry; the high-voltage oscillator and regulator, the overvoltage protection circuit, and the secondary load including the crt and the high-voltage multiplier. By disconnecting the appropriate circuit, the high voltage should come up. It may be helpful to use the following information, in sequence, to troubleshoot an inoperative high-voltage circuit.

1. Check the collector of Q1316 for approximately −0.7 volts to approximately +1.6 volts.

2. Check the positive end of C1318 for approximately +21 volts.

3. Check the collector of Q1318 for approximately +21 volts.

4. Disconnect and lift one end of CR1329.

5. Disconnect the crt base socket to eliminate crt loading.

6. Check or replace C1316.

7. If the oscillator still does not come up, the high-voltage multiplier could be defective. Remove the Vertical Preamp board to expose the multiplier and disconnect the center tap of the high-voltage transformer from the multiplier tie point.

Troubleshooting the Sweep Circuits. The sweep circuits should be repaired in the following order:

A (Sweep)
A INTEN (Intensified Sweep)
B DLY'D (Sweep)
MIX (Sweep)

A Sweep and Logic

1. Remove all external signals to the instrument, set TIME/DIV to 1 ms (lock knobs), set HORIZ DISPLAY to A and set TRIG MODE to AUTO.

2. Remove Q572 from its socket. This will cause only the Slow Non-Delaying Sweep Generator (A Sweep), which normally should be in operation, to stay at a low voltage level. Check the collector of Q984 for approximately +0.3 volt. Check the collector of Q1014 for approximately +16.4 volts. Check the collector of Q922 for approximately +14.6 volts.

Set TIME/DIV to 0.5 μs or faster. This should cause the Slow-Non-Delaying Sweep Generator to run up and the Fast Non-Delaying Sweep Generator to run down. Check the collector of Q984 for approximately +16.4 volts and check the collector of Q1014 for approximately +0.3 volt.

At this point, the A Sweep holdoff should be in a reset condition. Check TP588 for approximately −4 volts. Check the emitter of Q644 for approximately 0 volt.

When Q572 was removed from its socket, pin 16 of U600 went positive, which is the equivalent of a holdoff start pulse. Check pin 16 of U600 for approximately +2.5 volts. Check pin 17 of U600 for approximately +1.7 volts. Check TP572 for approximately 0 volt. Check pin 3 of U600 for approximately +0.2 volt.

3. Install Q572 and remove Q574 from its socket. This will cause only the Fast Non-Delaying Sweep Generator, which normally should be in operation, to stay at a start (high) voltage level. Check the collector of Q1014 for approximately +14 volts. Set TIME/DIV to 1 ms. Check the collector of Q984 for approximately +14 volts.

At this point the A Sweep holdoff should be at a high level. Check TP588 for approximately +2 volts. Check the emitter of Q644 for approximately +4.3 volts.

Now, pin 3 of U600 should have a low auto gate voltage. Check TP572 for approximately 0 volt. Check pin 16 of U600 for approximately 0 volt. Check pin 17 of U600 for approximately −0.7 volt. Check pin 6 of U600 for approximately +4.8 volts. Check pin 3 of U600 for approximately −0.2 volt. Install Q574 and check the collector of Q984 for a repetitive sweep waveform.

A INTEN Sweep and Logic

Remove all external signals to the instrument, set TIME/DIV to 1 ms (lock knobs), set HORIZ DISPLAY to A INTEN and set TRIG MODE to AUTO.

1. Remove Q572 from its socket. This will cause the A Intensified Sweep Generator (A Sweep), which normally should be in operation, to stay at a low voltage level. Check the collector of Q922 for approximately +0.3 volt. Check the collector of Q1014 for approximately +16.4 volts. Check the collector of Q984 for approximately +14 volts.

The A Sweep holdoff should now be in a reset condition. Check TP588 for approximately −4 volts. Check the emitter of Q644 for approximately 0 volt.

When Q572 was removed from its socket, pin 16 of U600 went positive, which is the equivalent of a holdoff start pulse. Check pin 16 of U600 for approximately +2.5 volts. Check pin 17 of U600 for approximately +1.7 volts. Check TP572 for approximately 0 volt. Check pin 3 of U600 for approximately +0.2 volt.

2. Install Q572 and remove Q574 from its socket. This will cause only the A Intensified Sweep Generator, (which normally should be in operation) to stay at a start (high) voltage level. Check the collector of Q922 for approximately +13.9 volts.

At this point, the A Sweep holdoff should be at a high voltage level. Check TP588 for approximately +2 volts. Check the emitter of Q644 for approximately +4.3 volts.

Pin 3 of U600 should now have a low auto gate voltage. Check TP572 for approximately 0 volt. Check pin 16 of U600 for approximately 0 volt. Check pin 17 of U600 for approximately −0.7 volt. Check pin 6 of U600 for approximately +4.8 volts. Check pin 3 of U600 for approximately −0.2 volt. Install Q574 and check the collector of Q922 for a repetitive sweep waveform.

B DLY'D Sweep and Logic

The A Sweep and A INTEN sweep should be working properly before starting this procedure. Remove all external signals to the instrument, set TIME/DIV to 1 ms (lock knobs), set HORIZ DISPLAY to B DLY'D and set TRIG MODE to AUTO.

1. Remove Q574 from its socket. Check the collector of Q922 for approximately +14.5 volts. Check the base of Q792 for approximately −5 volts. Check the collector of Q792 for approximately +1.2 volts. Check TP802 for approximately 0 volt. Check TP826 for approximately −1.8 volts. Check TP996 for approximately −3.7 volts. Check the collector of Q984 for approximately +14 volts.

2. Install Q574 and remove Q572. Check the collector of Q922 for approximately +0.2 volt. Check the base of Q792 for approximately −2 volts. Check the collector of Q792 for approximately −0.7 volt. Check TP802 for approximately 0 volt. Check TP826 for approximately −3.8 volts. Check TP996 for approximately −1.7 volts. Check the collector of Q984 for approximately 0.2 volt. Install Q572 and check the collector of Q984 for a repetitive sweep waveform.

MIX Sweep and Logic

The A Sweep, A INTEN Sweep and B DLY'D Sweep should be working properly before starting this procedure. Remove all external signals to the instrument, set A TIME/DIV to 1 ms, unlock knobs and set B TIME/DIV to 0.1 ms, set HORIZ DISPLAY to MIX, set TRIG MODE to AUTO and set B TRIGGER SOURCE to STARTS AFTER DELAY.

Compare the waveform obtained at pin 10 of J5 against the waveform at the collector of Q922 and check for similarity. Check TP996 for a delayed gate, with an amplitude of approximately −1.7 volts, that occurs during the run down ramp on the collector of Q922. The time position of the delayed gate can be controlled with DELAY TIME POSITION. Check the collector of Q984 for a fast ramp waveform that occurs during a slow ramp waveform. The fast ramp waveform runs down at a rate set by the B TIME/DIV control and is positioned in time by the DELAY TIME POSITION control.

Troubleshooting the Horizontal Amplifier. The Horizontal Amplifier contains push-pull circuitry that can be checked in the following manner:

Set TIME/DIV to 1 ms (lock knobs) and set TRIG MODE to SINGL SWP. Remove Q1114, Q956 and Q1026 from their sockets. Connect a voltmeter between the base of Q1152 and the base of Q1162; adjust R1130 for 0 volt. Check the voltages in the amplifier against the voltages listed on the Horizontal Amplifier schematic diagram. Check the voltage at the bases of Q1124 and Q1134 for balance and apply this balance check procedure to each stage, proceeding toward the amplifier output.

Install Q1114, Q956 and Q1026 in their sockets and check for a repetitive sweep.

Troubleshooting the Vertical System. The instrument front panel TRIG VIEW control provides a quick way to find trouble in this circuitry. Press the TRIG VIEW pushbutton and adjust A TRIGGER LEVEL control to bring the trace to the crt viewing area. If unable to obtain a trace, look for a problem in the Vertical Output Amplfier. If a trace can be obtained, look for a problem in the Channel 1 or Channel 2 Preamplifier or the Vertical Channel Switching circuitry.

When troubleshooting the vertical deflection system, the best procedure is to start from the input and work to the output of the problem-circuit area (determined by previous checks using TRIG VIEW pushbutton).

Preamplifier Troubleshooting

The following procedure can be used for Channel 1 or Channel 2 Preamplifier. Channel 1 is described as an example to identify circuit functions.

Remove any external signal from the instrument input. Check the input of U120 (pin 13) for 0 volt. Connect a voltmeter between pins 5 and 9 of U120 and adjust CH 1 VAR BAL (R110) for 0 volt. Measure from pin 5 or 9 of U120 to ground and check for the recommended voltage listed on the appropriate Vertical Preamp schematic diagram.

Connect the voltmeter between pins 5 and 9 of U140 and adjust CH 1 VOLTS/DIV BAL (R135) for 0 volt. Measure from pin 5 or 9 of U140 to ground and check for the recommended voltage on the diagram. Check the collectors of Q172 and Q182 for voltages listed on the diagram.

Connect the voltmeter between the collectors of Q178 and Q188 and adjust the vertical POSITION control for 0 volt. Measure from the collector of Q178 or Q188 to ground and check for voltages listed on the diagram.

Vertical Channel Switch Troubleshooting

The collector voltages of Q178 and Q188 must by balanced as detailed in the preceding steps before starting this procedure.

Set VERT MODE to CH 1 and check the dc voltages in the channel switching circuitry for the voltages listed on the Vertical Channel Switching schematic diagram. Do not check waveforms until dc operation is normal.

Vertical Output Amplifier Troubleshooting

Disconnect the delay line connection on the Vertical Preamp board. This requires the use of a soldering iron (a 40 to 60 Watt iron works best) to unsolder the delay line ground connection.

Check for the recommended voltages listed on the Vertical Output Amplifier diagram.

Troubleshooting the Z-Axis Circuit (CRT Circuit). Set TIME/DIV to 1 ms (lock knobs) and set TRIG MODE to SINGL SWP. Disconnect and lift one end of CR1343. Check the voltage at TP1364 for approximately +6 volts. Press the BEAM FINDER pushbutton and check the voltage at TP1364 for approximately +25 volts. If these voltages cannot be obtained, check the voltage across VR1362 for approximately +6.2 volts. Remove Q1362 from its socket and check the voltage at the base of Q1352 for approximately +1.3 volts. Check the base of Q1344 for approximately +0.6 volt.

If the above-mentioned voltages can be obtained, disconnect and lift one end of CR1341. Check the voltage swing at the collector of Q1338 for approximately +7.8 volts to −1.3 volts while turning INTENSITY control from full counterclockwise to full clockwise. If these voltages cannot be obtained, check the voltage at the base of Q1338 for −1.75 volts. Remove Q1332 from its socket. Disconnect J1333 and J1334 (coaxial-type end-lead connectors) from their sockets. Repeat the voltage swing check at the collector of Q1338 as performed previously.

Connect J1333, J1334, CR1343 and CR1341 to the circuit board. Install Q1362 and Q1332 in their sockets.

CORRECTIVE MAINTENANCE

Introduction

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical parts replacements for the 475A can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts list for value, tolerance, rating and description.

NOTE

Physical size and shape of a component may affect instrument performance, particularly at high frequencies. Always use direct-replacement components, unless it is known that a substitute will not degrade instrument performance.

Special Parts. In addition to the standard electronic components, some special components are used in the 475A. These components are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

Ordering Parts. When ordering replacement parts from Tektronix, Inc., it is imperative that all of the following information be included in the order to ensure receiving the proper parts.

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

2. Instrument serial number.

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

4. Tektronix Part number.

Soldering Techniques

WARNING

Always disconnect the instrument from the power source before attempting to solder in the instrument.

Ordinary 60/40 solder and a 15- to 40-watt pencil-type soldering iron can be used to accomplish the majority of the soldering to be done in the 475A. If a higher wattage-rating soldering iron is used on the etched circuit boards, excessive heat can cause the etched circuit wiring to separate from the board base material.

CAUTION

The Vertical Preamplifier Attenuator circuit boards are made of material easily damaged by excessive heat. When soldering to these boards, do not use a soldering iron with a rating of more than approximately 15 watts. Avoid prolonged applications of heat to circuit-board connections. Use only isopropyl alcohol when cleaning this circuit board.

The following technique should be used to replace a component on a circuit board. Most components can be replaced without removing the boards from the instrument.

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board, as it may damage the board.

2. When the solder begins to melt, pull the lead out gently. If unable to pull the lead without using force, try removing the other end of component as it may remove easier.

NOTE

The reason that some component leads seem troublesome to remove is due to a bend placed on each lead during machine insertion of the component in the circuit-board manufacturing process. The purpose of the bent leads is to hold the component in place during a flow-soldering, manufacturing process that solders all components at once.

If a component lead is extremely difficult to remove, it may be helpful to straighten the leads on the back side of the board with a small screwdriver or pliers while heating the soldered connection.

Desolder the component from the circuit board using heat on the component lead so that the solder will stay behind on the board. If it is desired to remove solder from a circuit board hole for easier installation of a new component, a vacuum-type desoldering tool or a solder-removing wick should be used for this purpose.

3. Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the holes in the board so the component is firmly seated against the board (or as positioned originally). If it does not seat properly, heat the solder and gently press the component into place.

4. Touch the iron to the connection and apply a small amount of solder to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink.

5. Clip the excess lead that protrudes through the board (if not clipped in step 3).

6. Clean the area around the solder connection with a flux-remover solvent. Be careful not to remove information printed on the board.

When soldering to the ceramic strips in the instrument a slightly larger soldering iron can be used. It is recommended that a solder containing about 3% silver be used when soldering to these strips to avoid destroying the bond to the ceramic material. This bond can be broken by repeated use of ordinary tin-lead solder or by the application of too much heat; however, occasional use of ordinary solder will not break the bond if excessive heat is not applied.

Observe the following precautions when soldering to a ceramic terminal strip:

1. Use a hot iron for a short time. Apply only enough heat to make the solder flow freely.

2. Maintain a clean, properly tinned tip.

3. Avoid putting pressure on the ceramic terminal strip.

4. Do not attempt to fill the terminal-strip notch with solder; use only enough solder to cover the wires adequately.

5. Clean the flux from the terminal strip with a flux-remover solvent.

If it becomes necessary to solder in the general area of any of the high-frequency contacts in the instrument, clean the contacts immediately upon completion of the soldering. Refer to Cleaning—Switch Contacts under PREVENTIVE MAINTENANCE for recommended cleaners and procedures.

Small Component Replacement

WARNING

Always disconnect the instrument from the power source before attempting to replace components.

General. The exploded-view drawings associated with the Mechanical Parts List (located at rear of manual) may be helpful in the removal or disassembly of individual components or sub-assemblies.

Transistor and IC Replacement. Transistors and IC's (integrated circuits) should not be replaced unless they are actually defective. If removed from their sockets during routine maintenance return them to their original sockets. Unnecessary replacement or switching of semiconductor devices may affect the calibration of the instrument. When a transistor is replaced, check the operation of the part of the instrument that may be affected.

Any replacement component should be of the original type or a direct replacement. Bend the leads to fit the socket and cut the leads to the same length as on the component being replaced. See Fig. 4-3 for lead configurations and basing used in this instrument.

If a replacement transistor is made by a different manufacturer than the original, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are wired for the standard basing as used for metal-cased transistors.

The chassis-mounted power supply transistors and their mounting bolts are insulated from the chassis. In addition, silicone grease is used to increase heat transfer capabilities. Install the insulators and replace the silicone grease when replacing these transistors. The grease should be applied to both sides of the mica insulators, and should be applied to the bottom side of the transistor where it comes in contact with the insulator.

WARNING

Handle silicone grease with care. Avoid getting silicone grease in the eyes. Wash hands thoroughly after use.

NOTE

After replacing a power transistor, check that the collector is not shorted to ground before applying power.

WARNING

Voltages are present on the exterior surface of the chassis-mounted power supply transistors if the power is applied to the instrument and the POWER switch is on. Also, voltages may be present several minutes after the instrument is turned off.

Interconnecting Pin Replacement. Two methods of interconnection are used in this instrument to connect the circuit boards with other boards and components. When the interconnection is made with a coaxial cable, a special end-lead connector plugs into a socket on the board. Other interconnections are made with a pin soldered onto the board. Two types of mating connections are used for these interconnecting pins. If the mating connector is on the end of a lead, an end-lead pin connector is used which mates with the interconnecting pin. The following information provides the replacement procedure for the various types of interconnecting methods.

a. COAXIAL-TYPE END-LEAD CONNECTORS.

Replacement of the coaxial-type end-lead connectors requires special tools and techniques; only experienced maintenance personnel should attempt replacement of these connectors. It is recommended that the cable or wiring harness be replaced as a unit. For cable or wiring harness part numbers, see the Mechanical Parts List. An alternative solution is to refer the replacement of the defective connector to your local Tektronix Field Office or representative.

b. CIRCUIT-BOARD PINS.

NOTE

A circuit-board pin replacement kit including necessary tools, instructions, and replacement pins is available from Tektronix, Inc. Order Tektronix Part No. 040-0542-00.

To replace a pin which is mounted on a circuit board, first disconnect any pin connectors. Then, unsolder the damaged pin and pull it out of the circuit board with a pair of pliers. Be careful not to damage the wiring on the board with too much heat. Remove the ferrule from the new interconnecting pin and press the new pin into the hole in the circuit board. Position the pin in the same manner as the old pin. Then, solder the pin on both sides of the circuit board. If the old pin was bent at an angle to mate with a connector, bend the new pin to match the assoicated pins.

c. CIRCUIT-BOARD PIN SOCKETS.

The pin sockets on the circuit boards are soldered to the rear of the board. To replace one of these sockets, first unsolder the pin (use a vacuum-type desoldering tool or a solder-removing wick to remove excess solder). Then straighten the tabs on the socket and remove it from the hole in the board. Place the new socket in the circuit board hole and press the tabs down against the board. Solder the tabs of the socket to the circuit board; be careful not to get solder into the socket.

NOTE

The spring tension of the pin sockets ensures a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as a connecting point for spring-loaded probe tips, alligator clips, etc.

e. END-LEAD PIN CONNECTORS.

The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the associated leads. To replace damaged end-lead pin connectors, remove the old pin connector from the end of the lead and clamp the replacement connector to the lead.

Some of the pin connectors are grouped together and mounted in a plastic holder; the overall result is that these connectors are removed and installed as a multi-pin connector. To provide correct orientation of this multi-pin connector when it is replaced, an arrow is stamped on the circuit board and a matching arrow is molded into the plastic housing of the multi-pin connector. Be sure these arrows are aligned as the multi-pin connector is replaced. If the individual end-lead pin connectors are removed from the plastic holder, note the color of the individual wires for replacement.

Ceramic Terminal Strip Replacement. Replacement strips (including studs) and spacers are supplied under separate part numbers. However, the old spacers may be re-used if they are not damaged. The applicable Tektronix Part Numbers for the ceramic strips and spacers used in this instrument are given in the Mechanical Parts List.

To replace a ceramic terminal strip, use the following procedure.

REMOVAL:

1. Unsolder all components and connections on the strip. To aid in replacing the strip, it may be advisable to mark each lead or draw a sketch to show location of the components and connections.

2. Pry or pull the damaged strip from the chassis.

3. If the spacers come out with the strip, remove them from the stud pins for use on the new strip (spacers should be replaced if they are damaged).

REPLACEMENT:

1. Place the spacers in the chassis holes.

2. Carefully press the studs of the strip into the spacers until they are completely seated. If necessary, use a soft mallet and tap very lightly, directly over the stud, to seat the strip completely.

3. If the stud extends through the spacers, cut off the excess.

4. Replace all components and connections. Observe the soldering precautions given under Soldering Techniques in this section.

Fuse Replacement. Table 4-4 gives the rating, location, and functions of the fuses used in this instrument.

TABLE 4-4

Fuse Rating, Location and Functions

Circuit Number	Rating	Location	Function
F1401	1.5 A Fast	Rear Panel	115-volt line
F1401	0.75 A Fast	Rear Panel	230-volt line
F1318	1.5 A Fast	Rear of Main Interface Board	High Voltage
F1601	15 A Fast	Front of Inverter Chassis	Inverter Input (Option 7 Only)

Cam Switch Replacement. A complete cam switch is actually a cam switch assembly. Each assembly consists of a delrin-material cam that is rotated by a front-panel knob and a set of contacts (mounted on an adjacent circuit board) that are actuated by the lobes on the cam.

CAUTION

Repair of cam-type switches should be undertaken only by experienced maintenance personnel. Switch alignment and spring tension of the contacts must be carefully maintained for proper operation of the switch. For this reason, it is recommended that the switch assembly be replaced as a unit. For assistance in maintenance of cam-type switches, contact your local Tektronix Field Office or representative.

If a cam switch must be removed from a circuit board the circuit board containing the cam switch must be removed from the instrument. See the circuit-board replacement part of this section for circuit board removal instructions.

Disconnect the flexible coupling between cam switch and variable controls. Remove two connecting screws from each support block that holds the cam to the circuit board. Carefully lift the cam assembly from the circuit board and perform an inspection, cleaning or replacement as intended.

Reassemble the cam-switch assembly by reversing the previous process. Give careful attention to alignment and spacing of support blocks as the cam is mated to its circuit board. Do not bend circuit boards at any time in reassembly and use a very low torque to tighten the mounting screws (two fingers on the screwdriver is enough torque).

Circuit Board Replacement

Occasionally it may be necessary to gain access to the reverse side of a circuit board or to remove one circuit board to gain access to another. The following procedures outline the necessary steps to facilitate instrument disassembly. Most of the connections to the circuit boards in the instrument are made with pin connectors. However, some connections are soldered to the board. Observe the soldering precautions given under Soldering Techniques given in this section.

WARNING

Always disconnect the instrument from the power source before attempting to remove circuit boards.

To aid in identifying and locating circuit boards in the instrument, see Fig. 4-5 for the locations of circuit boards. In the following circuit-board replacement procedure, determine the circuit board to be removed or replaced, find the name of the board listed within this procedure, and follow the removal or installation instructions. To aid in identifying small components described in this procedure, use the diagrams in Section 9, Mechanical Parts List, in this manual.

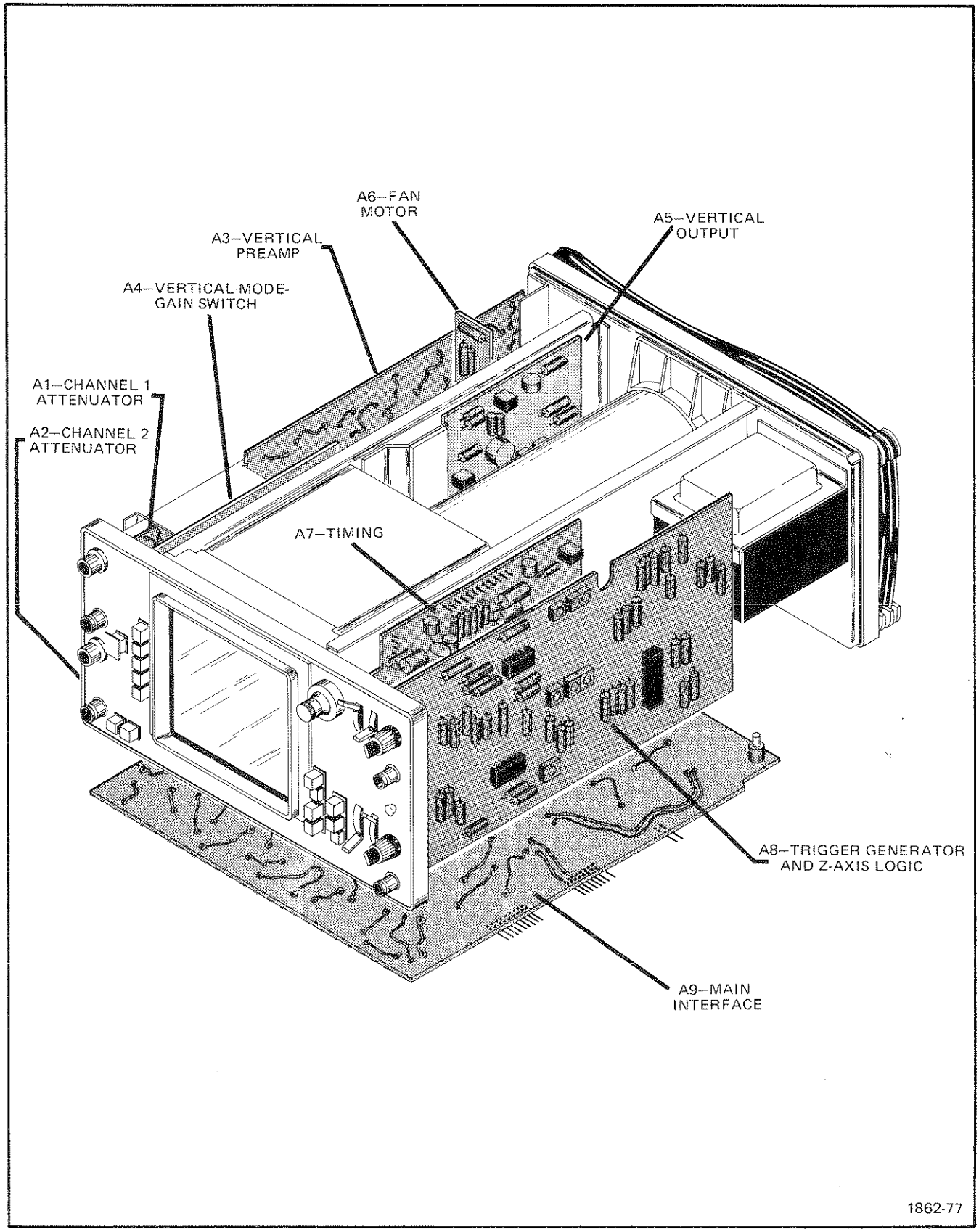


Fig. 4-5. Locations of circuit boards in the 475A Oscilloscope.

Vertical Preamp Board Removal. Remove the board as follows:

1. 475A DM44 only—Disconnect five multi-conductor ribbon-cables and one single conductor from the DM55 Main circuit board. Remove the screws from the rear of the Main circuit board chassis and separate the board and chassis assembly from the instrument chassis.

2. Remove both vertical POSITION control shafts. This requires a 0.050-inch Allen wrench to loosen the front setscrew in each coupling.

3. Remove the TRIG VIEW, 100 OR 20 MHz BW control shaft. Loosen the coupling setscrew with a 0.050-inch Allen wrench.

4. Remove the INVERT control extension shaft. Insert a scribe or small screwdriver between the end of the white plastic switch-shaft and the inside end of the black plastic extension-shaft and pry gently.

5. Disconnect eight coaxial cables from the front and back sides of the board and confirm color coding of each cable with its jack number in the following list. Record any exceptions to this procedure for reference when reassembling.

a. Cable to J380 is white with black and brown stripes.

b. Cable to J385 is white with black and red stripes.

c. Cable to J399 is white with a yellow stripe.

d. Cable to J430 is white with a violet stripe.

e. Cable to J405 is white with a blue stripe.

f. Cable to J410 is white with a green stripe.

g. Cable to J400 (back of board) is white with a brown stripe.

h. Cable to J349 (bottom, back of board, rear of INVERT switch) is white with a red stripe.

6. Disconnect the delay-line connection on the Vertical Preamp board. This requires the use of a soldering iron (a 40 to 60-Watt iron works best) to unsolder the delay-line ground connection.

7. Unsolder the capacitor lead at the Vertical Preamp board (bottom, back of board, between the rear of the INVERT switch and J349) using a 15-Watt soldering iron.

8. At the Vertical Preamp board unsolder one end of a wire braid that connects between the bottom of the Vertical Preamp and the Main Interface board under the high-voltage shield.

9. Disconnect three ribbon-cables from the Vertical Mode-Gain Switch board and confirm the number of wires in each cable with its plug number in the following list. Note locations of cables to facilitate correct reinstallation.

a. Disconnect a six-wire cable from P329.

b. Disconnect a seven-wire cable from P160.

c. Disconnect a ten-wire cable from P260.

10. At a feed-through terminal near U120 and U220, unsolder two 30-ohm resistors that connect each attenuator to the Vertical Preamp board. Loosen attenuator screws for clearance if necessary.

11. Remove the Vertical Preamp board mounting-hardware at eight locations described in the following list. A small Phillips screwdriver is required.

a. Remove the screw, cabinet-ground spring, and hexagonal post at center of the board.

b. Remove two screws that mount the board to two long posts on the main chassis near top and bottom center of the Vertical Preamp board.

c. Remove three screws that mount the board to the rear preamp bracket (at left edge of board).

d. Remove two screws at the right edge of the board (one screw mounts each attenuator chassis to the board).

12. Remove the Vertical Preamp circuit-board, using care to prevent damage to any of the components as the board is removed.

To install the Vertical Preamp circuit-board, reverse the removal procedure.

Vertical Mode-Gain Switch Board Removal. The Vertical Mode-Gain Switch board and the Channel 1 and Channel 2 attenuators are removed as a unit.

1. Remove the Vertical Preamp circuit-board as outlined previously.

2. Remove the two UNCAL light lenses (VAR VOLTS/DIV UNCAL). Pry them away from front panel with a fingernail and pull them straight out.

3. Remove the VAR and VOLTS/DIV knobs. Set these knobs fully clockwise and loosen their setscrews. This requires a 1/16-inch Allen wrench.

4. Remove the AC-GND-DC switch knobs by pulling the knobs away from the switch, using a tight finger-grip.

5. Remove both attenuator shields, using a small Phillips screwdriver (each is held with five screws and washers).

6. Disconnect four ribbon-cables from the Vertical Mode-Gain Switch board and confirm the number of wires in each cable with its plug number in the following list. Note the locations of cables to facilitate correct reinstallation.

a. Disconnect a five-wire cable from the Main Interface board at P300.

b. Disconnect a one-wire cable from the Main Interface board at P128.

c. Disconnect two three-wire cables from the VOLTS/DIV sensitivity indicator-lights at P310 and P320.

7. Unsolder the braid connecting the CH 2 attenuator to the Main Interface, at the Main Interface board.

8. Remove the four nuts that secure the attenuators to the front casting and remove the two screws that mount the board to two posts on the main chassis.

9. Remove the Vertical Mode-Gain Switch circuit-board and attenuator assembly from the instrument, using care to prevent damage to any of the components as the board is removed.

To install the Vertical Mode-Gain Switch circuit-board and attenuator assembly, reverse the removal procedure. To align the VERT MODE switch pushbuttons, hold the assembly in place with a slight forward pressure and use a small tool to reach through the front panel to align the buttons. Do not tighten the circuit-board securing screws until the securing nuts at the front of the attenuator chassis are tight and the circuit board is aligned properly.

Trigger Generator and Z-Axis Logic Board Removal. Remove the board as follows:

1. 475A DM44 only—Disconnect five multi-conductor ribbon-cables and one single conductor from the DM44 Main circuit board. Remove two screws from the rear of the main circuit-board chassis and separate the board chassis from the instrument chassis.

2. Remove the LOW LINE, READY, and TRIG light lenses. Pry them away from the front panel with a fingernail and pull them straight out.

3. Remove the POWER extension shaft from the power-switch plastic actuator. Use a small flat-blade screwdriver to pry apart the coupling of the shaft and actuator, using caution to prevent damage to the coupling.

4. Disconnect four ribbon-cables from the board as directed in the following list.

a. Disconnect a four-wire cable near Q752 at the top of the board (cable from B TRIGGER LEVEL control).

b. Disconnect a four-wire cable near J706, located two inches below the cable previously removed (cable from A TRIGGER LEVEL control).

c. Disconnect one-wire cable near the left end of J3 at the bottom of the board.

d. Disconnect a five-wire cable from P644 at the bottom, back of the board (cable from A TRIG HOLDOFF control).

5. Disconnect eight coaxial cables from the front and back sides of the board and confirm color coding of each cable with its jack number in the following list. Record any exceptions to this procedure for reference when reassembling.

a. Cable to J704 is white with a blue stripe.

b. Cable to J702 is white with a green stripe.

c. Cable to J706 is white with a yellow stripe.

d. Cable to J664 is white with black and brown stripes.

e. Cable to J674 is white with black and red stripes.

f. Cable to J694 is white with black and orange stripes.

g. Cable to J824 is white with an orange stripe.

h. Cable to J584 is white with a red stripe.

6. Unsolder the 33-ohm resistors from the external trigger input connectors.

7. Remove the POWER switch mounting-bracket from the board. A 3/16-inch nut driver will be required to remove a mounting nut.

8. Remove five board-mounting screws (two each at left and right edges, and one screw at the top center of the board).

9. Remove the Trigger Generator and Z-Axis Logic circuit-board from the instrument.

To install the Trigger Generator and Z-Axis Logic board, reverse the removal procedure.

Timing Board Removal. Remove the board as follows:

1. Remove the Trigger Generator and Z-Axis Logic circuit-board as outlined previously.

2. Remove the X10 MAG and UNCAL light lenses. Pry them away from the front panel with a fingernail and pull them straight out.

3. Remove the VAR and TIME/DIV knobs. Set these knobs fully clockwise and loosen their setscrews. A 1/16-inch Allen wrench is required.

4. Remove the hexagonal post and the board mounting-screws.

5. Remove the Timing circuit-board from the instrument. Use caution to prevent damage to the connecting pins on bottom of the board.

To install the Timing circuit-board, reverse the removal procedure.

Vertical Output Board Removal. Remove the board as follows:

1. Remove the Vertical Output circuit-board shield (if installed).

2. Disconnect the three-wire cable from the top-front of the Vertical Output board.

3. Disconnect two wires from the board at the crt neck pins.

4. Unsolder the delay-line ground terminal at the delay-line connection with the board (a 40 to 60-Watt soldering iron works best). Disconnect and dress the delay line away from the board.

5. Unsolder the flexible grounding braid from the case of integrated circuit U470 using a 40 to 60-Watt soldering iron.

6. Remove the integrated-circuit mounting-nut from the main chassis. A 1/4-inch open-end wrench may be necessary to remove the nut.

7. Remove the two circuit-board screws along the top edge of the board and remove the Vertical Output circuit-board.

To install the Vertical Output circuit-board, reverse the removal procedure.

Fan Motor Board Removal. Remove the board as follows:

1. Remove the Vertical Preamp circuit-board as outlined previously.

2. Disconnect a two-wire ribbon-cable at the Fan Motor board.

3. Loosen the setscrew in the fan impeller coupling with a 0.050-inch Allen wrench.

4. Remove two thread-forming screws nearest the Fan Motor circuit-board, that hold the fan motor mount to the main chassis.

5. Remove the fan motor and Fan Motor circuit-board as a unit.

To install the Fan Motor circuit-board, reverse the removal procedure.

Inverter Board Removal (Option 7 only). Remove the board as follows:

1. Remove the Vertical Output circuit-board shield (if installed).

2. Unsolder five wires from the power-transformer terminals and confirm each wire color with its location in the following list.

a. Wire to terminal 10 is white with a brown stripe.

b. Wire to terminal 10A is white with a red stripe.

c. Wire to terminal 11 is white with a gray stripe.

d. Wire to terminal 12A is white with an orange stripe.

e. Wi e to terminal 12 is white with a yellow stripe.

3. Remove two screws from the inverter chassis (one screw at the front and one at the rear of the inverter chassis, near the top of the instrument main chassis). Remove one remaining screw from the main chassis to the inverter chassis, accessible through the space along the bottom of the power transformer. A long Phillips screwdriver is necessary to remove all three screws.

4. Remove the Inverter chassis from the instrument, using care to prevent damage to interconnecting wires that pass through the hole in the main chassis.

5. Remove the screws holding the Inverter circuit-board to the Inverter chassis.

To install the Inverter circuit-board, reverse the removal procedure.

Power Supply Board Removal (475A DM44 only). Remove the board as follows:

1. Remove the Vertical Output circuit-board shield (if installed).

2. Disconnect one ribbon-cable from the rear of the 475A DM44 Main circuit-board and guide the plug through a slotted opening in the main circuit-board chassis.

3. Unsolder five-wires from the power transformer and confirm each wire color with its location in the following list.

a. Wire to terminal 10 is white with a brown stripe.

b. Wire to terminal 10A is white with a red stripe.

c. Wire to terminal 11 is white with an orange stripe.

d. Wire to terminal 12A is white with a yellow stripe.

e. Wire to terminal 12 is white with a green stripe.

4. Remove two screws from the Power Supply board chassis (one screw each at the front and rear of the Power Supply board chassis near the top of the 475A main chassis). Remove one remaining screw from the main chassis to the power supply chassis (accessible through the space along the bottom of power transformer). A long Phillips screwdriver is necessary to remove all three screws.

5. Remove the power supply chassis from the instrument, using care to prevent damage to interconnecting wires that pass through the hole in the main chassis.

6. Remove a piece of tape from the insulation-wrap to gain access to the board components.

7. Remove the two screws holding the Power Supply circuit-board to the power supply chassis.

8. Remove three Keps nuts and a plastic bar that hold a transistor and two integrated circuits to the power supply chassis.

9. Unsolder two ribbon-cables, noting the color codes and wire positions. If board replacement is intended, connect the wires to the new board.

To install the Power Supply circuit-board, reverse the removal procedure.

Main Interface Board Removal. If repair is necessary on the reverse side of the Main Interface circuit-board, it may be possible to gain access to that area by removal of one or two circuit boards as outlined previously. Consider this first or proceed with the Main Interface board removal procedure.

CAUTION

If the Main Interface board becomes defective, it is recommended that your local Tektronix Field Office or representative be contacted to arrange instrument repair at a Tektronix Service Center.

The Main Interface circuit-board can be removed as follows:

1. Remove the Vertical Preamp circuit-board as outlined previously.

2. Remove the Trigger Generator and Z-Axis Logic board as outlined previously.

3. Remove the high-voltage shield and remove the Vertical Output circuit-board shield (if installed).

4. Remove the BEAM FINDER and X10 MAG pushbutton extension-shafts. Insert a scribe or small screwdriver between the end of the white plastic switch-shaft and the inside end of the black plastic extension-shaft and pry gently.

5. Remove the INTENSITY, FOCUS, SCALE ILLUM, ASTIG and TRACE ROTATION control extension-shafts. Loosen the front setscrew in each coupling with a 0.050-inch Allen wrench.

6. Disconnnect twelve ribbon or wire cable-connectors from the Main Interface circuit-board and confirm the number and color of wires for each plug and its location in the following list.

a. Disconnect one-wire from pin E at the top-left of the board.

b. Disconnect a two-wire cable from pins B and C at the top-left of the board.

c. Disconnect a two-wire cable near the rear of the INTENSITY control (cable from the y-axis alignment coil).

d. Disconnect a two-wire cable near Q1482 (cable from the graticule lamps).

e. Disconnect a four-wire cable at the right-center of the board (cable from POSITION and FINE controls).

f. Disconnect a four-wire cable at the rear of the A TRIG HOLDOFF control (cable from the DELAY TIME POSITION control).

g. Disconnect a two-wire cable from the CALIBRATOR current loop.

h. Disconnect four, two-wire cables near F1318 at the bottom-left of the board. The cable wires to +15 are red with a brown stripe. The cable wires to −15 are violet with a brown stripe. Cable wires to the pins nearest the fuse (GND) are black. Cable wires to the remaining pins are red with a black stripe.

7. Disconnect two coaxial-cables from the left-center of the board. The cable to J1302 is white with a gray stripe and the cable to J1334 is white with black and orange stripes.

8. Disconnect the horizontal deflection plate leads at the crt. This requires a pair of long-nose pliers or tweezers for best removal or reinstallation.

9. Disconnect a three-wire cable from the Vertical Output board.

10. Disconnect a two-wire cable from the Fan Motor board.

11. Unsolder a 10-ohm, 1/2 watt resistor from the center-tap terminal of the ceramic thick-film resistor mounted near the Vertical Output circuit-board.

12. Unsolder ten wires from the Main Interface circuit-board and confirm each wire color with its location in the following list (all wires from crt socket).

a. Wire to pad 5 is white with a green stripe.

b. Wire to pad 10 is white with black and brown stripes.

c. Wire to pad 7 is white with a violet stripe.

d. Wire to pad 8 is white with a gray stripe.

e. Wire to the one-notch ceramic-strip is white with a yellow stripe.

f. Wire to the −2450 test point is solid red.

g. Wire to the right-hand notch on the three-notch ceramic-strip is white with an orange stripe.

h. Wire to pad 14 (lowest of a pair of wires between the large high-voltage capacitors) is white with brown and yellow stripes.

i. Wire to pad 1 (upper pad between the large high-voltage capacitors) is white with a brown stripe.

j. Wire to second notch on the five-notch ceramic-strip (notch containing junction of a 0.01 microfarad capacitor, a 10-megohm resistor, and a diode) is white with brown and red stripes.

13. Remove the three power transistor mounting-screws from Q1468, Q1426, and Q1448 on the rear subpanel bracket.

14. Remove the mounting screw from transistor Q1456 near the lower-rear corner of the board.

15. Remove the mounting screw from transistor Q1482 near the top-right corner of the board.

16. Remove the four hexagonal posts that mount the high-voltage shield. Use a 3/16-inch nut driver.

17. Remove seven Main Interface board mounting-screws.

18. Disconnect the crt anode-lead plug from the high-voltage multiplier jack. Ground this lead to the instrument main-chassis to remove any stored charge. Pry the multiplier jack from its mounting clip with a medium-size screwdriver.

19. Separate the Main Interface circuit-board from the instrument chassis, using care to prevent damage to components and wiring. Carefully thread the interconnecting cables through the board and chassis, as necessary, to avoid strain on any cable. Let the board pivot on the power-transformer leads still connected to the board.

Perform repairs on the reverse side of the Main Interface board, if repair is intended. To reinstall the board, reverse the removal procedure. If intentions are to replace the Main Interface circuit-board, continue with this procedure.

20. Unsolder the power-transformer wires from the Main Interface board and confirm each wire color with its location in Fig. 4-6. Record any exceptions to this procedure to facilitate reassembly.

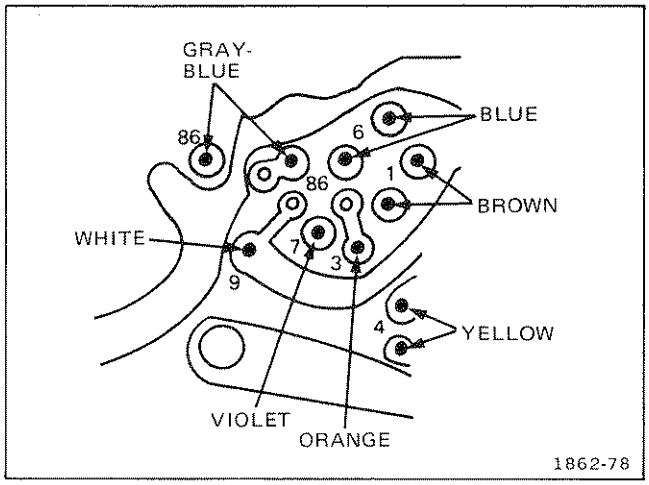


Fig. 4-6. Locations of power transformer secondary wires.

21. Remove the Main Interface circuit-board, using care to prevent strain on any of the wires.

22. Remove the solder from the holes in the circuit-board wire-terminal pads, where wires were removed in this procedure, to facilitate installation.

To install the Main Interface circuit-board, reverse the removal procedure.

Power Transformer Removal

CAUTION

If the Power Transformer becomes defective, it is recommended that your local Tektronix Field Office or representative be contacted to arrange instrument repair at a Tektronix Service Center. If the Power Transformer is to be replaced, be sure to replace only with a direct replacement Tektronix transformer.

The Power Transformer can be removed as follows:

1. Remove the Trigger Generator and Z-Axis Logic circuit-board as outlined previously.

2. Remove the regulating-range selector cover and the blue rear-panel of the instrument.

3. Option 4 only—Remove the power line input filter (emi filter).

4. Remove the transformer leads from the regulating-range selector body. It will be necessary to use a special pin removing tool available from Tektronix (Part Number 003-0707-00). It is only necessary to use this tool to remove the transformer leads from the regulating-range selector body. The leads may be installed by simply pushing them into place. Record the color and location of each wire to facilitate correct reassembly.

5. Option 7 only—Unsolder five wires from the transformer terminals and confirm each wire color with its location in the following list.

a. Wire to terminal 10 is white with a brown stripe.

b. Wire to terminal 10A is white with a red stripe.

c. Wire to terminal 11 is white with a gray stripe.

d. Wire to terminal 12A is white with an orange stripe.

e. Wire to terminal 12 is white with a yellow stripe.

6. 475A DM44 only—Unsolder five wires from the transformer terminals and confirm each wire color with its location in the following list.

a. Wire to terminal 10 is white with a brown stripe.

b. Wire to terminal 10A is white with a red stripe.

c. Wire to terminal 11 is white with an orange stripe.

d. Wire to terminal 12A is white with a yellow stripe.

e. Wire to terminal 12 is white with a green stripe.

7. Remove two screws and Keps nuts that hold the transformer bracket to the rear of the main chassis. Remove two Keps nuts that hold the transformer bracket to the main chassis and the transformer electrical shield. A 5/16-inch, nut-driver wrench is helpful for easiest removal of these nuts.

8. Unsolder the wires from the thermal cutout on the transformer bracket and note the wire colors.

9. Unsolder the transformer wires from the Main Interface board as directed in the Main Interface board removal procedure, part 20.

10. Remove the transformer from the instrument.

11. Remove the solder from the holes in the circuit-board wire-terminal pads, where wires were removed in this procedure, to facilitate installation.

To install a new Power Transformer, reverse this removal procedure.

Cathode-ray Tube Removal

WARNING

Use care when handling a crt. Protective clothing and safety glasses should be worn. Avoid striking it on any object which might cause it to crack or implode. When storing a crt, place it in a protective carton or set it face down on a smooth surface in a protected location with a soft mat under the faceplate to protect it from scratches.

1. 475A DM44 only—Disconnect three ribbon-cables from the DM44 main circuit-board. Remove two screws from the rear of the main circuit-board chassis and separate the board and chassis assembly from the instrument chassis.

2. Remove the Vertical Output circuit-board shield (if installed).

3. Remove two flat-head screws from the blue-plastic cover at the rear of the instrument. Carefully position the blue-plastic cover to allow access to the screws holding the crt rear cover, then remove the crt rear cover.

4. Disconnect the crt anode plug from the high-voltage jack and touch the lead to the chassis to remove any stored charge.

5. Disconnect the crt base socket from the rear of the crt.

6. Disconnect the four vertical deflection plate leads from the Vertical Output board at the crt neck pins.

7. Disconnect the two horizontal deflection plate leads from the Main Interface board at the crt neck pins (accessible through an opening at center of the Main Interface board).

8. Remove the crt bezel and implosion shield.

9. Hold one hand on the crt base and slowly push the crt forward, guiding the crt face with the other hand. Guide the anode plug through the crt shield opening while slowly pulling the crt out of the instrument. The plastic corner-pads may fall loose when the crt is removed; save them for reinstallation. Set the crt on a soft material to prevent scratching.

Cathode-ray Tube Installation

1. Position the crt rear-support (plastic centering bracket) inside the crt shield approximately 1-1/2-inches from the rear of the shield.

2. Check that the plastic corner-pads are in place and seated at the front corners of the crt opening.

3. Insert the crt into the shield. Guide the crt anode lead through the hole in the shield.

4. Slowly push the crt the rest of the way into the crt shield. If the crt does not go in all the way, pull it part way out and find the reason for binding. It may be necessary to reposition the rear-support bracket or a plastic corner-pad for best installation.

5. Clean the crt faceplate, implosion shield and bezel as directed under Cleaning—Exterior information at the beginning of this section and install the parts. Lightly tighten the four bezel screws (approximately 5-inch pounds).

6. Connect the crt base socket, install the crt rear cover with two round-head screws and install the blue-plastic cover on the rear of the instrument with two flat-head screws.

7. Connect the crt anode lead and carefully connect the deflection plate leads. After each lead is connected, lightly pull on the lead to be sure that it will remain in place.

8. 475A DM44 only—Install the DM44 main circuit-board chassis on the 475A chassis. Install two screws at the rear of the main circuit-board chassis and connect three ribbon-cables to the board.

9. If the crt was replaced, part of the 475A calibration will need to be checked or adjusted. See Table 4-5 under Recalibration After Repair (later in this section) for a listing of calibration checks and adjustments that need to be checked after crt replacement.

High-Voltage Multiplier Removal

1. Remove the Vertical Preamp circuit-board as outlined previously.

2. Remove the cathode-ray tube as outlined previously.

3. Remove the high-voltage shield from the Main Interface circuit-board and remove one screw near the INTENSITY potentiometer.

4. Remove four hexagonal posts, used to mount the high-voltage shield, from the Main Interface board with a 3/16-inch nut-driver.

5. Remove the two nylon nuts from the Main Interface board near C1328.

6. Remove three screws holding the multiplier shield to the main chassis and remove the shield.

7. Unsolder the black wire from the Multiplier at the Main Interface board.

8. Unsolder one wire from a post on the High-Voltage Multiplier.

9. Unsolder the flexible grounding-braid from the case of integrated circuit U470 (on the Vertical Output board), using a 40 to 60-Watt soldering iron.

10. Remove one screw that holds the crt neck shield to the black-plastic rear bracket.

11. Hold the crt base socket away from the neck shield and slide the shield to the rear of the instrument about 2 inches.

12. Pry the Multiplier jack from its mounting clip on the main chassis.

13. Remove the High-Voltage Multiplier. If necessary, carefully pry the Main Interface board away for easier removal and guide the Multiplier jack through the main chassis.

14. To install the High-Voltage Multiplier, reverse the removal procedure. Use the Cathode-ray Tube Installation procedure for installing the crt.

Delay Line Removal

1. Remove the cathode-ray tube as outlined previously.

2. Disconnect a two-wire cable near the rear of the INTENSITY control (cable from y-axis alignment coil).

3. Remove a screw connecting a solder lug and heavy braid from the Vertical Output board at the crt neck shield.

4. Remove one screw that holds the crt neck shield to the black-plastic rear bracket.

5. Hold the crt base socket away from the neck shield and remove the crt neck shield through the main chassis rear opening, using care to guide the y-axis coil cable through the board and chassis holes.

6. Remove the Keps nut and delay-line bracket holding the Delay Line to the main chassis.

7. Disconnect the Delay Line ends at the Vertical Preamp and Vertical Output boards. This may require the use of a soldering iron (a 40 to 60-Watt iron works best).

8. Remove the Delay Line, using care to guide the Delay Line ends through the main chassis holes without causing sharp bends in the line.

To install the Delay Line, reverse the removal procedure. Use the Cathode-ray Tube Installation procedure for installing the crt.

Recalibration After Repair

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. Table 4-5 lists the adjustments that may interact with a repair in a particular circuit. The table is also useful as a list of calibration adjustments that should be checked if an adjustment is made when performing the Calibration procedure. Perform a calibration check of each interaction, using the appropriate step in the Calibration procedure found in Section 6 of this manual.

Instrument Repackaging

If the Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted, complete instrument serial number and a description of the service required.

Save and re-use the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

1. Obtain a carton of corrugated cardboard having inside dimensions of no less than six inches more than the instrument dimensions; this will allow for cushioning. Refer to the following table for carton test strength requirements.
2. Surround the instrument with polyethylene sheeting to protect the finish of the instrument.
3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between carton and instrument, allowing three inches on all sides.
4. Seal carton with shipping tape or industrial stapler.

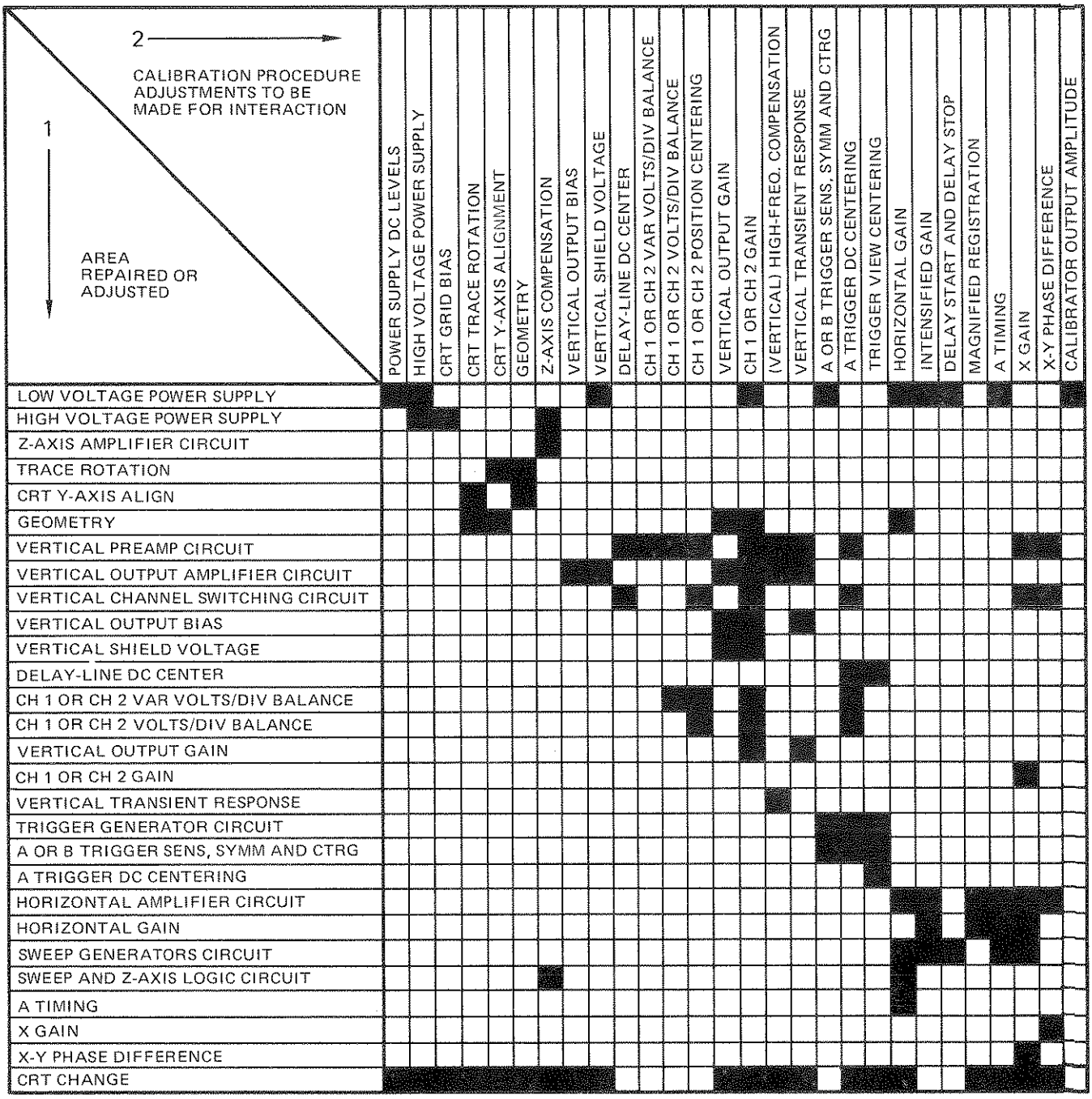
SHIPPING CARTON TEST STRENGTH

Gross Weight (lb)	Carton Test Strength (lb)
0-10	200
10-30	275
30-120	375
120-140	500
140-160	600

TABLE 4-5

1862-84

CALIBRATION INTERACTION AFTER REPAIR OR ADJUSTMENT



PERFORMANCE CHECK

IMPORTANT—PLEASE READ BEFORE USING THIS PROCEDURE

Introduction

The following procedure is intended to be used for incoming inspection to determine the acceptability of newly purchased or recently recalibrated instruments. This procedure does not check every facet of the instrument's calibration; rather it is concerned primarily with those portions of the instrument that are essential to measurement accuracy and correct operation. Removing the instrument cabinet is not necessary to perform this procedure. All checks are made from the front panel. This procedure is also useful as an aid in troubleshooting and preventive maintenance.

Using This Procedure

Outline. To aid in locating a step in the Performance Check, an outline is given preceding the Performance Check procedure.

Partial Procedures. A partial check of performance is often desirable after replacing components or to verify performance of a portion of the instrument betwen major recalibrations. To check only part of the instrument, set the controls as given under the nearest preceding Control Settings and use the Equipment Required list preceding the desired portion of the procedure.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories, or its equivalent, is required for a complete performance check of the 475A. Specifications given for the test equipment are the minimum necessary for accurate calibration. Therefore, some of the specifications listed here may differ from the actual performance capabilities of the test equipment. All test equipment is assumed to be correctly calibrated and operating within the listed specifications. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is needed.

Special Calibration Fixtures

Special Tektronix calibration fixtures are used only where they facilitate checking instrument performance. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Performance Check Equipment Alternatives

All of the listed test equipment is required to completely check this instrument. However, complete checking may not always be necessary or desirable. The user may be satisfied with checking only selected characteristics, thereby reducing the amount of test equipment actually required.

The equipment listed in the Performance Check Procedure is based on the first item of equipment given as an example of applicable equipment. When other equipment is substituted, control settings or equipment setups may need to be altered to meet the requirements of the substitute equipment. If the exact item of test equipment given as an example in the Test Equipment list is not available, first check the Specifications column carefully to see if any other equipment is available which might suffice. Then check the Usage column to see what this item is used for. If used for a check or adjustment that is of little or no importance to your measurement requirements, the item and corresponding step(s) can be deleted.

TABLE 5-1

Test Equipment Required For Performance Check

Description	Minimum Specifications	Usage	Examples
1. Amplitude Calibrator	Amplitude accuracy, within 0.25%; signal amplitude, 2 millivolts to 20 volts; output signal, 1 kilohertz square wave.	Vertical checks. Trigger view gain check; External Z-Axis check.	a. Tektronix PG 506 Calibration Generator.[1] b. Tektronix 067-0502-01 calibration fixture.
2. Sine-Wave Generator	Frequency, 350 kilohertz to above 250 megahertz; output amplitude, variable from 15 millivolts to 4 volts peak-to-peak; output impedance, 50 ohms; reference frequency, 50 to 350 kilohertz; amplitude accuracy, constant within 3% of reference frequency as output frequency changes.	Vertical centering, bandwidth and isolation checks; Trigger checks; X bandwidth check.	a. Tektronix SG 503 Leveled Sine-Wave Generator.[1] (Use for all frequencies.) b. Tektronix Type 191 Constant-Amplitude Signal Generator. (Use at frequencies of 100 megahertz and below). AND Wavetek Model 1001A (use only for checking 250 megahertz bandwidth and triggering).
3. Time-Mark Generator	Marker outputs, 2 nanoseconds to 0.5 second; marker accuracy, within 0.1%; trigger output, 1 millisecond to 0.1 microsecond, time coincident with markers.	Horizontal timing checks.	a. Tektronix TG 501 Time-Mark Generator.[1] b. Tektronix 2901 Time-Mark Generator.
4. Low-Frequency Generator	Frequency, 10 Hertz to 50 kilohertz; output amplitude, variable from 10 millivolts to 4 volts peak-to-peak.	Low-frequency trigger checks.	a. Tektronix SG 502 Oscillator.[1] b. General Radio 1310 B Oscillator with a binding post to BNC adapter.
5. Cable (2 required)	Impedance, 50 ohms; length, 42 inches; connectors, BNC.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 012-0057-01.
6. Cable (2 required)	Impedance, 50 ohms; length 18 inches; connectors. BNC.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 012-0076-00.
7. 50-Ohm Signal Pickoff	Frequency response, 50 kilohertz to 875 megahertz; impedance, 50 ohms for signal input, signal output and trigger output.	Trigger checks.	a. Tektronix CT-3 Signal Pickoff. Part Number 017-0061-00.
8. Adapter	Connectors, BNC Female to BNC Female.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 103-0028-00.

[1] **Requires a TM 500-Series Power Module.**

TABLE 5-1 (cont)

Description	Minimum Specifications	Usage	Examples
9. Adapter	Connectors, GR874 to BNC Female.	Trigger checks.	a. Tektronix Part Number 017-0063-00.
10. Adapter	Connectors, GR874 to BNC Male.	Used in Trigger System procedure for signal interconnection.	a. Tektronix Part Number 017-0064-00.
11. Elbow Adapter	Connectors, BNC Male to BNC Female.	Used in Trigger System procedure for signal interconnection.	a. Tektronix Part Number 103-0031-00.
12. T-Connector	Connectors, BNC	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 103-0030-00.
13. 10X Attenuator	Ratio, 10X; impedance, 50 ohms; connectors, BNC	Vertical bandwidth check. Trigger checks.	a. Tektronix Part Number 011-0059-02
14. 5X Attenuator	Ratio, 5X; impedance, 50 ohms; connectors, BNC	Trigger checks.	a. Tektronix Part Number 011-0060-02
15. Termination (2 required)	Impedance, 50 ohms; connectors, BNC.	Used throughout procedure for proper signal termination.	a. Tektronix Part Number 011-0049-01.
16. 10X Probe	Scale-factor switching; connector, BNC.	Scale factor check. Calibrator check.	a. Tektronix P6075 Probe (supplied with 475A oscilloscope). b. Tektronix P6065 Probe.
17. 500 MHz Filter	Impedance, 50 ohms; frequency, adjustable; connectors, BNC.	Used for High-Speed Timing checks.	a. Tektronix 500 MHz Filter calibration fixture. Part Number 067-0684-00.
18. Screwdriver	Length, three-inch shaft; bit size, 3/32 inch.	Used to adjust TRACE ROTATION, ASTIG, GAIN.	a. Xcelite R-3323.

OUTLINE FOR PERFORMANCE CHECK

DISPLAY AND VERTICAL SYSTEM CHECK

TRIGGER SYSTEM CHECK

HORIZONTAL SYSTEM CHECK

GATE OUTPUTS, EXTERNAL Z-AXIS AND CALIBRATOR CHECKS

PRELIMINARY PROCEDURE FOR PERFORMANCE CHECK

Operating Voltage

Before applying power to the instrument, check that the line voltage selector and the regulating range selector are in the correct positions for the line voltage the instrument will be operated on.

Power Source

Connect the 475A to a power source that meets the voltage and frequency requirements of this instrument.

Warm Up

Turn on the 475A and allow at least 20 minutes before starting the Performance Check procedure.

Operating Temperature

The performance of this instrument can be checked at an ambient temperature within −15° C to +55° C unless stated otherwise in the procedure. This instrument should be checked at an ambient temperature of +20° C to +30° C for best overall accuracy.

DISPLAY AND VERTICAL SYSTEM CHECK

Equipment Required

1. Amplitude Calibrator
2. Sine-Wave Generator
3. 42-inch 50-Ohm BNC Cable (2 required)
4. 18-inch 50-Ohm BNC Cable (2 required)
5. 10X Probe (see Table 5-1, 10X Probe examples)
6. 10X BNC Attenuator
7. 50-Ohm BNC Termination (2 required)
8. BNC Female-to-BNC Female Adapter
9. BNC T-Connector
10. Screwdriver

Control Settings

POWER	ON
Display	
INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange
Vertical (CH 1 and CH 2)	
POSITION	Midrange
VOLTS/DIV	10 mV
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 or 20 MHz BW	20
Trigger (A and B)	
COUPLING	AC
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	NORM
B TRIGGER SOURCE	STARTS AFTER DELAY
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM
Sweep	
A TIME/DIV	1 ms
B TIME/DIV	1 ms
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

1. Check Display Controls

a. Turn the INTENSITY control through its range and return to a normal intensity setting.

b. CHECK—For control of trace intensity from minimum to maximum intensity.

c. Turn CH 1 POSITION through its range and return to a midrange setting.

d. CHECK—That the trace can be positioned over the entire graticule area.

e. Set VERT MODE to CH 2, turn CH 2 POSITION through its range and return to a midrange setting.

f. CHECK—That the trace can be positioned over the entire graticule area.

g. Return VERT MODE to CH 1 and position the trace to the center horizontal graticule line.

h. CHECK—That the trace is aligned with the center horizontal graticule line.

i. ADJUST—TRACE ROTATION (front panel screwdriver adjustment) to align the trace with the center horizontal graticule line.

j. Turn the SCALE ILLUM control through its range.

k. CHECK—For control of graticule illumination from minimum to maximum settings.

l. Set the amplitude calibrator for a 50 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

m. Set A TRIGGER LEVEL for a stable display.

n. CHECK—For well-defined focusing on front corners of the displayed waveform.

o. ADJUST—FOCUS control and ASTIG (front panel screwdriver adjustment) together for the best-defined front corners on the displayed waveform.

p. Turn INTENSITY fully counterclockwise and press BEAM FINDER pushbutton.

q. CHECK—For a compressed waveform of normal intensity, within graticule area.

r. Release BEAM FINDER pushbutton and return INTENSITY to a normal setting.

2. Check Vertical Input Functions

a. Position the bottom of CH 1 display to the center horizontal graticule line.

b. Set CH 1 AC-GND-DC switch to GND.

c. CHECK—For no vertical deflection and that trace is at center horizontal graticule line.

d. Set CH 1 AC-GND-DC switch to AC.

e. CHECK—That display is centered in graticule area.

f. Move test signal cable to CH 2 input and set VERT MODE to CH 2.

g. Position the bottom of CH 2 display to the center horizontal graticule line.

h. Set CH 2 AC-GND-DC switch to GND.

i. CHECK—For no vertical deflection and that trace is at center horizontal graticule line.

j. Set CH 2 AC-GND-DC switch to AC.

k. CHECK—That display is centered in graticule area.

l. Disconnect all test equipment.

m. CHECK—That the light under 10 mV of CH 2 VOLTS/DIV knob is on.

n. Connect a 10X probe with a scale-factor switching connector to CH 2 input.

NOTE

Use a probe listed in test equipment required, Table 5-1, under 10X Probe examples.

o. CHECK—That the light under 10 mV is extinguished and the light under .1 V comes on.

p. Set VERT MODE to CH 1.

q. CHECK—That the light under 10 mV of CH 1 VOLTS/DIV knob is on.

r. Move the 10X probe to CH 1 input.

s. CHECK—That the light under 10 mV is extinguished and the light under .1 V comes on.

t. Remove the 10X probe.

3. Check CH 1 and CH 2 GAIN

a. Set the amplitude calibrator for a 50 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

b. Set CH 1 and CH 2 AC-GND-DC switches to DC.

c. CHECK—The display for 5 divisions of amplitude.

d. ADJUST—CH 1 GAIN, 10 mV adjustment, through the upper 10 mV access hole at left side of cabinet for 5 divisions of amplitude.

e. CHECK—All settings of CH 1 VOLTS/DIV for accuracy, within 3%, using the settings listed in Table 5-2.

TABLE 5-2
Vertical Deflection Accuracy

VOLTS/DIV Switch Setting	Amplitude Calibrator Output	Vertical Deflection in Divisions	Maximum Error for 3% Accuracy
5 mV	20 millivolts	4	Previously set
10 mV	50 millivolts	5	±0.15 div
20 mV	0.1 volt	5	±0.15 div
50 mV	0.2 volt	4	±0.12 div
0.1 V	0.5 volt	5	±0.15 div
0.2 V	1 volt	5	±0.15 div
0.5 V	2 volts	4	±0.12 div
1 V	5 volts	5	±0.15 div
2 V	10 volts	5	±0.15 div
5 V	20 volts	4	±0.12 div
10 V	50 volts	5	±0.15 div

f. Set VERT MODE to CH 2, set amplitude calibrator for a 50 millivolt output and move signal cable to CH 2 input.

g. CHECK—The display for 5 divisions of amplitude.

h. ADJUST—CH 2 GAIN, 10 mV adjustment, through the lower 10 mV access hole at left side of cabinet for 5 divisions of amplitude.

i. CHECK—All settings of CH 2 VOLTS/DIV for accuracy, within 3%, using the settings listed in Table 5-2.

4. CHECK CH 2 and CH 1 VAR VOLTS/DIV Range

a. Set the amplitude calibrator to 50 millivolts and set CH 1 and CH 2 VOLTS/DIV to 10 mV.

b. Turn CH 2 VAR VOLTS/DIV fully counterclockwise.

c. CHECK—That the CH 2 UNCAL light turns on when the CH 2 VAR VOLTS/DIV control is out of calibrated detent.

d. CHECK—That display amplitude reduces to 2 divisions or less.

e. Return CH 2 VAR VOLTS/DIV to calibrated detent.

f. Set VERT MODE to CH 1 and move signal cable to CH 1 input.

g. Turn CH 1 VAR VOLTS/DIV fully counterclockwise.

h. CHECK—That the CH 1 UNCAL light turns on when the CH 1 VAR VOLTS/DIV control is out of calibrated detent.

i. CHECK—That display amplitude reduces to 2 divisions or less.

j. Return CH 1 VAR VOLTS/DIV to calibrated detent.

5. Check ADD Mode Operation

a. Set VERT MODE to ADD and set CH 1 and CH 2 VOLTS/DIV to 10 mV.

b. Remove the test signal cable from CH 1 input. Connect to the cable: a BNC female-to-BNC female adapter, a BNC T-connector, two 18-inch 50-ohm BNC cables and connect the cables to CH 1 and CH 2 inputs.

c. Set the amplitude calibrator for a 20 millivolt output and center the display on graticule using equal settings of CH 1 and CH 2 POSITION controls.

d. CHECK—For a display of 4 divisions, within 3% (0.12 division).

e. Press INVERT pushbutton.

f. CHECK—That display amplitude reduces to approximately 0.

g. Return INVERT pushbutton to normal (button out).

h. Disconnect all test equipment.

6. Check ALT Mode Operation

a. Set VERT MODE to ALT, set 100 OR 20 MHz BW control to full bandwidth position and set A TRIGGER LEVEL fully clockwise.

b. Position the 2 traces approximately 4 divisions apart.

c. CHECK—That the traces alternate at all settings of TIME/DIV except X-Y.

7. Check CHOP Mode Operation

a. Set VERT MODE to CHOP, set TIME/DIV to 1 μs, set CH 1 and CH 2 AC-GND-DC switches to GND and adjust A TRIGGER LEVEL for a stable display.

b. CHECK—For complete blanking of switching transients between chopped segments.

c. CHECK—That the duration of 1 cycle is approximately 1 division.

8. Check Vertical Amplifier Bandwidth

a. Set VERT MODE to CH 1, set TIME/DIV to 0.5 ms and set CH 1 and CH 2 AC-GND-DC switches to DC.

NOTE

See test equipment required. Table 5-1, for selection of sine-wave generator with a 250 megahertz output.

b. Connect the sine-wave generator output cable to a 10X BNC attenuator, to a 50-ohm termination, to CH 1 input.

c. Set the sine-wave generator for a 6 division display of reference frequency. (It may be necessary to insert more attenuation to reduce display amplitude.)

NOTE

If generator has no reference frequency setting, set for 5 megahertz.

d. Without changing the generator output amplitude, increase the output frequency until the display is reduced to 4.2 divisions.

e. CHECK—For a generator frequency reading of 250 megahertz or more.

f. Set VERT MODE to CH 2 and move test signal setup to CH 2 input.

g. CHECK—Repeat the bandwidth check procedure, parts c, d and e.

9. Check Bandwidth Limit Operation

a. Set 100 OR 20 MHz BW control to 100.

NOTE

It may be necessary to change sine-wave generators. See test equipment required, Table 5-1 for selection of generator with an output of 100 megahertz and below.

b. Set the sine-wave generator for a 6 division display of reference frequency.

c. Without changing the generator output amplitude, increase the output frequency until the display is reduced to 4.2 divisions.

d. CHECK—For a generator reading of approximately 100 megahertz.

e. Set 100 OR 20 MHz BW control to 20.

f. Set the sine-wave generator for a 6 division display of reference frequency.

g. Without changing the generator output amplitude, increase the output frequency until the display is reduced to 4.2 divisions.

h. CHECK—For a generator reading of approximately 20 megahertz.

i. Return 100 OR 20 MHz BW control to full bandwidth.

10. Check Cascaded Bandwidth

a. Set VERT MODE to CH 1.

b. Connect CH 2 VERT SIGNAL OUT (output connector on rear panel) through a 42-inch 50-ohm BNC cable, to a 50-ohm termination and connect to CH 1 input.

c. Set the sine-wave generator for a 6 division display of reference frequency.

d. Without changing the generator output amplitude, increase the output frequency until the display is reduced to 4.2 divisions.

e. CHECK—For a reading of 50 megahertz or more.

f. Disconnect all test equipment.

TRIGGER SYSTEM CHECK

Equipment Required

1. Sine-Wave Generator
2. Low-Frequency Generator
3. Amplitude Calibrator
4. 50-Ohm Signal Pickoff
5. 42-Inch 50-Ohm BNC Cable
6. 18-Inch 50-Ohm BNC Cable (2 required)
7. GR-To-BNC Female Adapter
8. GR-To-BNC Male Adapter
9. BNC Female-To-BNC Female Adapter
10. BNC Elbow
11. BNC T-Connector
12. 10X BNC Attenuator
13. 5X BNC Attenuator
14. 50-Ohm BNC Termination (2 required)

Control Settings

POWER	ON

Display

INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	5 mV
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 OR 20 MHz BW	Full bandwidth (push in, then release)

Trigger (A and B)

COUPLING	AC
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	NORM
B TRIGGER SOURCE	**NORM (new setting)**
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

Sweep

A TIME/DIV	**50 μs (new setting)**
B TIME/DIV	**50 μs (new setting)**
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

11. Check A Low-Frequency Triggering

a. Connect the low-frequency generator output to a 42-inch 50-ohm BNC cable, to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables, to CH 1 input and A TRIGGER external input.

b. Set the low-frequency generator for a 5 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

c. CHECK—That a stable triggered display can be obtained in AC, LF REJ, HF REJ and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

d. Set CH 1 VOLTS/DIV to 5 mV.

e. Set the low-frequency generator for a 3 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

f. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

g. Set the low-frequency generator for a 2 division, 50 kilohertz display, then set A TRIGGER SOURCE to EXT (100 millivolts at external input).

h. CHECK—Repeat part c.

i. Set CH 1 VOLTS/DIV to 0.1 V and set A TRIGGER SOURCE to EXT ÷ 10.

j. Set the low-frequency generator for a 5 division, 50 kilohertz display (500 millivolts at inputs), then set CH 1 VOLTS/DIV to 0.5 V.

k. CHECK—Repeat part f.

l. Set CH 1 VOLTS/DIV to 10 mV and set A TRIGGER SOURCE to EXT.

m. Set the low-frequency generator for a 5 division, 50 kilohertz display (50 millivolts at external input), then set CH 1 VOLTS/DIV to 50 mV.

n. CHECK—Repeat part f.

o. Set A TRIGGER SOURCE to NORM, set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 10 ms and set 100 OR 20 MHz BW control to 20.

p. Set the low-frequency generator for a 5 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

q. CHECK—That a stable triggered display can be obtained in DC, HF REJ and AC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

r. Set A TRIGGER COUPLING to LF REJ.

s. CHECK—That a stable triggered display cannot be obtained with adjustment of A TRIGGER LEVEL.

t. Set CH 1 VOLTS/DIV to 5 mV and set A TRIGGER COUPLING to AC.

u. Set the low-frequency generator for a 3 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

v. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

w. Set the low-frequency generator for a 2 division, 60 Hertz display, then set A TRIGGER SOURCE to EXT (100 millivolts at external input).

x. CHECK—Repeat part q.

y. Set A TRIGGER COUPLING to LF REJ.

z. CHECK—Repeat part s.

aa. Set A TRIGGER COUPLING to AC.

ab. Set the low-frequency generator for a 1 division, 60 Hertz display (50 millivolts at external input).

ac. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

ad. Disconnect all test equipment.

NOTE

Use a sine-wave generator with an output of 100 megahertz and below for the following parts.

ae. Connect the sine-wave generator output cable to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables. Connect an 18-inch cable through a 50-ohm termination to CH 1 input and connect the other 18-inch cable through a 50-ohm termination to A TRIGGER external input.

af. Set TIME/DIV to 0.5 μs.

ag. Set the sine-wave generator for a 2 division, 3 megahertz display (100 millivolts at external input).

ah. Set A TRIGGER COUPLING to HF REJ.

@

ai. CHECK—That a stable triggered display cannot be obtained with adjustment of A TRIGGER LEVEL.

aj. Set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 2 μs and set A TRIGGER SOURCE to NORM.

ak. Set the sine-wave generator for a 5 division, 1 megahertz display, then set CH 1 VOLTS/DIV to 50 mV.

al. CHECK—Repeat part ai.

am. Return A TRIGGER COUPLING to AC.

an. Disconnect all test equipment.

12. Check B Low-Frequency Triggering

a. Set TIME/DIV to 50 μs, set CH 1 VOLTS/DIV to 5 mV and set HORIZ DISPLAY to B DLY'D. (B DLY'D sweep will not appear when not triggered).

b. Connect the low-frequency generator output to a 42-inch 50-ohm BNC cable, to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables, to CH 1 input and B TRIGGER external input.

c. Set the low-frequency generator for 50 kilohertz, then set the generator for a 5 division display and set CH 1 VOLTS/DIV to 50 mV.

d. CHECK—That a stable triggered display can be obtained in AC, LF REJ, HF REJ and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

e. Set CH 1 VOLTS/DIV to 5 mV.

f. Set the low-frequency generator for a 3 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

g. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

h. Set the low-frequency generator for a 2 division, 50 kilohertz display, then set B TRIGGER SOURCE to EXT (100 millivolts at external input).

i. CHECK—Repeat part d of this step.

j. Set CH 1 VOLTS/DIV to 10 mV.

k. Set the low-frequency generator for a 5 division, 50 kilohertz display (50 millivolts at external input), then set CH 1 VOLTS/DIV to 50 mV.

l. CHECK—Repeat part g.

m. Set B TRIGGER SOURCE to NORM, set CH 1 VOLTS/DIV to 5 mV and set TIME/DIV to 10 ms.

n. Set the low-frequency generator for a 5 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

o. CHECK—That a stable triggered display can be obtained in HF REJ, DC and AC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

p. Set B TRIGGER COUPLING to LF REJ.

q. CHECK—That a stable triggered display cannot be obtained with adjustment of B TRIGGER LEVEL.

r. Set CH 1 VOLTS/DIV to 5 mV and set B TRIGGER COUPLING to AC.

s. Set the low-frequency generator for a 3 division, 60 hertz display, then set CH 1 VOLTS/DIV to 50 mV.

t. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

u. Set the low-frequency generator for a 2 division, 60 hertz display, then set B TRIGGER SOURCE to EXT (100 millivolts at external input).

v. CHECK—Repeat part o.

w. Set B TRIGGER COUPLING to LF REJ.

x. CHECK—Repeat part q.

y. Set B TRIGGER COUPLING to AC.

z. Set the low-frequency generator for a 1 division, 60 Hertz display (50 millivolts at external input). (It may be necessary to maintain triggering as amplitude is reduced.)

aa. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

ab. Disconnect all test equipment.

NOTE

Use a sine-wave generator with an output of 100 megahertz and below for the following parts.

ac. Connect the sine-wave generator output cable to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables. Connect an 18-inch cable through a 50-ohm termination to CH 1 input and connect the other 18-inch cable through a 50-ohm termination to B TRIGGER external input.

ad. Set TIME/DIV to 0.5 μs and set B TRIGGER SOURCE to STARTS AFTER DELAY.

ae. Set the sine-wave generator for a 2 division, 3 megahertz display (100 millivolts at external input).

af. Set B TRIGGER COUPLING to HF REJ and set B TRIGGER SOURCE to EXT.

ag. CHECK—That a stable triggered display cannot be obtained with adjustment of B TRIGGER LEVEL.

ah. Set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 2 μs and set B TRIGGER SOURCE to STARTS AFTER DELAY.

ai. Set the sine-wave generator for a 5 division, 1 megahertz display, then set CH 1 VOLTS/DIV to 50 mV, and set B TRIGGER SOURCE to NORM.

aj. CHECK—Repeat part ag.

ak. Set B TRIGGER COUPLING to AC and set B TRIGGER SOURCE to STARTS AFTER DELAY.

13. Check B 40 Megahertz Triggering

a. Set TIME/DIV to 0.05 μs and set 100 OR 20 MHz BW to full bandwidth (push in, then release).

b. Set the sine-wave generator for a 1 division, 40 megahertz display, then set B TRIGGER SOURCE to EXT (50 millivolts at external input).

c. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

d. Set B TRIGGER SOURCE to NORM, set CH 1 VOLTS/DIV to 5 mV, set CH 2 VOLTS/DIV to 50 mV and move signal cable setup from B TRIGGER external input to CH 2 input.

e. Set the sine-wave generator for a 3 division, 40 megahertz display, set CH 1 VOLTS/DIV to 50 mV, retrigger if necessary, then set the display to graticule center with CH 1 POSITION.

f. Set VERT MODE to CH 2 and move the display to graticule center with CH 2 POSITION. (Retrigger if necessary.)

g. Return VERT MODE to CH 1.

h. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

i. Return B TRIGGER COUPLING to AC.

j. CHECK—That a stable triggered display can be obtained in NORM, CH 1 and CH 2 positions of B TRIGGER SOURCE with adjustment of B TRIGGER LEVEL.

k. Return B TRIGGER SOURCE to NORM.

14. Check A 40 Megahertz Triggering

a. Set HORIZ DISPLAY to A and check that A TRIGGER SOURCE is in NORM and A TRIGGER COUPLING is in AC.

b. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

c. Return A TRIGGER COUPLING to AC.

d. CHECK—That a stable triggered display can be obtained in CH 1 and CH 2 positions of A TRIGGER SOURCE with adjustment of A TRIGGER LEVEL.

e. Return A TRIGGER SOURCE to NORM and move test signal cable from CH 2 input to A TRIGGER external input.

f. Set the sine-wave generator for a 1 division, 40 megahertz display, then set A TRIGGER SOURCE to EXT.

g. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

h. Return A TRIGGER SOURCE to NORM and A TRIGGER COUPLING to AC.

i. Disconnect all test equipment.

15. Check A 250 Megahertz Triggering

NOTE

It may be necessary to change to a sine-wave generator with a 250 megahertz output.

Trigger jitter is measured horizontal trace excursion minus normal horizontal trace width observed at low frequency.

a. Connect the sine-wave generator output cable through a GR-to-BNC female adapter to the through signal input of the 50-ohm signal pickoff. Connect the through signal output of the signal pickoff to a GR-to-BNC male adapter, to a 10X BNC attenuator, to a 50-ohm BNC termination, to a BNC elbow, to A TRIGGER external input.

b. Connect the 10% signal output of the signal pickoff to an 18-inch 50-ohm BNC cable, to a 50-ohm termination, to CH 1 input.

c. Set the sine-wave generator for a 2.0 division, 250 megahertz display.

d. Set TIME/DIV to 0.01 μs and press X10 MAG to on.

e. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC, LF REJ and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

f. Set TIME/DIV to 0.1 ms and set A TRIGGER SOURCE to EXT.

g. Set the sine-wave generator for a 5 division display of reference frequency (250 millivolts at external input), then set to 250 megahertz.

NOTE

If generator has no reference frequency setting, set for 5 megahertz.

h. Set TIME/DIV to 0.01 μs.

i. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

j. Replace the 10X BNC attenuator in test signal setup with a 5X BNC attenuator (500 millivolts at external input) and set A TRIGGER COUPLING to LF REJ.

k. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A TRIGGER LEVEL.

16. Check B 250 Megahertz Triggering

a. Move test signal setup from A TRIGGER external input to B TRIGGER external input.

b. Set A TRIGGER SOURCE to NORM, set A TRIGGER COUPLING to AC, set HORIZ DISPLAY to B DLY'D, set B TRIGGER SOURCE to EXT and set B TRIGGER COUPLING to LF REJ.

c. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A and B TRIGGER LEVEL controls.

d. Replace the 5X BNC attenuator with a 10X BNC attenuator (250 millivolts at external input).

e. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of A and B TRIGGER LEVEL controls.

f. Set B TRIGGER SOURCE to STARTS AFTER DELAY and set TIME/DIV to 1 μs.

g. Set the sine-wave generator for a 2.0 division, 250 megahertz display.

h. Set B TRIGGER SOURCE to NORM and set TIME/DIV to 0.01 μs.

i. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC, LF REJ, and DC positions of B TRIGGER COUPLING with adjustment of A and B TRIGGER LEVEL controls.

j. Disconnect all test equipment.

17. Check TRIG MODE NORM Operation

a. Set HORIZ DISPLAY to A, set TIME/DIV to 1 ms, set X10 MAG to off (button out), set INTENSITY, if necessary, for a convenient trace intensity and set B TRIGGER COUPLING to AC.

b. Set the amplitude calibrator for a 50 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

c. Set A TRIGGER LEVEL for a stable triggered display.

d. Set TRIG MODE to NORM.

e. CHECK—For a stable triggered display.

f. Remove the test signal from CH 1 input.

g. CHECK—For no visible trace.

18. Check TRIG MODE SINGL SWP Operation

a. Return the test signal cable to CH 1 input.

b. Press and release SINGL SWP pushbutton.

c. Remove the test signal cable from CH 1 input.

d. Press and release SINGL SWP pushbutton.

e. CHECK—That READY light turns on.

f. Return the test signal cable to CH 1 input.

g. CHECK—That READY light is extinguished.

h. Press and release SINGL SWP pushbutton.

i. CHECK—For a single-sweep display (1 sweep only).

j. Set TRIG MODE to AUTO.

19. Check TRIG VIEW Operation

a. Move signal cable from CH 1 input to A TRIGGER external input and set A TRIGGER SOURCE to EXT.

b. Set the amplitude calibrator for a 200 millivolt output.

c. Press TRIG VIEW and hold it in.

d. Position the waveform for a maximum amplitude display with A TRIGGER LEVEL control.

e. CHECK—For approximately 4 divisions of display.

f. Release TRIG VIEW.

g. Disconnect all test equipment.

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NOTE

DM44 DIGITAL MULTIMETERS

FOR OSCILLOSCOPES WITH DIGITAL MULTIMETERS ATTACHED, REFER TO THE DIGITAL MULTIMETER MANUAL AT THIS POINT. CONTINUE WITH 475A DM44 HORIZONTAL SYSTEM PERFORMANCE CHECK, THEN RETURN TO **GATE OUTPUTS, EXTERNAL Z-AXIS AND CALIBRATOR CHECKS** *SECTION IN THIS PERFORMANCE CHECK PROCEDURE.*

FOR OSCILLOSCOPES WITHOUT DIGITAL MULTIMETERS, CONTINUE WITH **HORIZONTAL SYSTEM CHECK.**

HORIZONTAL SYSTEM CHECK

Equipment Required

1. Time-Mark Generator
2. Sine-Wave Generator
3. Amplitude Calibrator
4. 500 MHz Filter
5. 42-inch 50-Ohm BNC Cable (2 required)
6. 50-Ohm BNC Termination (2 required)
7. 10X Probe (see Table 5-1, 10X Probe examples)

Control Settings

POWER	ON

Display

INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	**0.5 V (new setting)**
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 OR 20 MHz BW	Full bandwidth (push in, then release)

Trigger (A and B)

COUPLING	AC
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	**NORM (new setting)**
B TRIGGER SOURCE	**STARTS AFTER DELAY (new setting)**
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

Sweep

A TIME/DIV	1 ms
B TIME/DIV	1 ms
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

20. Check VAR TIME/DIV Range

a. Set the time-mark generator for 5 millisecond time marks and connect through a 42-inch 50-ohm BNC cable, to a 50-ohm BNC termination, to CH 1 input.

b. Set A TRIGGER LEVEL for a stable triggered display, then set VAR TIME/DIV fully counterclockwise.

c. CHECK—That VAR TIME/DIV UNCAL light is illuminated.

d. CHECK—For at least 6 time marks between first and last graticule lines.

e. Return VAR TIME/DIV control to calibrated detent.

21. Check Sweep Length and Horizontal POSITION Range

a. Set time-mark generator for 1 millisecond time marks.

b. CHECK—Sweep length for approximately 10.1 divisions.

c. Turn POSITION and FINE (Horiz) controls fully clockwise. (Also check that each control will position the trace.)

d. CHECK—That the start of sweep is to the right of graticule center.

e. Turn POSITION and FINE (Horiz) controls fully counterclockwise.

f. CHECK—That the end of sweep is to the left of graticule center.

g. Recenter POSITION and FINE (Horiz) controls.

22. Check A Timing Accuracy

a. Set TIME/DIV to 0.01 μs, set the time-mark generator for 10 nanosecond time marks, set TRIG MODE to NORM, and set A TRIGGER LEVEL for a stable triggered display.

NOTE

Unless otherwise stated, set POSITION and FINE (Horiz) controls so first time mark will coincide with first graticule line and check that a time mark will coincide with last vertical graticule line.

b. CHECK—TIME/DIV settings from 0.01 μs to 5 ms/division for accuracy, at first and 11th graticule lines, within 1%, from +20° C to +30° C; within 3%, from −15° C to +55° C.

NOTE

Turn INTENSITY full on, note the start of sweep and exclude the first 25 nanoseconds from start of sweep when checking 0.01 and 0.02 μs/division. Set time-mark generator, as necessary, to provide 1 or more time marks/division as each TIME/DIV setting is selected, throughout the horizontal check procedure.

c. CHECK—TIME/DIV settings from 10 ms to 0.5 s/division for accuracy, at first and 11th graticule lines, within 2%, from +20° C to +30° C; within 3%, from −15° C to +55° C.

23. Check A INTEN Timing Accuracy

a. Set HORIZ DISPLAY to A INTEN, set TIME/DIV to 0.05 μs and set time-mark generator for 50 nanosecond time marks (DELAY TIME POSITION should be fully counterclockwise).

b. CHECK—TIME/DIV settings from 0.05 μs to 0.5 s/division for accuracy, at first and 11th graticule lines, within 2%, from +20° C to +30° C; within 3%, from −15° C to +55° C.

24. Check A INTEN Magnified Timing Accuracy

a. Set TIME/DIV to 0.05 μs, set time-mark generator for 5 nanosecond time marks and press X10 MAG to on.

b. CHECK—TIME/DIV settings from 0.05 μs to 0.5 s/division for accuracy, at first and 11th graticule lines, within 3%, from +20° C to +30° C; within 4%, from −15° C to +55° C (see following note).

NOTE

Turn INTENSITY fully on, note the start of sweep and exclude the first 25 nanoseconds from start of sweep or first 2 major unblanked divisions at normal intensity (whichever is greater) and all beyond the 100th division.

25. Check A Magnified Timing Accuracy

a. Set TIME/DIV to 0.01 μs, set A TRIGGER SOURCE to EXT and set A TRIGGER COUPLING to LF REJ.

b. Set the time-mark generator for 2 nanosecond time marks and connect trigger output through a 42-inch 50-ohm BNC cable, to a 50-ohm BNC termination, to A TRIGGER external input (if a 2901 time-mark generator is used, set trigger selector for 0.1 microsecond triggers).

Insert a 500 megahertz filter between the 50-ohm BNC termination and CH 1 input. Adjust the filter for minimum unwanted modulation from the time mark generator, as necessary, whenever 2 or 5 nanosecond time marks are used in this step.

c. Set CH 1 VOLTS/DIV to maintain a convenient display amplitude and set A TRIGGER LEVEL for a stable display. (It may be necessary to adjust A TRIGGER HOLDOFF for best triggered display through this step).

d. CHECK—TIME/DIV settings from 0.01 to 0.05 μs/division for accuracy, at first and 11th graticule lines, within 2%, from + 20°C to +30°C; within 4%, from −15°C to +55°C.

e. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval at all TIME/DIV settings (see following note).

NOTE

If waveform has modulation, check 2 division accuracy between adjacent time marks of equal amplitude.

Turn INTENSITY full on, note the start of sweep and exclude the first 25 nanoseconds from start of sweep or first 2 major unblanked divisions at normal intensity (whichever is greater) and all beyond the 100th division.

f. Remove the trigger cable setup from A TRIGGER external input, set A TRIGGER SOURCE to NORM and set A TRIGGER COUPLING to AC. Remove the 500 megahertz filter.

g. Set TIME/DIV to 0.1 μs, set time-mark generator for 0.1 microsecond time marks and set CH 1 VOLTS/DIV to maintain a convenient display amplitude.

h. CHECK—TIME/DIV settings from 0.1 μs to 5 ms/division for accuracy, at first and 11th graticule lines, within 2%, from +20°C to +30°C, within 4%, from −15°C to +55°C.

26. Check Differential Delay Time Accuracy

a. Set HORIZ DISPLAY to B DLY'D and set TIME/DIV to 0.05 μs. Pull and unlock DLY'D SWP knob, set to 0.01 μs and set X10 MAG to off.

b. Set time-mark generator for 50 nanosecond time marks.

c. Turn DELAY TIME POSITION to set time mark nearest 1.000 on dial to coincide with graticule center and note reading.

d. Turn DELAY TIME POSITION to set time mark nearest 2.000 on dial to coincide with graticule center and note reading.

e. CHECK—For a difference in readings of 1.000, within 0.010, from +15°C to +35°C; within 0.020, from −15°C to +55°C.

f. Turn DELAY TIME POSITION to set every adjacent time-mark to coincide with graticule center and note reading.

g. CHECK—Each reading between any 2 adjacent time-marks for 1.000, within 0.010, from +15°C to +35°C; within 0.020, from −15°C to +55°C. Also, check the difference between any time marks separated by more than 1 major dial division not to exceed maximum error as listed in Table 5-3.

TABLE 5-3
Differential Delay Time Accuracy

Difference in Major Dial Divisions	Maximum Error +15°C to +35°C	Maximum Error −15°C to +55°C
1.000	±0.010	±0.020
2.000	±0.019	±0.029
3.000	±0.027	±0.042
4.000	±0.033	±0.053
5.000	±0.039	±0.064
6.000	±0.043	±0.073
7.000	±0.047	±0.082
8.000	±0.049	±0.089
9.000	±0.050	±0.095

h. CHECK—Display time accuracy as directed in part g, at all settings listed in Table 5-4 not to exceed maximum error listed in Table 5-3.

TABLE 5-4
Delay Time Settings

DELAY TIME POSITION Exclusions	A TIME/DIV Switch Setting	B TIME/DIV Switch Setting	[1]Time-Mark Generator Setting
Exclude dial settings of 0.000 through 1.000	0.05 μs	0.01 μs	50 nanosecond
	0.1 μs	0.01 μs	0.1 microsecond
	0.2 μs	0.02 μs	0.2 microsecond
	0.5 μs	0.05 μs	0.5 microsecond
Exclude dial settings of 0.000 through 0.050	1 μs	0.1 μs	1 microsecond
	2 μs	0.2 μs	2 microsecond
	5 μs	0.5 μs	5 microsecond
	10 μs	1 μs	10 microsecond
	20 μs	2 μs	20 microsecond
	50 μs	5 μs	50 microsecond
	0.1 ms	10 μs	0.1 millisecond
	0.2 ms	20 μs	0.2 millisecond
	0.5 ms	50 μs	0.5 millisecond
	1 ms	0.1 ms	1 millisecond
	2 ms	0.2 ms	2 millisecond
	5 ms	0.5 ms	5 millisecond
	10 ms	1 ms	10 millisecond
	20 ms	2 ms	20 millisecond
	50 ms	5 ms	50 millisecond
	0.1 s	10 ms	0.1 second
	0.2 s	20 ms	0.2 second
	0.5 s	50 ms	0.5 second

[1]If the time-mark generator being used does not have a 1-2-5 sequence, set for 1 or more time marks/division on DELAY TIME POSITION dial.

27. Check Delay Time Jitter

a. Set DLY'D SWP to 0.2 μs, set A TIME/DIV to 1 ms and set time-mark generator for 1 millisecond time marks.

b. Set DELAY TIME POSITION to 1.000 on dial and position nearest time-mark to graticule center.

c. CHECK—That jitter on the leading edge of the time mark does not exceed 1 division (60 Hertz line) or 2.5 division (50 Hertz line).

d. Set DELAY TIME POSITION to view each time-mark from 2.000 to 9.000 on dial and check delay time jitter for limits stated in part c.

28. Check MIX (Mixed Sweep) Timing Accuracy

a. Set DLY'D SWP to 0.02 μs, A TIME/DIV to 0.05 μs, HORIZ DISPLAY to MIX and DELAY TIME POSITION fully clockwise.

b. Set time-mark generator for 50 nanosecond time-marks.

c. CHECK—A TIME/DIV settings from 0.02 μs to 0.5 s/division for accuracy at 2nd and 10th graticule lines (8 division timing), within 3%. Exclude the first 0.5 division from start of sweep when checking A sweep. Set DLY'D SWP at least 1 sweep setting faster than A sweep setting on all ranges. Set time-mark generator to maintain appropriate time marks.

d. Set DELAY TIME POSITION fully counterclockwise, DLY'D SWP to 0.05 μs, A TIME/DIV to 0.1 μs and set time-mark generator for 50 nanosecond time marks.

e. CHECK—DLY'D SWP settings from 0.05 μs to 0.5 s/division for accuracy at 2nd and 10th graticule lines (8 division timing), within 3%. Exclude the first 0.2 division or 0.1 microsecond (whichever is greater) after the transition of A to B. Set DLY'D SWP at least 1 sweep setting faster than A sweep setting on all ranges. Set time-mark generator to maintain appropriate time marks.

f. Disconnect all test equipment.

29. Check X Gain

a. Set TRIG MODE to AUTO, set DLY'D SWP to lock knobs, set TIME/DIV to X-Y, set VERT MODE to CH 2 and set X (CH 1) VOLTS/DIV to 10 mV.

b. Set amplitude calibrator to 50 millivolts and connect to X (CH 1) input through a 42-inch 50-ohm BNC cable.

c. Set X (CH 1) and Y (CH 2) POSITION controls to set the 2-dot display at graticule center.

d. CHECK—The deflection between the 2 displayed dots for 5 divisions within 3%.

e. Disconnect all test equipment.

30. Check X Bandwidth

NOTE

See test equipment required, Table 5-1, for selection of sine-wave generator with an output of 100 megahertz and below.

a. Connect the sine-wave generator output cable to a 50-ohm termination, to X input.

b. Set the sine-wave generator for a 4 division horizontal display of reference frequency.

c. Increase the frequency of the sine-wave generator until the display is reduced to 2.8 divisions.

d. CHECK—The sine-wave generator for a reading of 3 megahertz or higher.

e. Disconnect all test equipment.

GATE OUTPUTS, EXTERNAL Z-AXIS AND CALIBRATOR CHECKS

Equipment Required

1. Amplitude Calibrator
2. 42-Inch 50-ohm BNC Cable (2 required)
3. 50-Ohm BNC Termination
4. 10X Probe (see Table 5-1, 10X Probe examples)

Control Settings

POWER	ON

Display

INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	**2 V (new setting)**
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	**CH 1 (new setting)**
100 OR 20 MHz BW	**20 (new setting)**

Trigger (A and B)

COUPLING	AC
LEVEL	**Fully clockwise (new setting)**
SLOPE	+
A TRIGGER SOURCE	NORM
B TRIGGER SOURCE	STARTS AFTER DELAY
TRIG MODE	AUTO
A TRIG HOLDOFF	NORM

Sweep

A TIME/DIV	**10 μs (new setting)**
B TIME/DIV	**10 μs (new setting)**
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	**A INTEN (new setting)**
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

31. Check A and B +GATE Outputs

a. Connect A +GATE (output connector on rear panel) to CH 1 input through a 42-inch 50-ohm BNC cable.

b. CHECK—The display for a positive pulse amplitude of approximately 5 volts (it may be necessary to increase INTENSITY to view leading edge of positive pulse).

c. Move cable from A +GATE to B +GATE (output connectors on rear panel).

d. CHECK—Repeat part b.

e. Disconnect the cable between B +GATE and CH 1 connectors.

32. Check CH 2 VERT SIGNAL OUT

a. Set HORIZ DISPLAY to A, set TIME/DIV to 0.5 ms, set CH 1 VOLTS/DIV to 0.1 V and set CH 2 VOLTS/DIV to 5 mV.

b. Set VERT MODE to CHOP, set CH 1 and CH 2 POSITION controls for 2 traces superimposed on center horizontal graticule line, then set VERT MODE to CH 1.

c. Connect CH 2 VERT SIGNAL OUT (output connector on rear panel) to CH 1 input through a 42-inch 50-ohm BNC cable.

d. Set amplitude calibrator for a 20 millivolt output and connect to CH 2 input through a 42-inch 50-ohm BNC cable.

e. Set A TRIGGER LEVEL for a stable triggered display.

f. CHECK—The square-wave display for approximately 1 division of amplitude with the bottom of waveform near center horizontal graticule line.

g. Set CH 1 VOLTS/DIV to 50 mV and insert a 50-ohm termination between CH 1 input and the connected BNC cable.

h. CHECK—Repeat part f.

i. Disconnect all test equipment.

33. Check EXT Z-AXIS Operation

a. Set amplitude calibrator for a 5 volt output and connect to EXT Z-AXIS (input connector on rear panel) through a 42-inch 50-ohm BNC cable.

b. CHECK—For noticeable modulation at normal intensity. Adjust VAR TIME/DIV, if necessary to observe modulation, then return to calibrated detent.

c. Disconnect all test equipment.

34. Check CALIBRATOR Operation

a. Set CH 1 VOLTS/DIV to 10 mV and set TIME/DIV to 1 ms.

b. Connect a 10X probe with a scale-factor switching connector between CH 1 input and CALIBRATOR current loop.

NOTE

Use a probe listed in test equipment required, Table 5-1, under 10X Probe examples.

c. CHECK—The square-wave display for 3 divisions of amplitude and for approximately 1 cycle/division.

d. Disconnect all test equipment.

This completes the performance check procedure for the 475A. If the instrument has met all performance requirements given in this procedure, it is currently calibrated and within specifications.

CALIBRATION

IMPORTANT—PLEASE READ BEFORE USING THIS PROCEDURE

Introduction

The following procedure returns the 475A to correct calibration. All limits and tolerances given in this procedure are calibration guides and should not be interpreted as instrument specifications except as specified in the performance requirements portion of the Specifications section in this Service manual.

Calibration Interval

To ensure instrument accuracy, check the calibration of the 475A every 1000 hours of operation, or every 6 months if used infrequently. Before complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section of this manual.

Tektronix Field Service

Tektronix, Inc. provides complete instrument repair and recalibration at local Field Service Centers and at the Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

Using This Procedure

Outline. To aid in locating a step in the Calibration procedure, an outline is given preceding the Calibration procedure.

Calibration Procedure. Completion of each step in the Calibration procedure ensures that this instrument meets the electrical specifications given in the first section of this manual. Where possible, instrument performance is checked before an adjustment is made. For best overall instrument performance when performing a complete calibration procedure, make each adjustment to the exact setting, even if the CHECK— is within the allowable tolerance. It will be necessary to remove the cabinet in order to have full access to the internal adjustments and test points.

Partial Procedures. A partial check or adjustment is often desirable after replacing components or to touch up the adjustment of a portion of the instrument between major recalibrations. To check or adjust only part of the instrument, set the controls as given under the nearest preceding Control Settings and use the Equipment Required list preceding the desired portion of the procedure. To prevent unnecessary recalibration of other parts of the instrument, readjust only if the tolerance given in the CHECK— part of the step is not met. If readjustment is necessary, also check any steps listed in the INTERACTION— part of the step.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories, or its equivalent, is required for complete calibration of the 475A. Specifications given for the test equipment are the minimum necessary for accurate calibration. Therefore, some of the specifications listed here may differ from the actual performance capabilities of the test equipment. All test equipment is assumed to be correctly calibrated and operating within the listed specifications. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is needed.

Special Calibration Fixtures

Special Tektronix calibration fixtures are used only where they facilitate instrument calibration. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Calibration Equipment Alternatives

All of the listed test equipment is required to completely check and calibrate this instrument. However, complete checking or calibration may not always be necessary or desirable. The user may be satisfied with checking only selected characteristics, thereby reducing the amount of test equipment actually required.

The equipment listed in the Calibration procedure is based on the first item of equipment given as an example of applicable equipment. When other equipment is substituted, control settings or calibration setup may need to be altered to meet the requirements of the substitute equipment. If the exact item of test equipment given as an example in the Test Equipment list is not availble, first check the Specifications column carefully to see if any other equipment is available which might suffice. Then check the Usage column to see what this item is used for. If used for a check or adjustment that is of little or no importance to your measurement requirements, the item and corresponding step(s) can be deleted.

TABLE 6-1

Test Equipment Required For Calibration

Description	Minimum Specifications	Usage	Examples
1. Variable Auto-transformer.	Capable of supplying 1.2 amperes over a range of 103.5 to 126.5 volts.	Low-voltage power supply checks.	a. General Radio W8MT3VM Variac Autotransformer.
2. Digital Voltmeter	Range, 0 to 150 volts; dc voltage accuracy, within 0.15%; display, 4 1/2 digits.	Low-voltage power supply checks and adjustments; CRT grid bias check; Vertical and horizontal centering adjustments; Calibrator output voltage adjustment.	a. Tektronix DM 501 Digital Multimeter.[1] b. Any digital voltmeter that meets minimum specifications.
3. DC Voltmeter	Range, 0 to 2500 volts; calibrated to 1% accuracy at 2450 volts.	High-voltage power supply check.	a. Triplett Model 630—NA. b. Simpson Model 262.
4. Test Oscilloscope system with 10X probes.	Bandwidth, DC to 100 megahertz; minimum deflection factor, 5 mV/division; accuracy, within 3%; dual trace.	CRT Z-Axis compensation; Vertical 2 mV gain adjustment; A Trigger Hold-off check; High-speed timing adjustment; A and B +Gate output signals check.	a. Tektronix 465 Oscilloscope with 2 10X probes (included). b. Tektronix 475A Oscilloscope with 2 10X probes (included).
5. Amplitude Calibrator	Amplitude accuracy, within 0.25%; signal amplitude, 2 millivolts to 20 volts; output signal, 1 kilohertz square wave.	Vertical checks and adjustments; Trigger View gain check; X gain adjustment; External Z-Axis check.	a. Tektronix PG 506 Calibration Generator.[1] b. Tektronix 067-0502-01 calibration fixture.
6. Sine-Wave Generator	Frequency, 350 kilohertz to above 250 megahertz; output amplitude, variable from 15 millivolts to 4 volts peak-to-peak; output impedance, 50 ohms; reference frequency, 50 to 350 kilohertz; amplitude accuracy, constant within 3% of reference frequency as output frequency changes.	Vertical centering, bandwidth and isolation checks; Trigger checks and adjustments; X bandwidth check.	a. Tektronix SG 503 Leveled Sine-Wave Generator.[1] (use for all frequencies.) b. Tektronix Type 191 Constant-Amplitude Signal Generator. (use at frequencies of 100 megahertz and below). AND Wavetek Model 1001A (use only for checking 200 megahertz bandwidth and triggering.)

[1]**Requires a TM 500-Series Power Module.**

TABLE 6-1 (cont)

Description	Minimum Specifications	Usage	Examples
7. Time-Mark Generator	Marker outputs, 2 nanoseconds to 0.5 second; marker accuracy, within 0.1%; trigger output, 1 millisecond to 0.1 microsecond, time coincident with markers.	CRT Y-Axis and geometry adjustments; Auto trigger check; Horizontal timing checks and adjustments.	a. Tektronix TG 501 Time-Mark Generator.[1] b. Tektronix 2901 Time-Mark Generator.
8. Low-Frequency Generator	Frequency, 10 Hertz to 50 kilohertz; output amplitude, variable from 10 millivolts to 4 volts peak-to-peak.	Low-Frequency trigger checks.	a. Tektronix SG 502 Oscillator.[1] b. General Radio 1310B Oscillator with a binding post to BNC adapter.
9. Square-Wave Generator	Repetition rate, 1 kHz to 100 kHz; risetime, 1 nanosecond or less from fast-rise output; output amplitude at least 60 volt pulse supplying at least 11 milliamperes from high-amplitude output; aberrations, within 2% from fast-rise output.	Vertical Systems compensation adjustments.	a. Tektronix PG 506[1]. b. Tektronix Type 106 Square-Wave Generator.
10. Tunnel Diode Pulser	Output amplitude, approximately 200 millivolts into 50 ohms; risetime, approximately 100 picoseconds into 50 ohms; aberrations less than 1% into 50 ohms.	Driven by PG 506 or Type 106 for Vertical transient response checks and adjustments; Trigger View risetime and delay checks.	a. Tektronix Tunnel Diode Pulser calibration fixture. Part Number 067-0681-01.
11. 50-Ohm Signal Pickoff	Frequency response, 50 kilohertz to 875 megahertz; impedance, 50 ohms for signal input, signal output and trigger output.	Trigger checks and adjustments.	a. Tektronix CT-3 Signal Pickoff. Part Number 017-0061-00.
12. Current Probe	Sensitivity, 1 milliampere/millivolt; bandwidth, 8.5 kilohertz to 100 megahertz.	Used for major recalibration of Horizontal High-Speed Timing.	a. Tektronix P6022 AC Current Probe with Passive Termination.
13. Cable (2 required)	Impedance, 50 ohms; length, 42 inches; connectors, BNC.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 012-0057-01.
14. Cable (2 required)	Impedance, 50 ohms; length 18 inches; connectors, BNC.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 012-0076-00.
15. Adapter	Connectors, GR874 to BNC Female.	Vertical compensation adjustments. Trigger adjustments.	a. Tektronix Part Number 017-0063-00.

[1]**Requires a TM 500-Series Power Module.**

TABLE 6-1 (cont)

Description	Minimum Specifications	Usage	Examples
16. Adapter	Connectors, GR874 to BNC Male.	Used in Trigger adjustment procedure for signal interconnection.	a. Tektronix Part Number 017-0064-00.
17. Adapter	Connectors, BNC Female to BNC Female.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 103-0028-00.
18. Elbow Adapter	Connectors, BNC Male to BNC Female.	Used in Trigger system procedure for signal interconnection.	a. Tektronix Part Number 103-0031-00.
19. T-Connector	Connectors, BNC.	Used throughout procedure for signal interconnection.	a. Tektronix Part Number 103-0030-00.
20. 10X Attenuator	Ratio, 10X; impedance, 50 ohms; connectors, BNC.	Vertical System compensation adjustments. Vertical bandwidth check. Trigger adjustments.	a. Tektronix Part Number 011-0059-02.
21. 5X Attenuator	Ratio, 5X; impedance, 50 ohms; connectors, BNC.	Vertical System compensation adjustments. Trigger adjustments.	a. Tektronix Part Number 011-0060-02.
22. 2X Attenuator	Ratio, 2X; impedance, 50 ohms; connectors, BNC.	Vertical System compensation adjustments.	a. Tektronix Part Number 011-0069-02.
23. Termination (2 required)	Impedance, 50 ohms; connectors, BNC.	Used throughout procedure for proper signal termination.	a. Tektronix Part Number 011-0049-01.
24. 500 MHz Filter	Impedance, 50 ohms; frequency, adjustable; connectors, BNC.	Used for High-Speed Timing checks and adjustments.	a. Tektronix 500 MHz Filter calibration fixture. Part Number 067-0684-00.
25. Screwdriver	Length, three-inch shaft; bit size 3/32 inch.	Used throughout procedure to adjust variable resistors.	a. Xcelite R-3323.
26. Low-Capacitance Screwdriver	Length; approximately 4 inches; bit size 3/32 inch.	Used throughout procedure to adjust all variable capacitors.	a. J.F.D. Electronics Adjustment Tool Number 5284.
27. Adapter	Connectors, BNC male to miniature probe tip.	Used for Vertical System compensation adjustments.	a. Tektronix Part Number 013-0084-01.

OUTLINE FOR CALIBRATION PROCEDURE

PRELIMINARY PROCEDURE FOR CALIBRATION

Operating Voltage

Before applying power to the instrument, check that the line voltage selector and the regulating range selector are in the correct positions for the line voltage the instrument will be operated on.

Cabinet Removal

Remove the cabinet from the instrument as outlined in the Maintenance section of this manual. Also, remove the vertical output circuit board cover from the top of main chassis. This will allow access to vertical output adjustments.

WARNING

Power should not be applied to the instrument when cleaning or replacing parts. When the instrument is operated with the cabinet removed, do not touch exposed connections or components. High voltage exists at several points and transistors may have elevated cases throughout the instrument.

Power Source

Connect the 475A through the autotransformer to a power source that meets the voltage and frequency requirements of this instrument.

Warm Up

Turn on the 475A, set the autotransformer output voltage to the center of the voltage range selected by the line voltage selector and allow at least 20 minutes warm up before starting the calibration procedure.

Operating Temperature

This instrument should be calibrated at an ambient temperature of +20° C to +30° C for best overall accuracy. This instrument can be calibrated within environmental limits listed in the Specifications section of this manual to approximate the expected environmental usage.

Step Titles

Each procedure step is preceded by a number and each procedure part is set in alphabetical order. Steps containing adjustments and checks are titled (Adjust) steps; steps containing only checks are titled (Check) steps. Where possible, the performance requirement is checked before an adjustment is made. If a check meets its requirements, it is not necessary to make the related adjustment.

POWER SUPPLY

Equipment Required

1. Variable Autotransformer
2. Digital Voltmeter
3. DC Voltmeter
4. Screwdriver

Before you begin, see **ADJUSTMENT LOCATIONS 1** *in the pullout pages.*

Control Settings

POWER	ON

Display

INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	10 mV
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 OR 20 MHz BW	20

Trigger (A and B)

COUPLING	AC
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	NORM
B TRIGGER SOURCE	STARTS AFTER DELAY
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

Sweep

A TIME/DIV	1 ms
B TIME/DIV	1 ms
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

1. Adjust Power Supply DC Levels

a. Connect the digital voltmeter between test points listed in Table 6-2 and ground on main interface board. See ADJUSTMENT LOCATIONS 1.

TABLE 6-2

Power Supply Accuracy

Power Supply	Test Point	Tolerance	Reading
+50 volt	+50 V	0.5%	+49.75 to +50.25
+15 volt	+15 V	1.5%	+14.77 to +15.23
−15 volt	−15 V	1.5%	−14.77 to −15.23
+5 volt	+5 V	1.5%	+4.92 to +5.08
−8 volt	−8 V	1.5%	−7.88 to −8.12
+110 volt	+110 V	3%	+106.7 to +113.3

NOTE

If +50 volt supply is within specified tolerance, proceed with part c. If +50 volt adjustment is to be made, the accuracy of all circuits will be affected. The entire calibration procedure should be performed to verify instrument performance.

b. ADJUST—+50 volt supply. R1430, for +50 volts within 50 millivolts. See ADJUSTMENT LOCATIONS 1.

c. Decrease line voltage with the variable autotransformer until the LOW LINE indicator light starts to blink.

d. CHECK—The variable autotransformer ac voltmeter for approximately 104 volts ac or less.

e. Return the variable autotransformer to 115 volts ac.

2. Check High Voltage Power Supply

a. Set the POWER switch to off.

b. Connect the dc voltmeter positive lead to ground and connect negative leads to TP2450. See ADJUSTMENT LOCATIONS 1.

c. Set the POWER switch to ON.

d. CHECK—For a reading of −2450 volts within 49 volts.

e. Set the POWER switch to off and disconnect the dc voltmeter. Return the POWER switch to ON.

DISPLAY AND Z AXIS

Equipment Required

1. Digital Voltmeter
2. Amplitude Calibrator
3. Time-Mark Generator
4. Test Oscilloscope With 10X Probe
5. 42-Inch 50-Ohm BNC Cable
6. 50-Ohm BNC Termination
7. Screwdriver
8. Low-Capacitance Screwdriver

Before you begin, see **ADJUSTMENT LOCATIONS 1** *in the pullout pages.*

Control Settings

POWER	ON

Display

INTENSITY	**Fully counterclockwise (new setting)**
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	10 mV
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 OR 20 MHz BW	20

Trigger (A and B)

COUPLING	AC
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	NORM
B TRIGGER SOURCE	STARTS AFTER DELAY
TRIG MODE	**SINGL SWP (new setting)**
A TRIGGER HOLDOFF	NORM

Sweep

A TIME/DIV	1 ms
B TIME/DIV	1 ms
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

3. Adjust CRT Grid Bias

a. Connect the digital voltmeter between TP1364 and ground. See ADJUSTMENT LOCATIONS 1.

b. Set INTENSITY control for a reading of +15 volts.

c. CHECK—The display for a well-defined spot of low intensity near left vertical graticule line. Adjust FOCUS and POSITION (Horiz) if necessary.

d. ADJUST—CRT Grid Bias, R1375, for the dimmest, visible spot. See ADJUSTMENT LOCATIONS 1.

e. Turn CH 1 POSITION, FOCUS and INTENSITY controls fully clockwise.

f. CHECK—For a reading of +20 volts to +30 volts.

g. Press BEAM FINDER pushbutton.

h. CHECK—For a reading of approximately +25 volts.

i. Release BEAM FINDER pushbutton and disconnect all test equipment.

j. Set INTENSITY, FOCUS and CH 1 POSITION controls to midrange. Set TRIG MODE to AUTO.

k. Adjust FOCUS and INTENSITY controls for a well-defined trace of normal intensity.

4. Check Display Controls

a. Turn the INTENSITY control from fully counterclockwise to fully clockwise and return to normal intensity.

b. CHECK—For trace intensity to increase smoothly from minimum to maximum intensity.

c. Turn the FOCUS control through its range and return to focused trace.

d. CHECK—For trace defocus at each extreme position of the FOCUS control.

e. Turn ASTIG control (front panel screwdriver adjustment) through its range.

f. CHECK—For control of trace focus.

g. Set the amplitude calibrator for a 20 millivolt output and connect to CH 1 through a 42-inch 50-ohm BNC cable.

h. Adjust A TRIGGER LEVEL for a stable display.

i. ADJUST—FOCUS and ASTIG controls for well-defined front corners on the displayed waveform.

j. Turn INTENSITY control fully counterclockwise and press BEAM FINDER pushbutton.

k. CHECK—For a compressed waveform of normal intensity.

l. Release BEAM FINDER pushbutton, return INTENSITY to a normal setting and disconnect all test equipment.

m. Turn the SCALE ILLUM control through its range.

n. CHECK—For a smooth increase in illumination.

o. Position the trace to the center horizontal graticule line.

p. CHECK—That the trace is aligned with the center horizontal graticule line.

q. ADJUST—TRACE ROTATION (front panel screwdriver adjustment) to align the trace with the center horizontal graticule line.

5. Adjust CRT Y-Axis Alignment

a. Connect 1 millisecond time marks from the time-mark generator through a 42-inch 50-ohm BNC cable and a 50-ohm termination to the CH 1 input.

b. Set CH 1 VOLTS/DIV to 50 mV. Position the display baseline below crt viewing area.

c. Adjust A TRIGGER LEVEL, FOCUS and INTENSITY controls for a well-defined, stable display.

d. Adjust the TIME/DIV and VAR TIME/DIV controls for exactly 1 time mark/division with coincidence of time marks on each major vertical graticule line.

e. CHECK—For no more than 0.1 division of tilt when comparing the center time mark to the center vertical graticule line.

f. ADJUST —Y-Axis Alignment, R1385, to align the center time mark with the center vertical graticule line. See ADJUSTMENT LOCATIONS 1.

g. INTERACTION—Between Y-Axis Alignment and TRACE ROTATION adjustment. Repeat both adjustments for best display.

6. Adjust Geometry

a. CHECK—The display for no more than 0.1 division of vertical bowing of the time marks at left and right edges of the graticule.

b. ADJUST—Geometry, R1390, for minimum bowing of the time marks at left and right edges of the graticule. See ADJUSTMENT LOCATIONS 1.

c. INTERACTION—Between Geometry adjustment and Y-Axis Alignment. Repeat both adjustments for best display.

d. Remove the time-mark signal cable and 50-ohm termination from CH 1 input. Return VAR TIME/DIV to calibrated detent.

e. CHECK—For no more than 0.1 division of trace curvature when trace is positioned to the top and bottom graticule lines.

7. Adjust Z-Axis Compensation

NOTE

Any reference to 475A through the calibration procedure refers to the instrument under calibration.

a. Connect a 10X probe from the test oscilloscope to the 475A Z-Axis fast-rise test point, TP1366. See ADJUSTMENT LOCATIONS 1.

b. Connect a 42-inch 50-ohm BNC cable from the test oscilloscope external trigger input to the 475A A +GATE output connector (on rear panel) and set the 475A TIME/DIV to 0.05 μs.

c. Set test oscilloscope: time/division to 0.2 microsecond, volts/division to 0.2, trigger source to external and adjust trigger level to view the positive step of the Z-Axis waveform.

d. Adjust 475A INTENSITY for a positive step amplitude of 1 volt (5 divisions) on test oscilloscope display. See Figure 6-1.

e. CHECK—For a flat-top waveform in the first 20 nanoseconds from front corner. See Figure 6-1.

f. ADJUST—Z-Axis Compensation, C1352, using a low-capacitance screwdriver, for the best flat-top waveform in the first 20 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 1.

g. Disconnect all test equipment.

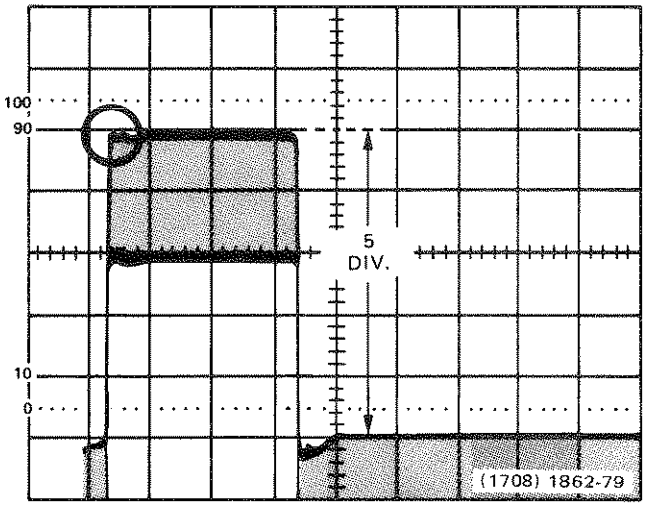

Fig. 6-1. Typical display when Z-Axis Compensation is properly adjusted. Circle surrounds compensated portion of waveform.

VERTICAL SYSTEM

Equipment Required

1. Sine-Wave Generator
2. Digital Voltmeter
3. Amplitude Calibrator
4. Square-Wave Generator
5. Test Oscilloscope With 10X Probes
6. Tunnel-Diode Pulser Calibration Fixture
7. GR-To-BNC Female Adapter
8. BNC Female-To-BNC Female Adapter
9. BNC T-Connector
10. 42-Inch 50-Ohm BNC Cable (2 required)
11. 18-Inch 50-Ohm BNC Cable (2 required)
12. 10X BNC Attenuator
13. 5X BNC Attenuator
14. 50-Ohm BNC Termination (2 required)
15. Screwdriver
16. Low-Capacitance Screwdriver
17. BNC Male-to-Probe tip adapter

Before you begin, see **ADJUSTMENT LOCATIONS 1&2** *in the pullout pages.*

Control Settings

POWER	ON

Display

INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	**10 mV (new setting)**
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 OR 20 MHz BW	20

Trigger (A and B)

COUPLING	AC
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	NORM
B TRIGGER SOURCE	STARTS AFTER DELAY
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

Sweep

A TIME/DIV	**1 ms (new setting)**
B TIME/DIV	**1 ms (new setting)**
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

8. Adjust Vertical Output Bias

a. Set the amplitude calibrator for a 20 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

b. ADJUST—Vertical Output Bias, R488, for maximum amplitude of the display. See ADJUSTMENT LOCATIONS 2-B.

c. Disconnect all test equipment.

9. Adjust Vertical Shield Voltage

a. Measure the voltage on each vertical deflection plate with the digital voltmeter. (Take readings at the terminals of the ceramic thick-film resistor mounted near the Vertical Output circuit board.) See ADJUSTMENT LOCATIONS 2-B.

b. While measuring voltage level at the resistor terminals (approximately +34 volts), check the display for a trace and note the voltage on each deflection plate.

NOTE

If trace disappears during voltage measurement, the vertical output circuitry is oscillating with the measuring equipment. To stop the oscillation, connect a small 1,000-ohm resistor between the positive lead of the digital voltmeter and the point being measured.

c. Adjust CH 1 POSITION control for equal voltage on both vertical deflection plates and note the final reading.

d. Remove the 1,000-ohm resistor if used, and connect the digital voltmeter positive lead to TP1395. See ADJUSTMENT LOCATIONS 1.

e. CHECK—For a reading within 0.5 volts of final reading noted in part c.

f. ADJUST—Vertical Shield Volts, R1395, for a reading equal to the final reading noted in part c. See ADJUSTMENT LOCATIONS 1.

NOTE

The preceding procedure is intended to initially set the vertical shield voltage. If the best crt focus is required, readjust Vertical Shield Volts, R1395, FOCUS and ASTIG together for best overall focus.

g. Disconnect all test equipment.

10. Adjust Delay-Line DC Center

a. Connect the digital voltmeter across the delay-line end pins on the vertical preamp circuit board. See ADJUSTMENT LOCATIONS 2-A.

b. Adjust the CH 1 POSITION control for a reading of 0 volts.

c. Connect the digital voltmeter between chassis ground and one of the delay-line end pins.

d. CHECK—For a reading of 0 volts.

e. ADJUST—Delay-Line DC Centering, R385, for a reading of 0 volts. See ADJUSTMENT LOCATIONS 2-A.

f. Disconnect all test equipment.

11. Adjust CH 1 VAR VOLTS/DIV Balance

a. Set CH 1 POSITION for a trace on the center horizontal graticule line.

@

b. CHECK—That the CH 1 UNCAL light turns on when the CH 1 VAR VOLTS/DIV control is out of calibrated detent.

c. CHECK—The display for 2 divisions or less of trace shift when turning the CH 1 VAR VOLTS/DIV control through its range.

d. ADJUST—CH 1 Variable Balance, R110, for minimum shift when turning the CH 1 VAR VOLTS/DIV control through its range. See ADJUSTMENT LOCATIONS 2-A.

e. Return CH 1 VAR VOLTS/DIV control to calibrated detent.

12. Adjust CH 1 VOLTS/DIV Balance

a. CHECK—The display for 0.5 division or less of trace shift when switching CH 1 VOLTS/DIV from 10 mV to 5 mV.

b. ADJUST—CH 1 VOLTS/DIV Balance, R135, for minimum trace shift when switching CH 1 VOLTS/DIV from 10 mV to 5 mV. See ADJUSTMENT LOCATIONS 2-A.

13. Adjust CH 2 VAR VOLTS/DIV Balance

a. Set VERT MODE to CH 2, set CH 2 VOLTS/DIV to 10 mV and adjust CH 2 POSITION for a trace on the center horizontal graticule line.

b. CHECK—That the CH 2 UNCAL light turns on when the CH 2 VAR VOLTS/DIV control is out of calibrated detent.

c. CHECK—The display for 2 divisions or less of trace shift when turning the CH 2 VAR VOLTS/DIV control through its range.

d. ADJUST—CH 2 Variable Balance, R210, for minimum trace shift when turning the CH 2 VAR VOLTS/DIV control through its range. See ADJUSTMENT LOCATIONS 2-A.

e. Return the CH 2 VAR VOLTS/DIV control to calibrated detent.

14. Adjust CH 2 VOLTS/DIV Balance

a. CHECK—The display for 0.5 division or less of trace shift when switching CH 2 VOLTS/DIV from 10 mV to 5 mV.

b. ADJUST—CH 2 VOLTS/DIV Balance, R235, for minimum trace shift when switching CH 2 VOLTS/DIV from 10 mV to 5 mV. See ADJUSTMENT LOCATIONS 2-A.

15. Adjust CH 2 INVERT Balance

a. Set CH 2 VOLTS/DIV to 10 mV and adjust CH 2 POSITION for a trace on the center horizontal graticule line.

b. CHECK—The display for 1 division or less of trace shift when INVERT pushbutton is pressed from normal to inverted.

c. ADJUST—Invert Balance, R215, for minimum trace shift when INVERT pushbutton is pressed from normal to inverted. See ADJUSTMENT LOCATIONS 2-A.

d. Return INVERT pushbutton to normal (button out).

16. Adjust CH 2 POSITION Centering

a. Set CH 2 VOLTS/DIV to 20 mV and set AC-GND-DC switch to AC.

NOTE

See test equipment required, Table 6-1, for selection of sine-wave generator with an output of 100 megahertz and below.

b. Connect the sine-wave generator output cable through a 50-ohm termination to CH 2 input.

c. Set the sine-wave generator for a 6 division, 350-kilohertz display, then set CH 2 VOLTS/DIV to 5 mV.

d. CHECK—That top of display can be positioned at least to the center horizontal graticule line and that bottom of display can be positioned at least to the center horizontal graticule line.

e. ADJUST—CH 2 Position Centering, R276, so the top and bottom of display can be positioned through the center horizontal graticule line an equal amount. See ADJUSTMENT LOCATIONS 2-A.

17. Adjust CH 1 Position Centering

a. Set VERT MODE to CH 1, set CH 1 VOLTS/DIV to 20 mV and AC-GND-DC switch to AC.

b. Move test signal cable to CH 1 input.

c. Set the sine-wave generator for a 6 division display, then set CH 1 VOLTS/DIV to 10 mV.

d. CHECK—That top of display can be positioned at least to the center horizontal graticule line and that bottom of display can be positioned at least to the center horizontal graticule line.

e. ADJUST—CH 1 Position Centering, R176, so the top and bottom of display can be positioned through the center horizontal graticule line an equal amount. See ADJUSTMENT LOCATIONS 2-A.

f. Disconnect all test equipment.

18. Check CH 1 and CH 2 AC-GND-DC Functions

a. Set CH 1 and CH 2 AC-GND-DC switches to DC, set amplitude calibrator for a 20 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

b. Position the bottom of CH 1 display to the center horizontal graticule line.

c. Set CH 1 AC-GND-DC switch to GND.

d. CHECK—For no vertical deflection and that trace is at center horizontal graticule line.

e. Set CH 1 AC-GND-DC switch to AC.

f. CHECK—That display is centered in graticule area.

g. Move test signal cable to CH 2 input and set VERT MODE to CH 2.

h. Position the bottom of CH 2 display to the center horizontal graticule line.

i. Set CH 2 AC-GND-DC switch to GND.

j. CHECK—For no vertical deflection and that trace is at center horizontal graticule line.

k. Set CH 2 AC-GND-DC switch to AC.

l. CHECK—That display is centered in graticule area.

m. Disconnect all test equipment.

19. Check Scale-Factor Indicator Lights

a. CHECK—That the light under 10 mV of CH 2 VOLTS/DIV knob is on.

b. Connect a 10X probe with a scale-factor switching connector to CH 2 input.

NOTE

Use a probe listed in test equipment required, Table 6-1, under test oscilloscope examples.

c. CHECK—That the light under 10 mV is extinguished and the light under .1 V comes on.

d. Set VERT MODE to CH 1.

e. CHECK—That the light under 10 mV of CH 1 VOLTS/DIV knob is on.

f. Move the 10X probe to CH 1 input.

g. CHECK—That the light under 10 mV is extinguished and the light under .1 V comes on.

h. Remove the 10X probe.

20. Adjust CH 1 Gain and Vertical Output Gain

a. Set VERT MODE to CH 1, set CH 1 VOLTS/DIV to 5 mV and set CH 1 AC-GND-DC switch to DC.

b. Set the amplitude calibrator for a 20 millivolt output and connect to CH 1 input through a 42-inch 50-ohm BNC cable.

c. Set the test oscilloscope: time/div to 1 millisecond, both volts/div to 10 millivolts, vertical mode to add, Channel 2 to invert and trigger source to normal.

d. Connect both 10X probes from the test oscilloscope to the delay-line end pins on the Vertical Preamp circuit board. See ADJUSTMENT LOCATIONS 2-A.

e. ADJUST—CH 1 5 mV Gain, R195, for 200 millivolts peak-to-peak (4 divisions of display) on the test oscilloscope. See ADJUSTMENT LOCATIONS 2-A.

f. Disconnect the 10X probes from delay line.

g. ADJUST—Vertical Output Gain, R449, for exactly 4 divisions of amplitude. See ADJUSTMENT LOCATIONS 2-B.

h. Set CH 1 VOLTS/DIV to 10 mV and set the amplitude calibrator for a 50 millivolt output.

i. ADJUST—CH 1 10 mV Gain, R165, for exactly 5 divisions of amplitude. See ADJUSTMENT LOCATIONS 2-A.

j. CHECK—All settings of CH 1 VOLTS/DIV for accuracy, within 3%, using the settings listed in Table 6-3.

TABLE 6-3

Vertical Deflection Accuracy

VOLTS/DIV Switch Setting	Amplitude Calibrator Output	Vertical Deflection in Divisions	Maximum Error for 3% Accuracy
5 mV	20 millivolts	4	Previously set
10 mV	50 millivolts	5	Previously set
20 mV	0.1 volts	5	±0.15 div
50 mV	0.2 volts	4	±0.12 div
0.1 V	0.5 volts	5	±0.15 div
0.2 V	1 volts	5	±0.15 div
0.5 V	2 volts	4	±0.12 div
1 V	5 volts	5	±0.15 div
2 V	10 volts	5	±0.15 div
5 V	20 volts	4	±0.12 div
10 V	50 volts	5	±0.15 div

21. Adjust CH 2 Gain

a. Set VERT MODE to CH 2, set CH 2 VOLTS/DIV to 5 mV and set CH 2 AC-GND-DC switch to DC.

b. Set the amplitude calibrator for a 20 millivolt output and move signal cable to CH 2 input.

c. ADJUST—CH 2, 5 mV Gain, R295, for exactly 4 divisions of amplitude. See ADJUSTMENT LOCATIONS 2-A.

d. Set CH 2 VOLTS/DIV to 10 mV and set the amplitude calibrator for a 50 millivolt output.

e. ADJUST—CH 2, 10 mV Gain, R265, for exactly 5 divisions of amplitude. See ADJUSTMENT LOCATIONS 2-A.

f. Press CH 2 INVERT pushbutton to invert CH 2 display.

g. CHECK—That inverted gain is equal to normal gain within 1% (0.04 division).

h. Return CH 2 INVERT pushbutton to normal (button out).

i. CHECK—All settings of CH 2 VOLTS/DIV for accuracy within 3% using the settings listed in Table 6-3.

22. Check CH 1 and CH 2 VAR VOLTS/DIV Range

a. Set the amplitude calibrator to 50 millivolts and set CH 1 and CH 2 VOLTS/DIV to 10 mV.

b. Turn CH 2 VAR VOLTS/DIV fully counterclockwise.

c. CHECK—That display reduces to less than 2 divisions of amplitude.

d. Return CH 2 VAR VOLTS/DIV to calibrated detent.

e. Set VERT MODE to CH 1 and move signal cable to CH 1 input.

f. Turn CH 1 VAR VOLTS/DIV fully counterclockwise.

g. CHECK—That display reduces to less than 2 divisions of amplitude.

h. Return CH 1 VAR VOLTS/DIV to calibrated detent.

23. Check ADD Mode Operation

a. Set VERT MODE to ADD and set CH 1 and CH 2 VOLTS/DIV to 10 mV.

b. Remove the test signal cable from CH 1 input. Connect to the cable; a BNC female-to-BNC female adapter, a BNC T-connector, two 18-inch 50-ohm BNC cables, then the CH 1 and CH 2 inputs.

c. Set the amplitude calibrator for a 20 millivolt output and center display on graticule using equal settings of CH 1 and CH 2 POSITION controls.

d. CHECK—For a display of 4 divisions within 3% (0.12 division).

e. Remove the test signal cables.

24. Check Compression and Expansion

a. Set VERT MODE to CH 1.

b. Connect 20 millivolts of output from amplitude calibrator to CH 1 input through a 42-inch 50-ohm BNC cable and note exact amplitude of the display at graticule center.

c. Position top of display to the top graticule line.

d. CHECK—The display for 0.1 division or less of compression or expansion.

e. Position bottom of display to the bottom graticule line.

f. CHECK—The display for 0.1 division or less of compression or expansion.

g. Move the test signal cable to CH 2 input, set VERT MODE to CH 2 and note exact amplitude of the 2 division display at graticule center.

h. Position top of display to the top graticule line.

i. CHECK—The display for 0.1 division or less of compression or expansion.

j. Position bottom of display to the bottom graticule line.

k. CHECK—The display for 0.1 division or less of compression or expansion.

25. Check Cascaded Gain

a. Set VERT MODE to CH 1 and set CH 1 and CH 2 VOLTS/DIV to 5 mV.

b. Set the amplitude calibrator for an output of 10 millivolts into CH 2 input.

c. Connect a 42-inch 50-ohm BNC cable from CH 2 VERT SIGNAL OUT (on rear panel), through a 50-ohm termination to CH 1 input.

d. CHECK—For a display of 4 divisions within 1 division.

e. Disconnect all test equipment.

26. Check ALT Mode Operation

a. Set VERT MODE to ALT, set 100 OR 20 MHz BW control to full bandwidth position and set A TRIGGER LEVEL fully clockwise.

b. Position the 2 traces approximately 4 divisions apart.

c. CHECK—That the sweeps alternate at all settings of TIME/DIV except X-Y.

27. Check CHOP Mode Operation

a. Set VERT MODE to CHOP, set TIME/DIV to 1 μs, set CH 1 and CH 2 AC-GND-DC switches to GND and adjust A TRIGGER LEVEL for a stable display.

b. CHECK—For complete blanking of switching transients between chopped segments.

c. CHECK—That the duration of one cycle is approximately 1 division.

28. Adjust High-Frequency Compensation

a. Set CH 1 and CH 2 VOLTS/DIV to 10 mV, set VERT MODE to CH 1, set TIME/DIV to 20 μs and set CH 1 and CH 2 AC-GND-DC switches to DC.

b. Connect the square-wave generator fast-rise + output through a GR-to-BNC female adapter, to a 42-inch 50-ohm BNC cable, to a 10X BNC attenuator, to a 50-ohm termination, to CH 1 input.

c. Set the square-wave generator for a 5 division, 10 kilohertz display.

d. CHECK—The display for a flat-top waveform within +4%, −4%, or a total of 4% aberrations.

e. ADJUST—R109 for the best flat-top waveform in the first 20 microseconds from front corner. See ADJUSTMENT LOCATIONS 2-A.

f. ADJUST—R494B for the best flat-top waveform in the first 15 microseconds (approximately) from front corner. See ADJUSTMENT LOCATIONS 2-B.

NOTE

R494B is a factory optional component and may not appear in your instrument.

g. Set TIME/DIV to 10 μs.

h. ADJUST—R139 for a flat-top waveform in the first 5 microseconds from front corner. See ADJUSTMENT LOCATIONS 2-A.

i. Set TIME/DIV to 5 μs.

j. ADJUST—R475 for a flat-top waveform in the first 2 microseconds from front corner. See ADJUSTMENT LOCATIONS 2-B.

k. Set the square-wave generator repetition rate to 100 kilohertz.

l. Set TIME/DIV to 0.5 μs.

m. CHECK—The display for a flat-top waveform within +4%, −4%, or a total of 4% aberrations.

n. ADJUST—C471, for a flat-top waveform in the first 200 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 2-B.

o. Set TIME/DIV to 0.1 μs.

p. ADJUST—C477 for a flat-top waveform in the first 50 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 2-B.

q. Set VERT MODE to CH 2, set TIME/DIV to 20 μs, and move test signal from CH 1 input to CH 2 input.

r. Adjust the square-wave generator for a 5 division, 10 kilohertz display.

s. CHECK—The display for a flat-top waveform within +4%, −4%, or a total of 4% aberrations.

t. ADJUST—R209 for the best flat-top waveform in the first 20 microseconds from front corner. See ADJUSTMENT LOCATIONS 2-A.

u. Set TIME/DIV to 10 μs.

v. ADJUST—R239 for a flat-top waveform in the first 5 microseconds from front corner. See ADJUSTMENT LOCATIONS 2-A.

w. Set TIME/DIV to 5 μs.

x. ADJUST—R475 for the best flat-top waveform in both CH 1 and CH 2 in the first 2 microseconds from front corner. See ADJUSTMENT LOCATIONS 2-B.

y. Set the square-wave generator repetition rate to 100 kilohertz.

z. Set TIME/DIV to 0.5 μs.

aa. CHECK—The display for a flat-top waveform within +4%, −4%, or a total of 4% aberrations.

ab. ADJUST—C471 for the best flat-top waveform in both CH 1 and CH 2 in the first 200 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 2-B.

ac. Set TIME/DIV to 0.1 μs.

ad. ADJUST—C477 for the best flat-top waveform in both CH 1 and CH 2 in the first 50 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 2-B.

ae. Repeat parts u through ad if necessary for the best flat-top waveform in both CH 1 and CH 2.

af. Disconnect all test equipment.

29. Adjust CH 1 VOLTS/DIV Compensation

NOTE

C10, in the CH 1 Preamp, is set at the factory to give C50, in the CH 2 Preamp, enough range to match CH 2 input capacitance with CH 1 input capacitance. Unless there is a circuit malfunction, C10 should not need readjustment.

a. Set VERT MODE to CH 1, TIME/DIV to 0.2 ms and 100 or 20 MHz BW control to 20.

b. Connect a 10X probe to the CH 1 input.

c. Connect the square-wave generator high-amplitude output through a GR to BNC female adapter, to a 5X BNC attenuator, to a 50 Ω BNC termination, to a BNC-to-probetip adapter, to the tip of the 10X probe.

d. Adjust the square-wave generator for a 5 division, 1 kilohertz display and add or remove attenuators as needed to maintain a 5 division display throughout steps 29 and 30.

e. Adjust the probe compensation adjustment for the best flat-top waveform. Do not readjust probe compensation throughout the remainder of steps 29 and 30.

f. Set CH 1 VOLTS/DIV to 5 mV.

g. CHECK—The display for a flat-top waveform within 2%.

h. Set CH 1 VOLTS/DIV to 20 mV.

i. CHECK—The display for a flat-top waveform within 2%.

j. ADJUST—C36 and C37 in Channel 1 for the best flat-top waveform.

k. Set CH 1 VOLTS/DIV to 50 mV.

l. CHECK—The display for a flat-top waveform within 2%.

m. ADJUST—C34 and C35 in Channel 1 for the best flat-top waveform.

n. Set CH 1 VOLTS/DIV to .1 V.

o. CHECK—The display for a flat-top waveform within 2%.

p. ADJUST—C32 and C33 in Channel 1 for the best flat-top waveform.

q. Set CH 1 VOLTS/DIV to .2 V.

r. CHECK—The display for a flat-top waveform within 2%.

s. Set CH 1 VOLTS/DIV to .5 V.

t. CHECK—The display for a flat-top waveform within 2%.

u. Set CH 1 VOLTS/DIV to 1 V.

v. CHECK—The display for a flat-top waveform within 2%.

w. ADJUST—C30 and C31 in Channel 1 for the best flat-top waveform.

x. CHECK—The display in the 1 V, 2 V and 5 V positions of CH 1 VOLTS/DIV for a flat-top waveform within 2%.

30. Adjust CH 2 VOLTS/DIV Compensation

a. Set VERT MODE to CH 2, assemble the test signal setup as called for in part 29-b and connect to CH 2 input.

b. Adjust the square-wave generator for a 5 division, 1 kilohertz display and add or remove attenuators as necessary to maintain a 5 division display throughout this step.

c. CHECK—The display for a flat-top waveform within 2%.

d. ADJUST—C50 in Channel 2 for the best flat-top waveform using a low-capacitance screwdriver. See ADJUSTMENT LOCATIONS 2-A.

e. Set CH 2 VOLTS/DIV to 5 mV.

f. CHECK—The display for a flat-top waveform within 2%.

g. Set CH 2 VOLTS/DIV to 20 mV.

h. CHECK—The display for a flat-top waveform within 2%.

i. ADJUST—C36 and C37 in Channel 2 for the best flat-top waveform.

j. Set CH 2 VOLTS/DIV to 50 mV.

k. CHECK—The display for a flat-top waveform within 2%.

l. ADJUST—C34 and C35 in Channel 2 for the best flat-top waveform.

m. Set CH 2 VOLTS/DIV to .1 V.

n. CHECK—The display for a flat-top waveform within 2%.

o. ADJUST—C32 and C33 in Channel 2 for the best flat-top waveform.

p. Set CH 2 VOLTS/DIV to .2 V.

q. CHECK—The display for a flat-top waveform within 2%.

r. Set CH 2 VOLTS/DIV to .5 V.

s. CHECK—The display for a flat-top waveform within 2%.

t. Set CH 2 VOLTS/DIV to 1 V.

u. CHECK—The display for a flat-top waveform within 2%.

v. ADJUST—C30 and C31 in Channel 2 for the best flat-top waveform.

w. CHECK—The display in the 1 V, 2 V and 5 V positions of CH 2 VOLTS/DIV for a flat-top waveform within 2%.

x. Disconnect all test equipment.

31. Adjust Vertical Transient Response

a. Set CH 1 and CH 2 VOLTS/DIV to 10 mV, set VERT MODE to CH 1 and TIME/DIV to 0.01 μs and set 100 OR 20 MHz BW control to full bandwidth position.

b. Connect a 100 kilohertz signal from the square-wave generator high amplitude output through a GR-to-BNC female adapter and a 42-inch 50-ohm BNC cable to the input of the tunnel diode pulser calibration fixture. Connect the output of the tunnel diode pulser through a 5X BNC attenuator and a 50-ohm termination to the CH 1 input.

c. Increase the square-wave generator amplitude and adjust the pulser triggered level until the display suddenly increases to about 4.6 divisions of amplitude; do not overdrive. Use the resultant positive-step amplitude to check or adjust vertical response. Keep VAR VOLTS/DIV in calibrated detent.

d. CHECK—The display for flat-top and aberrations within +4%, −4%, or a total of 4% in the first 10 nanoseconds from front corner.

e. ADJUST—R450, C450, R470, C470, R175, C175, R112, C112, R466, C466, R133 and C133 for a flat-top waveform and aberrations within 4%, in the first 20 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 2. Use the low capacitance screwdriver to adjust variable capacitors.

NOTE

The following part f, is intended as a guide to return a greatly misadjusted vertical to proper calibration.

f. CALIBRATION AID—Set R450 for minimum resistance (fully counterclockwise). Adjust C450 for minimum aberrations with a fast leading edge. Set R470 near maximum resistance (near clockwise stop). Adjust C470 for the best flat-top display, 5 to 10 nanoseconds from front corner. Set R175 near maximum resistance (near clockwise stop). Adjust C175 for the best flat-top display 10 to 20 nanoseconds from front corner. Set R112 near minimum resistance (near counterclockwise stop). Adjust C112 for uniform aberrations. Adjust R466, C466, R133 and C133 for best aberrations and flat-top display. Adjust C450 for a fast leading edge and best response.

g. INTERACTION—All transient response adjustments interact in this step. Repeat the adjustment procedure in part e, as necessary to obtain optimum response.

h. Set CH 1 VOLTS/DIV to 50 mV and remove the 5X attenuator from the test signal setup. Note the slope, if slope exists, in the first 2 nanoseconds from the front corner.

i. ADJUST—C104 for the same slope between the 10 mV and 50 mV positions of the CH 1 VOLTS/DIV in the first 2 nanoseconds from the front corner. See ADJUSTMENT LOCATIONS 2-A.

j. Set CH 1 VOLTS to 10 mV and replace the 5X attenuator in the test-signal setup.

k. ADJUST—C175 for a flat-top waveform in the first 2 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 2-A.

l. Set VERT MODE to CH 2 and move test signal setup to CH 2 input.

m. CHECK—The display for flat-top and aberrations within +4%, −4%, or a total of 4% in the first 10 nanoseconds from front corner.

n. ADJUST—R275, C275, R212, C212, R233 and C233 for a flat-top waveform and aberrations within 4%, in the first 20 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 2-A.

o. CALIBRATION AID—Set R275 near maximum resistance (near clockwise stop). Adjust C275 for the best flat-top display, 10 to 20 nanoseconds from front corner. Set R212 near minimum resistance (near counterclockwise stop). Adjust C212 for uniform aberrations. Adjust R233 and C233 for the best aberrations and flat-top display.

p. INTERACTION—All transient response adjustments interact in this step. Repeat part n, as necessary, to obtain optimum response.

q. CALIBRATION AID—It may be necessary to readjust R450, C450, R470, C470, R466 and C466 for a flat-top display and aberrations within 4% in both CH 1 and CH 2. Readjust as necessary, using part f calibration aid.

r. Set CH 2 VOLTS/DIV to 50 mV and remove the 5X attenuator in the test-signal setup. Note the slope, if slope exists, in the first 2 nanoseconds from the front corner.

s. ADJUST—C204 for the same slope between 10 mV and 50 mV positions of CH 2 VOLTS/DIV in the first 2 nanoseconds from the front corner. See ADJUSTMENT LOCATIONS 2-A.

t. Set CH 2 VOLTS/DIV to 10 mV and replace the 5X attenuator in the test-signal setup.

u. ADJUST—C275 for a flat-top waveform in the first 2 nanoseconds from front corner. See ADJUSTMENT LOCATIONS 2-A.

v. Disconnect all test equipment.

32. Check Vertical Amplifier Bandwidth

a. Set CH 1 and CH 2 VOLTS/DIV to 10 mV, set VERT MODE to CH 1 and TIME/DIV to 0.5 ms.

NOTE

See test equipment required, Table 6-1, for selection of sine-wave generator with a 250 megahertz output.

b. Connect the sine-wave generator output cable to a 5X BNC attenuator, to a 50 ohm termination, to CH 1 input.

c. Set the sine-wave generator for a 6 division display of reference frequency.

NOTE

If generator has no reference frequency setting, set for 5 megahertz. If generator being used is other than the generators listed in Test Equipment required, Table 6-1, more attenuation may be needed to reduce amplitude.

d. Increase frequency until the display is reduced to 4.2 divisions.

e. CHECK—For a reading of 250 megahertz or more.

f. Set VERT MODE to CH 2 and move test signal setup to CH 2 input.

g. Repeat the bandwidth check procedure, parts c, d and e.

33. Check Bandwidth Limit Operation

a. Set 100 OR 20 MHz BW control to 100.

NOTE

It may be necessary to change sine-wave generators. See Table 6-1 for selection of generator with an output of 100 megahertz and below.

b. Set the sine-wave generator for a 6 division display of reference frequency.

c. Increase frequency until the display is reduced to 4.2 divisions.

d. CHECK—For a reading of approximately 100 megahertz.

e. Set 100 OR 20 MHz BW control to 20.

f. Set the sine-wave generator for a 6 division display of reference frequency.

g. Increase frequency until the display is reduced to 4.2 divisions.

h. CHECK—For a reading of approximately 20 megahertz.

i. Return 100 OR 20 MHz BW control to full bandwidth.

34. Check Cascaded Bandwidth

a. Set VERT MODE to CH 1.

b. Connect CH 2 VERT SIGNAL OUT (output connector on rear panel) through a 42-inch 50-ohm BNC cable, to a 50-ohm termination and connect to CH 1 input.

c. Set the sine-wave generator for a 6 division display of reference frequency.

d. Increase frequency until the display is reduced to 4.2 divisions.

e. CHECK—For a reading of 50 megahertz or more.

f. Disconnect cable and termination from CH 2 VERT SIGNAL OUT and CH 1 input. Remove 5X attenuator from test signal setup.

35. Check Vertical Channel Isolation

a. Set CH 2 VOLTS/DIV to 0.2 V and CH 1 AC-GND-DC switch to GND.

b. Set the sine-wave generator for a 4 division, 50 megahertz display.

c. Set CH 1 and CH 2 VOLTS/DIV to 20 mV and set VERT MODE to CH 1.

d. CHECK—The display amplitude for 0.4 division or less.

e. Set CH 1 AC-GND-DC switch to DC, set CH 2 AC-GND-DC switch to GND and set VERT MODE to CH 2.

f. Move test signal setup to CH 1.

g. CHECK—The display amplitude for 0.4 division or less.

h. Disconnect all test equipment.

TRIGGER SYSTEM

Equipment Required

1. Sine-Wave Generator
2. Low-Frequency Generator
3. Amplitude Calibrator
4. Square-Wave Generator
5. Time-Mark Generator
6. Tunnel-Diode Pulser Calibration Fixture
7. 50-Ohm Signal Pickoff
8. 42-Inch 50-Ohm BNC Cable
9. 18-Inch 50-Ohm BNC Cable (2 required)
10. GR-To-BNC Female Adapter
11. GR-To-BNC Male Adapter
12. BNC Female-To-BNC Female Adapter
13. BNC Elbow
14. BNC T-Connector
15. 10X BNC Attenuator
16. 5X BNC Attenuator
17. 50-Ohm BNC Termination (2 required)
18. Screwdriver

Before you begin, see **ADJUSTMENT LOCATIONS 2&3** *in the pullout pages.*

Control Settings

POWER	ON

Display

INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	**10 mV (new setting)**
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	**DC (new setting)**
INVERT	Off (button out)
VERT MODE	**CH 1 (new setting)**
100 OR 20 MHz BW	Full bandwidth (push in, then release)

Trigger (A and B)

COUPLING	AC
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	**EXT (new setting)**
B TRIGGER SOURCE	STARTS AFTER DELAY
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

Sweep

A TIME/DIV	**2 μs (new setting)**
B TIME/DIV	**2 μs (new setting)**
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

36. Adjust A Trigger Sensitivity, Symmetry and Centering

NOTE

See test equipment required, Table 6-1, for selection of sine-wave generator with an output of 100 megahertz and below.

a. Connect the sine-wave generator output cable through a GR-to-BNC female adapter to the through signal input of the 50-ohm signal pickoff. Connect the through signal output of the signal pickoff to a GR-to-BNC male adapter, to a 10X BNC attenuator, to a 50-ohm BNC termination, to a BNC elbow, to A TRIGGER external input.

b. Connect the 10% signal output of the signal pickoff to an 18-inch 50-ohm BNC cable, to a 50-ohm termination, to CH 1 input.

c. Set the sine-wave generator for a 3.5 division, 350 kilohertz display. (35 millivolts at external input).

d. Set CH 1 VOLTS/DIV to 20 mV and position the display start to graticule center with POSITION (Horiz).

e. Turn A TRIGGER LEVEL slowly counterclockwise through the range of stable triggering and note maximum amplitude of positive slope before the first peak of displayed waveform. See Figure 6-2.

f. CHECK—The triggered display for an amplitude of 0 to 0.2 division of positive slope before the first peak of displayed waveform when turning A TRIGGER LEVEL slowly counterclockwise through the range of stable triggering. See Figure 6-2.

NOTE

The preceding check is for calibration purposes only, if unable to obtain a proper display (as described in part f), check trigger operation as directed in performance check section to determine if trigger sensitivity needs adjustment.

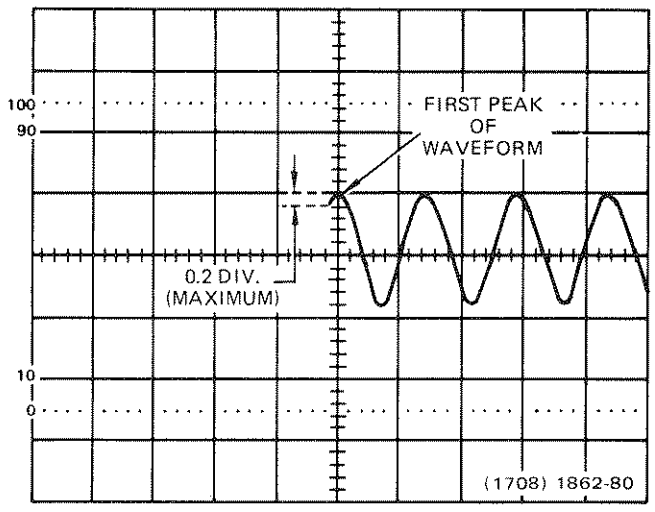

Fig. 6-2. Typical display when checking Trigger Sensitivity.

g. ADJUST—A Trigger Sensitivity, R565, for a maximum amplitude of 0.2 division of positive slope before the first peak of displayed waveform when turning A TRIGGER LEVEL slowly counterclockwise through the range of stable triggering. See ADJUSTMENT LOCATIONS 3.

h. Set CH 1 VOLTS/DIV to 50 mV.

i. Set the sine-wave generator for a 4 division, 350 kilohertz display (200 millivolts at external input) and center the display on center horizontal graticule line.

j. Set A TRIGGER SLOPE to − and set A TRIGGER LEVEL for a triggered display.

NOTE

The following parts k, l and m require that a short circuit be placed between the 2 terminals at the rear of A TRIGGER SLOPE/LEVEL control. (A short circuit allows viewing of + and − slope without disturbing A TRIGGER LEVEL. Any convenient way of shorting the terminals may be used; screwdriver tip, alligator clip, etc).

k. Note where the display starts on first negative slope, short together the rear terminals of A TRIGGER SLOPE/LEVEL control and note where the display starts on first positive slope.

l. CHECK—For a 0.5 division of overlap to 2 divisions of space between the start of negative slope and the start of positive slope. See Figure 6-3.

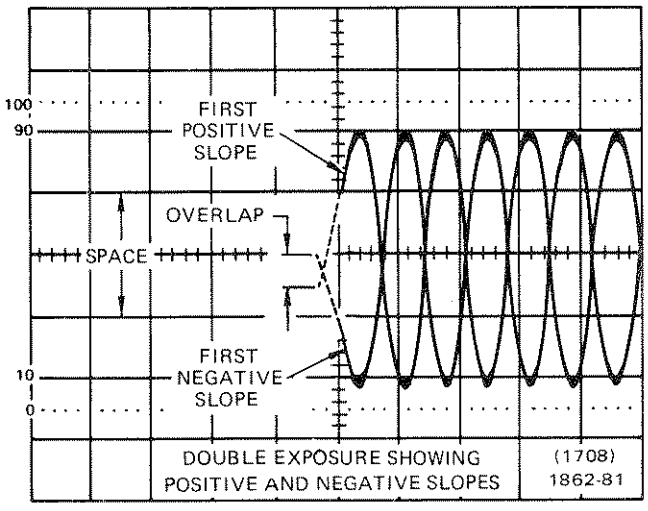

Fig. 6-3. Typical display when checking Trigger Symmetry.

m. ADJUST—A Trigger Symmetry, R547, for 0.7 division of space between the start of negative slope and the start of positive slope. (Apply and remove the short circuit between the terminals several times while making adjustment.) See ADJUSTMENT LOCATIONS 3.

n. Set CH 1 VOLTS/DIV to 0.5 V, set A TRIGGER SLOPE to +, set A TRIGGER SOURCE to NORM and set A TRIGGER LEVEL for a stable triggered display.

o. CHECK—TRIG light for an on indication.

p. CHECK—That A TRIGGER LEVEL knob index is approximately aligned with 0 on front panel.

NOTE

If A TRIGGER LEVEL knob index is aligned with 0, preceed with part s.

q. Set A TRIGGER LEVEL knob index to 0.

r. ADJUST—A Trigger Centering, R534, for a stable triggered display. See ADJUSTMENT LOCATIONS 3.

s. INTERACTION—Between A Trigger Sensitivity, A Trigger Symmetry and A Trigger Centering adjustments. Repeat the adjustments as necessary.

37. Adjust B Trigger Sensitivity, Symmetry and Centering

a. Disconnect the test signal setup from A TRIGGER external input and connect to B TRIGGER external input.

b. Set CH 1 VOLTS/DIV to 10 mV, set B TRIGGER SOURCE to EXT and set HORIZ DISPLAY to B DLY'D.

c. Set the sine-wave generator for a 3.5 division, 350 kilohertz display (35 millivolts at external input), then set CH 1 VOLTS/DIV to 20 mV.

d. Turn B TRIGGER LEVEL slowly counterclockwise through the range of stable triggering and note maximum amplitude of positive slope before the first peak of displayed waveform. See Figure 6-2.

e. CHECK—The triggered display for a full length sweep and for an amplitude of 0 to 0.2 division of positive slope before the first peak of displayed waveform when turning B TRIGGER LEVEL slowly counterclockwise through the range of stable triggering. See Figure 6-2.

NOTE

The preceding check is for calibration purposes only. If unable to obtain a proper display (as described in part e), check trigger operation as directed in performance check section to determine if trigger sensitivity needs adjustment.

f. ADJUST—B Trigger Sensitivity, R785, for a maximum amplitude of 0.2 division of positive slope before the first peak of displayed waveform and for a full length sweep, when turning B TRIGGER LEVEL slowly counterclockwise through the range of stable triggering. See ADJUSTMENT LOCATIONS 3.

g. Set CH 1 VOLTS/DIV to 50 mV.

h. Set the sine-wave generator for a 4 division, 350 kilohertz display (200 millivolts at external input) and center the display on center horizontal graticule line.

i. Set B TRIGGER SLOPE to − and set B TRIGGER LEVEL for a triggered display.

NOTE

The following parts j, k and l require that a short circuit be placed between the 2 terminals at the rear of B TRIGGER SLOPE/LEVEL control. (A short circuit allows viewing of + and − slope without disturbing B TRIGGER LEVEL. Any convenient way of shorting the terminals may be used; screwdriver tip, alligator clip, etc.).

j. Note where the display starts on first negative slope, short together the rear terminals of B TRIGGER SLOPE/LEVEL control and note where the display starts on first positive slope.

k. CHECK—For 0.5 division of overlap to 2 divisions of space between the start of negative slope and the start of positive slope. See Figure 6-3.

l. ADJUST—B Trigger Symmetry, R767, for 0.7 division of space between the start of negative slope and the start of positive slope. (Apply and remove the short circuit between the terminals several times while making adjustment.) See ADJUSTMENT LOCATIONS 3.

m. Set CH 1 VOLTS/DIV to 0.5 V, set B TRIGGER SLOPE to +, set B TRIGGER SOURCE to NORM and set B TRIGGER LEVEL for a stable triggered display.

n. CHECK—That B TRIGGER LEVEL knob index is approximately aligned with 0 on front panel.

NOTE

If B TRIGGER LEVEL knob index is aligned with 0, proceed with part q.

o. Set B TRIGGER LEVEL knob index to 0.

p. ADJUST—B Trigger Centering, R745, for a stable triggered display. See ADJUSTMENT LOCATIONS 3.

q. INTERACTION—Between B Trigger Sensitivity, B Trigger Symmetry and B Trigger Centering adjustments. Repeat the adjustments as necessary.

38. Adjust A Trigger DC Centering

a. Set HORIZ DISPLAY to A, set A TRIGGER SOURCE to NORM, set A TRIGGER COUPLING to DC and set A TRIGGER LEVEL to 0.

b. Set CH 1 POSITION to obtain a stable triggered display.

c. CHECK—That entire display is within the graticule area.

d. Set the display to graticule center with CH 1 POSITION.

e. ADJUST—Normal Trigger DC Centering, R425, for a stable triggered display. See ADJUSTMENT LOCATIONS 2-A.

f. Set A TRIGGER SOURCE to CH 1.

g. Set CH 1 POSITION to obtain a stable triggered display.

h. CHECK—That entire display is within the graticule area.

i. Set the display to graticule center with CH 1 POSITION.

j. ADJUST—Channel 1 DC Trigger Centering, R403, for a stable triggered display. See ADJUSTMENT LOCATIONS 2-A.

k. Set VERT MODE to CH 2, set A TRIGGER SOURCE to CH 2, set CH 2 VOLTS/DIV to 0.5 V and move test signal setup from CH 1 input to CH 2 input.

l. Set CH 2 POSITION to obtain a stable triggered display.

m. CHECK—That display is within the graticule area.

39. Check B Trigger DC Centering

a. Set HORIZ DISPLAY to B DLY'D, set B TRIGGER SOURCE to NORM, set B TRIGGER COUPLING to DC and set B TRIGGER LEVEL to 0.

b. Set CH 2 POSITION to obtain a stable triggered display.

c. CHECK—That entire display is within the graticule area.

d. Set B TRIGGER SOURCE to CH 2.

e. Set CH 2 POSITION to obtain a stable triggered display.

f. CHECK—That entire display is within the graticule area.

g. Set VERT MODE to CH 1, set B TRIGGER SOURCE to CH 1 and move test signal setup from CH 2 input to CH 1 input.

h. Set CH 1 POSITION to obtain a stable triggered display.

i. CHECK—That entire display is within the graticule area.

40. Check B Internal 40 Megahertz Triggering

a. Set TIME/DIV to 0.05 μs, set CH 1 VOLTS/DIV to 5 mV, set A and B TRIGGER SOURCE to NORM and set A and B TRIGGER COUPLING to AC.

b. Move test signal setup from B TRIGGER external input to CH 2 input.

c. Set the sine-wave generator for a 3 division, 40 megahertz display.

d. Set CH 1 and CH 2 VOLTS/DIV to 50 mV and move the display to graticule center with CH 1 POSITION.

e. Set VERT MODE to CH 2 and move the display to graticule center with CH 2 POSITION.

f. Return VERT MODE to CH 1.

g. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

h. Return B TRIGGER COUPLING to AC.

i. CHECK—That a stable triggered display can be obtained in NORM, CH 1 and CH 2 positions of B TRIGGER SOURCE with adjustment of B TRIGGER LEVEL.

j. Return B TRIGGER SOURCE to NORM.

41. Check A Internal 40 Megahertz Triggering

a. Set HORIZ DISPLAY to A, set A TRIGGER SOURCE to NORM and set A TRIGGER COUPLING to AC.

b. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

c. Return A TRIGGER COUPLING to AC.

d. CHECK—That a stable triggered display can be obtained in NORM, CH 1 and CH 2 positions of A TRIGGER SOURCE with adjustment of A TRIGGER LEVEL.

e. Return A TRIGGER SOURCE to NORM.

42. Check A Internal 250 Megahertz Triggering

a. Set the sine-wave generator for a 2.0 division, 250 megahertz display.

NOTE

It may be necessary to change to a sine-wave generator with a 250 megahertz output.

Trigger jitter is measured horizontal trace excursion minus normal horizontal trace width observed at low frequency.

b. Set TIME/DIV to 0.01 μs and press X10 MAG to on.

c. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC, LF REJ and DC positions of A TRIGGER COUPLING with adjustments of A TRIGGER LEVEL.

d. Return A TRIGGER COUPLING to AC and set A TRIGGER SOURCE to CH 1.

e. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A TRIGGER LEVEL.

f. Set VERT MODE to CH 2 and set sine-wave generator for a 2.0 division, 250 megahertz display.

g. Set A TRIGGER SOURCE to CH 2.

h. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A TRIGGER LEVEL.

i. Return A TRIGGER SOURCE to NORM.

43. Check B Internal 250 Megahertz Triggering

a. Set HORIZ DISPLAY to B DLY'D.

b. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC, LF REJ, and DC positions of B TRIGGER COUPLING with adjustment of A and B TRIGGER LEVEL controls.

c. Return B TRIGGER COUPLING to AC and set B TRIGGER SOURCE to CH 2.

d. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A and B TRIGGER LEVEL controls.

e. Set VERT MODE to CH 1 and set B TRIGGER SOURCE to CH 1.

f. Set the sine-wave generator for a 2.0 division, 250 megahertz display.

g. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A and B TRIGGER LEVEL controls.

44. Check B External 40 Megahertz Triggering

NOTE

It may be necessary to change to a sine-wave generator with an output of 100 megahertz and below.

a. Move test signal setup from CH 2 to B TRIGGER external input.

b. Set TIME/DIV to 0.05 μs, set CH 1 VOLTS/DIV to 10 mV and return X10 MAG to off (button out).

c. Set the sine-wave generator for a 5 division, 40 megahertz display. (50 millivolts at external input).

d. Set CH 1 VOLTS/DIV to 50 mV and set B TRIGGER SOURCE to EXT.

e. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

45. Check A External 40 Megahertz Triggering

a. Move test signal setup from B TRIGGER external input to A TRIGGER external input.

b. Set HORIZ DISPLAY to A and set A TRIGGER SOURCE to EXT.

c. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

46. Check A External 250 Megahertz Triggering

NOTE

It may be necessary to change to a sine-wave generator with a 250 megahertz output.

a. Set the sine-wave generator for a 5 division display of reference frequency (250 millivolts at external input), then set to 250 megahertz.

NOTE

If generator has no reference frequency setting, set for 5 megahertz.

b. Set TIME/DIV to 0.01 μs and press X10 MAG to on.

c. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

d. Replace the X10 BNC attenuator with a 5X BNC attenuator (500 millivolts at external input) and set A TRIGGER COUPLING to LF REJ.

e. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A TRIGGER LEVEL.

47. Check B External 250 Megahertz Triggering

a. Replace the 5X BNC attenuator with a 10X BNC attenuator and move test signal setup from A TRIGGER external input to B TRIGGER external input (250 millivolts at external input).

b. Set A TRIGGER SOURCE to NORM, set A TRIGGER COUPLING to AC and set HORIZ DISPLAY to B DLY'D.

c. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of A and B TRIGGER LEVEL controls.

d. Replace the 10X BNC attenuator with a 5X BNC attenuator (500 millivolts at external input) and set B TRIGGER COUPLING to LF REJ.

e. CHECK—That a stable triggered display, with no more than 0.2 division of jitter, can be obtained with adjustment of A and B TRIGGER LEVEL controls.

f. Disconnect all test equipment.

48. Check B LF REJ, HF REJ and Low-Frequency Triggering

a. Return X10 MAG to off (button out), set B TRIGGER SOURCE to NORM, set TIME/DIV to 50 μs and set CH 1 VOLTS/DIV to 5 mV.

b. Connect the low-frequency generator output to a 42-inch 50-ohm BNC cable, to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables, to CH 1 input and B TRIGGER external input.

c. Set the low-frequency generator for a 5 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

d. CHECK—That a stable triggered display can be obtained in LF REJ, HF REJ, DC and AC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

e. Set CH 1 VOLTS/DIV to 5 mV.

f. Set the low-frequency generator for a 3 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

g. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

h. Set the low-frequency generator for a 2 division, 50 kilohertz display, then set B TRIGGER SOURCE to EXT (100 millivolts at external input).

i. CHECK—Repeat part d of this step.

j. Set CH 1 VOLTS/DIV to 10 mV.

k. Set the low-frequency generator for a 5 division, 50 kilohertz display (50 millivolts at external input), then set CH 1 VOLTS/DIV to 50 mV.

l. CHECK—Repeat part g.

m. Set B TRIGGER SOURCE to NORM, set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 20 ms and set 100 OR 20 MHz BW control to 20.

n. Set the low-frequency generator for a 5 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

o. CHECK—That a stable triggered display can be obtained in HF REJ, DC and AC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

p. Set CH 1 VOLTS/DIV to 5 mV.

q. Set the low-frequency generator for a 3 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

r. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

s. Set B TRIGGER COUPLING to LF REJ.

t. CHECK—That a stable triggered display cannot be obtained with adjustment of B TRIGGER LEVEL.

u. Set the low-frequency generator for a 2 division, 60 Hertz display, then set B TRIGGER SOURCE to EXT (100 millivolts at external input).

v. CHECK—Repeat part o.

w. Set the low-frequency generator for a 1 division, 60 Hertz display (50 millivolts at external input).

x. CHECK—That a stable triggered display can be obtained in AC and DC positions of B TRIGGER COUPLING with adjustment of B TRIGGER LEVEL.

y. Set B TRIGGER COUPLING to LF REJ.

z. CHECK—Repeat part t.

aa. Disconnect all test equipment.

NOTE

Use a sine-wave generator with an output of 100 megahertz and below for the following parts.

ab. Connect the sine-wave generator output cable to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables. Connect an 18-inch cable through a 50-ohm termination to CH 1 input and connect the other 18-inch cable through a 50-ohm termination to B TRIGGER external input.

ac. Set TIME/DIV to 0.5 μs.

ad. Set the sine-wave generator for a 2 division, 3 megahertz display (100 millivolts at external input).

ae. Set B TRIGGER COUPLING to HF REJ.

af. CHECK—That a stable triggered display cannot be obtained with adjustment of B TRIGGER LEVEL.

ag. Set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 2 μs and set B TRIGGER SOURCE to NORM.

ah. Set the sine-wave generator for a 5 division, 1 megahertz display, then set CH 1 VOLTS/DIV to 50 mV.

ai. CHECK—Repeat part af.

aj. Disconnect all test equipment.

49. Check A LF REJ, HF REJ and Low-Frequency Triggering

a. Set HORIZ DISPLAY to A, set TIME/DIV to 50 μs and set CH 1 to 5 mV.

b. Connect the low-frequency generator output to a 42-inch 50-ohm BNC cable, to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables, to CH 1 input and A TRIGGER external input.

c. Set the low-frequency generator for a 5 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

d. CHECK—That a stable triggered display can be obtained in LF REJ, HF REJ, DC and AC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

e. Set CH 1 VOLTS/DIV to 5 mV.

f. Set the low-frequency generator for a 3 division, 50 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

g. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

h. Set the low-frequency generator for a 2 division, 50 kilohertz display, then set A TRIGGER SOURCE to EXT (100 millivolts at external input).

i. CHECK—Repeat part d.

j. Set CH 1 VOLTS/DIV to 0.1 V and set A TRIGGER SOURCE to EXT ÷ 10.

k. Set the low-frequency generator for a 5 division, 50 kilohertz display (500 millivolts at external input), then set CH 1 VOLTS/DIV to 0.5 V.

l. CHECK—Repeat part g.

m. Set CH 1 VOLTS/DIV to 10 mV and set A TRIGGER SOURCE to EXT.

n. Set the low-frequency generator for a 5 division, 50 kilohertz display (50 millivolts at external input), then set CH 1 VOLTS/DIV to 50 mV.

o. CHECK—Repeat part g.

p. Set A TRIGGER SOURCE to NORM, set CH 1 VOLTS/DIV to 5 mV and set TIME/DIV to 20 ms.

q. Set the low-frequency generator for a 5 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

r. CHECK—That a stable triggered display can be obtained in HF REJ, DC and AC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

s. Set CH 1 VOLTS/DIV to 5 mV.

t. Set the low-frequency generator for a 3 division, 60 Hertz display, then set CH 1 VOLTS/DIV to 50 mV.

u. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

v. Set A TRIGGER COUPLING to LF REJ.

w. CHECK—That a stable triggered display cannot be obtained with adjustment of A TRIGGER LEVEL.

x. Set the low-frequency generator for a 2 division, 60 Hertz display, then set A TRIGGER SOURCE to EXT (100 millivolts at external input).

y. CHECK—Repeat part r.

z. Set the low-frequency generator for a 1 division, 60 Hertz display (50 millivolts at external input).

aa. CHECK—That a stable triggered display can be obtained in AC and DC positions of A TRIGGER COUPLING with adjustment of A TRIGGER LEVEL.

ab. Set A TRIGGER COUPLING to LF REJ.

ac. CHECK—Repeat part w.

ad. Disconnect all test equipment.

NOTE

Use a sine-wave generator with an output of 100 megahertz and below for the following.

ae. Connect the sine-wave generator output cable to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables. Connect an 18-inch cable through a 50-ohm termination to CH 1 input and connect the other 18-inch cable through a 50-ohm termination to A TRIGGER external input.

af. Set TIME/DIV to 0.5 μs.

ag. Set the sine-wave generator for a 2 division, 3 megahertz display (100 millivolts at external input).

ah. Set A TRIGGER COUPLING to HF REJ.

ai. CHECK—That a stable triggered display cannot be obtained with adjustment of A TRIGGER LEVEL.

aj. Set CH 1 VOLTS/DIV to 5 mV, set TIME/DIV to 2 μs and set A TRIGGER SOURCE to NORM.

ak. Set the sine-wave generator for a 5 division, 1 megahertz display, then set CH 1 VOLTS/DIV to 50 mV.

al. CHECK—Repeat part ai.

50. Adjust TRIGGER VIEW Centering

a. Set A TRIGGER COUPLING to AC and set A TRIGGER SOURCE to EXT.

b. Set the sine-wave generator for a 1 division, 1 megahertz display (50 millivolts at external input) and adjust A TRIGGER LEVEL for a stable triggered display.

c. Press TRIG VIEW and hold it in.

d. CHECK—That display center is within 1 division of the center horizontal graticule line.

e. ADJUST—Trigger View Centering, R673, to center the display on the center horizontal graticule line. See ADJUSTMENT LOCATIONS 3.

f. Release TRIG VIEW.

g. Disconnect all test equipment.

51. Check TRIG VIEW Deflection Factor

a. Set TIME/DIV to 1 ms.

b. Set the amplitude calibrator for a 200 millivolt output and connect to A TRIGGER external input through a 42-inch 50-ohm BNC cable.

c. Press TRIG VIEW and hold it in.

d. Position the display to graticule center with A TRIGGER LEVEL.

e. CHECK—For approximately 4 divisions of display.

f. Release TRIG VIEW.

g. Disconnect all test equipment.

52. Check TRIG VIEW Risetime

a. Set TIME/DIV to 5 μs.

b. Connect a 100 kilohertz signal from the square-wave generator high amplitude output through a GR-to-BNC female adapter and a 42-inch 50-ohm BNC cable to the input of the tunnel diode pulser calibration fixture. Connect the output of the tunnel diode pulser through a 50-ohm termination to A TRIGGER external input.

c. Press TRIG VIEW and hold it in.

d. Adjust A TRIGGER LEVEL to set the display to graticule center.

e. Increase the square-wave generator amplitude and adjust the pulser triggered level until the display suddenly increases to about 5 divisions of amplitude.

f. Set TIME/DIV to 0.01 μs, set X10 MAG to on and set leading edge of waveform to graticule center.

g. CHECK—The display between the 10% and 90% points on the leading edge of waveform for 4 horizontal divisions or less (4 nanoseconds or less, risetime).

h. Release TRIG VIEW.

53. Check TRIG VIEW Delay Difference

a. Remove the test signal setup from A TRIGGER external input and disconnect the 50-ohm termination from the pulser. Connect the output of the tunnel diode pulser to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch BNC cables, Connect a cable through a 50-ohm termination to CH 1 input and connect other cable through a 50-ohm termination to A TRIGGER external input.

b. Set TIME/DIV to 0.05 μs, set X10 MAG to off and set CH 1 VOLTS/DIV to 20 mV.

c. Adjust the pulser triggered level until the display suddenly increases.

d. Press and hold TRIG VIEW, and adjust A TRIGGER LEVEL to set the center of overall display amplitude to graticule center and note amplitude of the display.

e. Release TRIG VIEW, set CH 1 VAR VOLTS/DIV for same amplitude noted in part d and set the center of overall display amplitude to graticule center with CH 1 POSITION.

f. Set TIME/DIV to 0.01 μs, set X10 MAG to on and set leading edge of waveform to graticule center with POSITION (Horiz).

g. Press TRIG VIEW and note difference in horizontal position from graticule center.

h. CHECK—For 2.5 divisions or less (2.5 nanoseconds or less of difference).

i. Release TRIG VIEW.

j. Disconnect all test equipment.

54. Check LINE Triggering

a. Set CH 1 VAR VOLTS/DIV to calibrated detent, set X10 MAG to off, set A TRIGGER SOURCE to LINE and set TIME/DIV to 5 ms.

b. Press and hold TRIG VIEW.

c. CHECK—For a triggered display starting on the slope selected by A TRIGGER SLOPE.

d. Release TRIG VIEW.

55. Check A TRIGGER LEVEL Control External Range

a. Set TIME/DIV to 1 ms, set CH 1 VOLTS/DIV to 1 V and set A TRIGGER SOURCE to EXT.

b. Connect the low-frequency generator output to a 42-inch 50-ohm BNC cable, to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables, to CH 1 input and A TRIGGER external input.

c. Set the low-frequency generator for a 4 division, 1 kilohertz display.

d. CHECK—That display is triggered through midrange and not triggered at both stops of A TRIGGER LEVEL in + and − positions of A TRIGGER SLOPE.

56. Check B TRIGGER LEVEL Control External Range

a. Set HORIZ DISPLAY to B DLY'D, set B TRIGGER SOURCE to EXT and set A TRIGGER SOURCE to NORM.

b. Move test signal cable from A TRIGGER external input to B TRIGGER external input.

c. CHECK—That display is triggered through midrange and not triggered at both stops of B TRIGGER LEVEL in + and − positions of B TRIGGER SLOPE.

57. Check SINGL SWP Triggering

a. Set HORIZ DISPLAY to A and set CH 1 VOLTS/DIV to 5 mV.

b. Set the low-frequency generator for a 5 division, 1 kilohertz display, then set CH 1 VOLTS/DIV to 50 mV.

c. Set A TRIGGER LEVEL for stable triggering with display start at top of first positive peak.

d. Set CH 1 AC-GND-DC switch to GND and momentarily press SINGL SWP pushbutton of TRIG MODE.

e. CHECK—That READY light turns on.

f. Set CH 1 AC-GND-DC switch to DC.

g. CHECK—For a display of 1 sweep and that READY light is extinguished.

58. Check TRIG MODE NORM Triggering

a. Set TRIG MODE to NORM and set A TRIGGER LEVEL for a stable triggered display.

b. Set CH 1 AC-GND-DC switch to GND.

c. CHECK—For no visible trace.

d. Disconnect all test equipment.

59. Check TRIG MODE AUTO Triggering

a. Set TRIG MODE to AUTO, set TIME/DIV to 10 ms, CH 1 VOLTS/DIV to 0.5 V and set CH 1 AC-GND-DC switch to DC.

b. Set the time-mark generator for 10 millisecond time marks and connect through a 42-inch 50-ohm BNC cable, to a 50-ohm BNC termination, to CH 1 input.

c. CHECK—That a stable triggered display can be obtained with adjustment of A TRIGGER LEVEL.

d. Set TIME/DIV to 0.1 s and set the time-mark generator for 0.1 second time marks.

e. CHECK—That a stable triggered display cannot be obtained with adjustment of A TRIGGER LEVEL.

HORIZONTAL SYSTEM

Equipment Required

1. Time-Mark Generator
2. Sine-Wave Generator
3. Digital Voltmeter
4. Amplitude Calibrator
5. Test Oscilloscope
6. Current Probe
7. 42-Inch 50-Ohm BNC Cable (2 required)
8. 18-Inch 50-Ohm BNC Cable (2 required)
9. 50-Ohm BNC Termination (2 required)
10. BNC Female-To-BNC Female Adapter
11. BNC T-Connector
12. 500 MHz Filter
13. Screwdriver
14. Low-Capacitance Screwdriver (use for all variable capacitance adjustments)

Before you begin, see **ADJUSTMENT LOCATIONS 4** *in the pullout pages.*

Control Settings

POWER	ON

Display

INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	0.5 V
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 OR 20 MHz BW	Full bandwidth (push in, then release)

Trigger (A and B)

COUPLING	**AC (new setting)**
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	NORM
B TRIGGER SOURCE	**STARTS AFTER DELAY (new setting)**
TRIG MODE	AUTO
A TRIGGER HOLDOFF	NORM

Sweep

A TIME/DIV	**1 ms (new setting)**
B TIME/DIV	**(1 ms new setting)**
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	Fully counterclockwise
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

NOTE

DM44 DIGITAL MULTIMETERS.

FOR OSCILLOSCOPES WITH DIGITAL MULTIMETERS ATTACHED, REFER TO THE DIGITAL MULTIMETER MANUAL AT THIS POINT. CONTINUE WITH THE 475A DM44 HORIZONTAL SYSTEM CALIBRATION PROCEDURE, THEN RETURN TO **GATE OUTPUTS, EXTERNAL Z-AXIS AND CALIBRATOR** *SECTION IN THIS CALIBRATION PROCEDURE.*

FOR OSCILLOSCOPES WITHOUT DIGITAL MULTIMETERS, CONTINUE WITH **HORIZONTAL SYSTEM CALIBRATION.**

60. Adjust Horizontal Gain

a. Set the time-mark generator for 1 millisecond time marks and connect through a 42-inch 50-ohm BNC cable and 50-ohm BNC termination to CH 1 input.

b. Set A TRIGGER LEVEL for a stable triggered display.

NOTE

Unless otherwise stated, set POSITION and FINE (Horiz) controls so first time mark will coincide with first vertical graticule line and check that a time mark will coincide with last vertical graticule line.

c. CHECK—That first and 11th time marks coincide with graticule lines, within 1%, from +20°C to +30°C; within 3%, from −15°C to +55°C.

d. ADJUST—Horizontal Gain, R1155, for 1 time-mark/division. See ADJUSTMENT LOCATIONS 4-B.

NOTE

Effective range of R1155 is determined by the selected value of R1154. The value of R1154 may be altered to obtain necessary range for R1155.

e. Press X10 MAG pushbutton and set time-mark generator for 0.1 millisecond time marks.

f. CHECK—That X10 MAG light is illuminated.

g. CHECK—That first and 11th time marks coincide with graticule lines, within 2%, from +20°C to +30°C; within 4%, from −15°C to +55°C.

h. Set X10 MAG pushbutton to off and set the time-mark generator for 1 millisecond time marks.

61. Adjust Intensified Gain

a. Set HORIZ DISPLAY to A INTEN.

b. CHECK—That first and 11th time marks coincide with graticule lines, within 2%, from +20°C to +30°C; within 3%, from −15°C to +55°C.

c. ADJUST—Intensified Gain, R950, for 1 time-mark/division. See ADJUSTMENT LOCATIONS 4-B.

62. Adjust Delay Start and Delay Stop

a. Pull and unlock DLY'D SWP knob (B TIME/DIV) and set to 10 μs. Set HORIZ DISPLAY to B DLY'D and set DELAY TIME POSITION to 1.000 on dial.

b. CHECK—That the start of displayed time mark is near beginning of sweep.

c. ADJUST—Delay Start, R938, so that the start of displayed time mark starts at beginning of sweep. See ADJUSTMENT LOCATIONS 4-B.

d. Turn DELAY TIME POSITION to set the start of displayed time mark to coincide with graticule center and note reading on dial.

e. Turn DELAY TIME POSITION to set time mark nearest 9.000 on dial to coincide with graticule center and note reading.

f. CHECK—For a difference in readings, noted in parts d and e, of 8.000, within 0.049, from +15°C to +35°C; within 0.089, from −15°C to +55°C.

NOTE

If the difference in readings in part f was within specifications, proceed with part i.

g. Add the dial reading noted in part d, to 8.000 and set DELAY TIME POSITION dial to indicate the sum.

h. ADJUST—Delay Stop, R936, to set the start of displayed time mark to coincide with graticule center. See ADJUSTMENT LOCATIONS 4-B.

i. INTERACTION—Between Delay Start and Delay Stop adjustments. Repeat parts a through h as necessary.

63. Check 1 Millisecond Differential Delay Time Accuracy

a. Turn DELAY TIME POSITION to set time mark nearest 1.000 on dial to graticule center and note reading.

b. Turn DELAY TIME POSITION to set time mark nearest 2.000 on dial to graticule center and note reading.

c. CHECK—For a difference in readings of 1.000, within 0.010, from +15°C to +35°C; within 0.020, from −15°C to +55°C.

d. Turn DELAY TIME POSITION to set every adjacent time mark to graticule center and note reading.

e. CHECK—Each reading between any 2 adjacent time marks for 1.000, within 0.010, from +15°C to +35°C; within 0.020, from −15°C to +55°C. Also, check the difference between any time marks separated by more than 1 major dial division for maximum error as listed in Table 6-4.

TABLE 6-4

1 Millisecond Differential Delay Time Accuracy

Difference in Major Dial Divisions	Maximum Error +15°C to +35°C	Maximum Error −15°C to +55°C
1.000	±0.010	±0.020
2.000	±0.019	±0.029
3.000	±0.027	±0.042
4.000	±0.033	±0.053
5.000	±0.039	±0.064
6.000	±0.043	±0.073
7.000	±0.047	±0.082
8.000	±0.049	±0.089
9.000	±0.050	±0.095

64. Adjust Magnified Registration

a. Set DLY'D SWP to 1 ms (lock knobs) and set HORIZ DISPLAY to A.

b. Set the time-mark generator for 5 millisecond time marks.

c. Press X10 MAG pushbutton, set the center time mark of the display to graticule center with POSITION (Horiz), then set X10 MAG pushbutton to off.

d. CHECK—That center time mark is within 0.5 division of graticule center.

e. ADJUST—Magnified Registration, R1130, to set center mark to graticule center. See ADJUSTMENT LOCATIONS 4-B.

f. Repeat parts c through e, as necessary, for minimum shift when switching from magnified to unmagnified.

65. Check VAR TIME/DIV Range

a. Set VAR TIME/DIV fully counterclockwise.

b. CHECK—That TIME/DIV UNCAL light is illuminated.

c. CHECK—For at least 6 time marks in 10 divisions.

d. Return VAR TIME/DIV control to calibrated detent.

66. Check Sweep Length and Horizontal POSITION Range

a. Set time-mark generator for 1 millisecond time marks.

b. CHECK—Sweep length for at least 10.1 divisions.

c. Turn POSITION and FINE (Horiz) controls fully clockwise. (Also check that each control will position the trace).

d. CHECK—That the start of sweep is to the right of graticule center.

e. Turn POSITION and FINE (Horiz) controls fully counterclockwise.

f. CHECK—That the end of sweep is to the left of graticule center.

g. Recenter POSITION and FINE (Horiz) controls.

67. Adjust 10 Microsecond Timing

a. Set TIME/DIV to 10 μs, set time-mark generator for 10 microsecond time marks and align the first time mark with first graticule line using POSITION and FINE (Horiz) controls.

b. CHECK—That the first and 11th time marks coincide with graticule lines, within 1%, from +20° C to +30° C; within 3%, from −15° C to +55° C.

c. ADJUST—C1064 for 1 time-mark/division. See ADJUSTMENT LOCATIONS 4-A.

d. Set HORIZ DISPLAY to B DLY'D, pull and unlock DLY'D SWP knob and set to 0.2 μs.

e. Turn DELAY TIME POSITION to set time mark nearest 1.000 on dial to coincide with graticule center and note reading.

f. Turn DELAY TIME POSITION to set time mark nearest 9.000 on dial to coincide with graticule center and note reading.

g. CHECK—For a difference in readings, noted in parts e and f, of 8.000, within 0.049, from +15° C to +35° C; within 0.089, from −15° C to +55° C.

NOTE

If the difference in readings in part g was within specifications, proceed with step 68. Otherwise proceed with part h.

h. Add the dial reading noted in part e, to 8.000 and set DELAY TIME POSITION to indicate the sum.

i. ADJUST—C1023 to set the start of displayed time mark to coincide with graticule center. See ADJUSTMENT LOCATIONS 4-A.

j. INTERACTION—Between setting of DELAY TIME POSITION at 1.000 and adjustment of C1023. Repeat parts e through i as necessary to obtain a difference in readings of 8.000, within limits specified in part g.

68. Adjust 0.1 Microsecond Timing

a. Set HORIZ DISPLAY to A, set DLY'D SWP to 10 μs (lock knobs) and set TIME/DIV to 0.1 μs.

b. Set time-mark generator for 0.1 microsecond time marks.

c. CHECK—That first and 11th time marks coincide with graticule lines, within 1%, from +20° C to +30° C; within 3%, from −15° C to +55° C.

d. ADJUST—C1009 for 1 time mark/division. See ADJUSTMENT LOCATIONS 4-B.

e. Set HORIZ DISPLAY to B DLY'D, pull and unlock DLY'D SWP knob and set to 0.01 μs.

f. Turn DELAY TIME POSITION to set time mark nearest 1.000 on dial to coincide with graticule center and note reading.

g. Turn DELAY TIME POSITION to set time mark nearest 9.000 on dial to coincide with graticule center and note reading.

h. CHECK—For a difference in readings of 8.000, within 0.049, from +15° C to +35° C; within 0.089 from −15° C to +55° C.

NOTE

If the difference in readings in part h was within specifications, proceed with step 69. Otherwise proceed with part i.

i. Add the dial reading noted in part f, to 8.000 and set DELAY TIME POSITION to indicate the sum.

j. ADJUST—C1025 to set the start of display time mark to coincide with graticule center. See ADJUSTMENT LOCATIONS 4-A.

k. INTERACTION—Between setting of DELAY TIME POSITION at 1.000 and adjustment of C1025. Repeat parts f through j as necessary to obtain a difference in readings of 8.000, within limits specified in part h.

69. Adjust Horizontal Output Centering

a. Set HORIZ DISPLAY to A, set DLY'D SWP to 0.1 μs (lock knobs), set TIME/DIV to X-Y, set VERT MODE to CH 2 and set CH 1 AC-GND-DC switch to GND.

b. Set the dot display to graticule center with X (CH 1) and Y (CH 2) POSITION controls.

c. Connect the digital voltmeter (set to read at least 50 volts) negative lead to GND test point on main interface circuit board and compare readings between the collectors (transistor cases) of Q1204 and Q1214. See ADJUSTMENT LOCATIONS 4-B.

d. Set POSITION (HORIZ) for equal readings between the transistor collectors of Q1204 and Q1214 and note the final reading.

e. CHECK—For a reading of approximately +50 volts.

f. ADJUST—Horizontal DC Centering R1256, for a reading of +50 volts. See ADJUSTMENT LOCATIONS 4-B.

g. Disconnect the digital voltmeter.

NOTE

The preceding procedure is intended to initially set the Horizontal Output Centering. It may be helpful to readjust Horizontal DC Centering, R1256, later in this procedure if step 71 must be performed.

70. Adjust High-Speed Timing (Visual Method)

NOTE

This step is intended to check high-speed timing and, if necessary, perform minor recalibration. If timing cannot be adjusted to within specified accuracy, major recalibration will be performed in step 71.

a. Set TIME/DIV to 0.05 μs, set VERT/MODE to CH 1, press X10 MAG to on, set A TRIGGER SOURCE to EXT and set A TRIGGER COUPLING to LF REJ.

b. Set the time-mark generator for 5 nanosecond time marks and connect trigger output through a 42-inch 50-ohm BNC cable to a 50-0hm BNC termination, to A TRIGGER external input. (If a 2901 time-mark generator is used, set trigger selector for 0.1 microsecond triggers).

Insert a 500 megahertz filter between the 50-ohm BNC termination and CH 1 input. Adjust the filter for minimum unwanted modulation from the time-mark generator, as necessary, through the high-speed timing procedure.

c. Set CH 1 VOLTS/DIV to maintain a convenient display amplitude in this step. Set A TRIGGER LEVEL for a stable triggered display through the high-speed timing procedure.

d. CHECK—That first and 11th time marks coincide with graticule lines, within 2%, from +20°C to +30°C; within 4%, from −15°C to +55°C.

e. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval. (See following note).

NOTE

(1) If waveform has modulation, check 2 division accuracy between adjacent time marks of equal amplitude.

(2) Turn INTENSITY full on and position the spot at start of the sweep to graticule area with POSITION (Horiz).

Exclude the first 25 nanoseconds from start of sweep or first 2 major unblanked divisions at normal intensity (whichever is greater) and all beyond the 100th division.

f. ADJUST—C1253 and C1233, in equal amounts, for 1 cycle/division. See ADJUSTMENT LOCATIONS 4-B.

g. Set TIME/DIV to 0.02 μs and set time-mark generator for 2 nanosecond time-marks.

NOTE

It may be necessary to adjust A TRIGGER HOLDOFF for best triggered display through this step.

h. CHECK—That first and 11th time marks coincide with graticule lines, within 2%, from +20°C to +30°C; within 4%, from −15°C to +55°C.

i. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval.

j. ADJUST—C1179 for 1 cycle/division. See ADJUSTMENT LOCATIONS 4-B.

k. INTERACTION—Between 0.05 and 0.02 microsecond magnified timing. Set TIME/DIV to 0.05 μs, set time-mark generator for 5 nanosecond time marks and repeat parts d through i as necessary for best timing accuracy.

l. Set TIME/DIV to 0.01 μs.

m. CHECK—That first and 6th cycles coincide with graticule lines, within 2%, from +20° C to +30° C; within 4%, from −15° C to +55° C.

n. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval.

o. ADJUST—1 Nanosecond Timing, R1075, for 1 cycle/2 divisions. See ADJUSTMENT LOCATIONS 4-A.

NOTE

If timing cannot be adjusted to within specified accuracy, proceed with step 71. If timing is within specified accuracy, proceed with step 72.

71. Adjust High-Speed Timing (Current Probe Method)

NOTE

This step is intended only for major recalibration of high-speed timing. Any reference to 475A through the calibration procedure refers to the instrument under calibration.

a. Set TIME/DIV to 0.02 μs, center the display on graticule with POSITION (Horiz) and press X10 MAG to on.

b. Set time-mark generator for 2 nanosecond time marks and set CH 1 VOLTS/DIV to maintain a convenient display amplitude through this step.

c. Connect the current probe with passive termination to channel 1 of test oscilloscope. Set passive termination to 1 mA/mV.

d. Connect the probe head around the crossed horizontal deflection plate leads. See ADJUSTMENT LOCATIONS 4-B. See Figure 6-4 for proper probe connection.

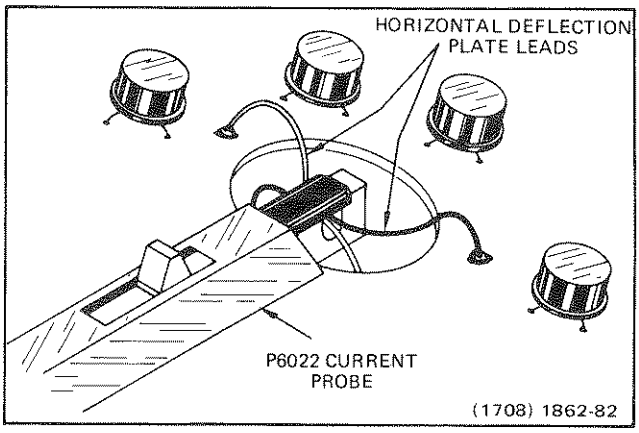

Fig. 6-4. Proper connection of current probe to horizontal deflection plate leads for High-Speed Timing calibration.

e. Set the test oscilloscope: vertical mode to channel 1, time/division to 0.2 microseconds, X10 magnifier to on and channel 1 volts/division to 20 millvolts. Position current pulse at beginning of sweep to graticule center.

f. CHECK—Test oscilloscope display for a symmetrical, flat-top current waveform similar to that in Figure 6-5.

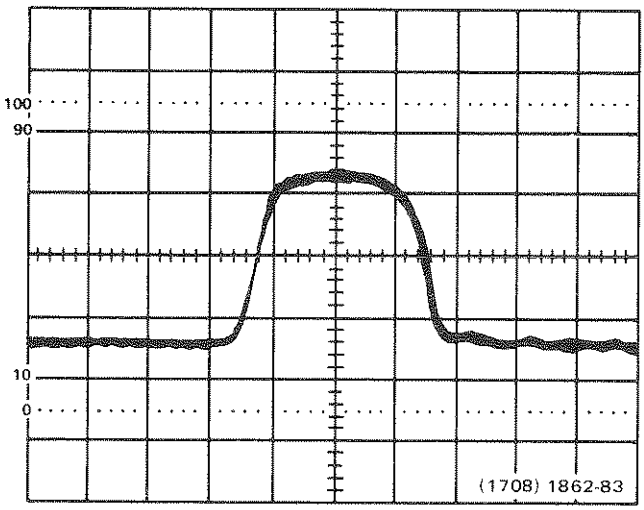

Fig. 6-5. Typical display on test oscilloscope when High-Speed Timing is properly adjusted. (475 set at 2 nanoseconds/division).

g. ADJUST— C1253, C1233, C1179, R1185 and R1175 for a symmetrical, flat-top current waveform. See ADJUSTMENT LOCATIONS 4-B.

h. CALIBRATION AID—Preset C1253 and C1233 for approximately 1/4 of maximum capacitance, preset C1179 near maximum capacitance (near clockwise stop) and preset R1185 near maximum resistance (near clockwise stop).

Adjust R1175 for a flat top and fast leading edge on current waveform at 475A TIME/DIV settings of 0.02 μs and 0.01 μs. Adjust R1185 for best overall flat top on current waveform at 475A TIME/DIV setting of 0.02 μs. C1253 and C1233 may be adjusted individually for a symmetrical current waveform with a fast trailing edge.

NOTE

It may be helpful to readjust Horizontal DC Centering, R1256, for best symmetrical current waveform. See ADJUSTMENT LOCATIONS 4-B.

i. INTERACTION—Between all adjustments in this step. Repeat the adjustment procedure in part g, as necessary, to obtain the best symmetrical, flat-top current waveform.

j. Set 475A TIME/DIV to 0.05 μs and set time-mark generator for 5 nanosecond time marks.

k. CHECK—That first and 11th cycles coincide with graticule lines, within 2%, from +20° C to +30° C; within 4%, from −15° C to +55° C.

l. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval. (See following note.

NOTE

(1) If waveform has amplitude modulation, check 2 division accuracy between adjacent time marks of equal amplitude.

(2) Turn INTENSITY full on and position the spot at start of the sweep to graticule area with POSITION (Horiz).

Exclude the first 25 nanoseconds from start of sweep or first 2 major unblanked divisions at normal intensity (whichever is greater) and all beyond the 100th division.

m. ADJUST—C1253 and C1233, in equal amounts, for 1 cycle/division. See ADJUSTMENT LOCATIONS 4-B.

n. Set TIME/DIV to 0.02 μs and set time-mark generator for 2 nanosecond time marks.

NOTE

In the following parts, it may be necessary to adjust R1185 and R1175 to maintain a symmetrical, flat-top current waveform.

o. CHECK—That first and 11th cycles coincide with graticule lines, within 2%, from +20° C to +30° C; within 4%, from −15° C to +55° C.

p. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval.

q. ADJUST—C1179 for 1 cycle/division. See ADJUSTMENT LOCATIONS 4-B.

r. INTERACTION—Between 0.05 and 0.02 microsecond magnified timing. Repeat parts j through p, as necessary for best timing accuracy.

s. Set TIME/DIV to 0.01 μs.

t. CHECK—That first and 6th cycles coincide with graticule lines, within 2%, from +20° C to +30° C; within 4%, from −15° C to +55° C.

u. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval.

v. ADJUST—1 Nanosecond Timing, R1075, for 1 cycle/2 divisions. See ADJUSTMENT LOCATIONS 4-A.

w. Disconnect the current probe without disturbing the deflection plate leads.

x. INTERACTION—Between timing with current probe connected and timing without current probe. Repeat parts j through u for best timing accuracy. (Disregard note between n and o).

y. Set X10 MAG to off, TIME/DIV to 0.1 μs, set CH 1 AC-GND-DC switch to DC and set time-mark generator for 0.1 microsecond time marks.

z. CHECK—That first and 11th time marks coincide with graticule lines, within 1%, from +20° C to +30° C; within 3%, from −15° C to +55° C.

aa. ADJUST—C1009 for 1 time mark/division. See ADJUSTMENT LOCATIONS 4-B.

ab. INTERACTION—Between adjustment of C1009 and high-speed timing. If adjustment was made in part aa, press X10 MAG to on and repeat parts j through v for best timing accuracy.

ac. Remove the trigger cable setup from A TRIGGER external input, set A TRIGGER SOURCE to NORM and set A TRIGGER COUPLING to AC.

72. Check A Timing Accuracy

a. Set CH 1 AC-GND-DC switch to DC, set CH 1 VOLTS/DIV to 0.5 V and set TRIG MODE to NORM.

b. CHECK—TIME/DIV settings from 0.01 μs to 5 ms/division for accuracy, at first and 11th graticule lines, within 1%, from +20° C to +30° C; within 3%, from −15° C to +55° C. Set time-mark generator to maintain appropriate time marks through this step. Exclude the first 25 nanoseconds from start of sweep when checking 0.01 and 0.02 μs/division.

c. CHECK—TIME/DIV settings from 10 ms to 0.5 s/division for accuracy, at first and 11th graticule lines, within 2%, from +20° C to +30° C; within 3%, from −15° C to +55° C.

73. Check A INTEN Timing Accuracy

a. Set HORIZ DISPLAY to A INTEN and set DELAY TIME POSITION fully counterclockwise.

b. CHECK—TIME/DIV settings from 0.05 μs to 0.5 s/division for accuracy, at first and 11th graticule lines, within 2%, from +20° C to +30° C; within 3%, from −15° C to +55° C. Set time-mark generator to maintain appropriate time marks.

74. Check A INTEN Magnified Timing Accuracy

a. Press X10 MAG to on.

b. CHECK—TIME/DIV settings from 0.05 μs to 0.5 s/division for accuracy, at first and 11th graticule lines, within 3%, from +20° C to +30° C; within 4%, from −15° C to +55° C. Set time-mark generator to maintain appropriate time marks. See NOTE following step 71, part l.

75. Check A Magnified Timing Accuracy

a. Set HORIZ DISPLAY to A.

b. CHECK—TIME/DIV settings from 0.01 μs to 5 ms/division for accuracy, at first and 11th graticule lines, within 2%, from +20° C to +30° C; within 4%, from −15° C to +55° C. Set time-mark generator to maintain appropriate time marks through this step. See NOTE following step 71, part l.

c. CHECK—TIME/DIV settings from 10 ms to 0.5 s/division for accuracy, at first and 11th graticule lines, within 3%, from +20° C to +30° C; within 4%, from −15° C to +55° C.

d. CHECK—That accuracy is within 5% (0.1 division) over any 2 division interval at all TIME/DIV settings.

76. Check Differential Delay Time Accuracy

a. Set HORIZ DISPLAY to B DLY'D and set TIME/DIV to 0.05 μs. Pull and unlock DLY'D SWP knob, set to 0.01 μs and set X10 MAG to off.

b. Set time-mark generator for 50 nanosecond time marks.

c. Turn DELAY TIME POSITION to set time mark nearest 1.000 on dial to coincide with graticule center and note reading.

d. Turn DELAY TIME POSITION to set time mark nearest 2.000 on dial to coincide with graticule center and note reading.

e. CHECK—For a difference in readings of 1.000, within 0.010, from +15°C to +35°C; within 0.020, from −15°C to +55°C.

f. Turn DELAY TIME POSITION to set every adjacent time mark to coincide with graticule center and note reading.

g. CHECK—Each reading between any 2 adjacent time marks for 1.000, within 0.010, from +15°C to +35°C; within 0.020, from −15°C to +55°C. Also, check the difference between any time marks separated by more than 1 major dial division for maximum error as listed in Table 6-5.

TABLE 6-5

Differential Delay Time Accuracy

Difference in Major Dial Divisions	Maximum Error +15°C to +35°C	Maximum Error −15°C to +55°C
1.000	±0.010	±0.020
2.000	±0.019	±0.029
3.000	±0.027	±0.042
4.000	±0.033	±0.053
5.000	±0.039	±0.064
6.000	±0.043	±0.073
7.000	±0.047	±0.082
8.000	±0.049	±0.089
9.000	±0.050	±0.095

h. CHECK—Differential delay time accuracy as directed in part g, at all settings listed in Table 6-6 not to exceed maximum error listed in Table 6-5.

TABLE 6-6

Delay Time Settings

DELAY TIME POSITION Exclusions	A TIME/DIV Switch Setting	B TIME/DIV Switch Setting	[1]Time-Mark Generator Setting
Exclude dial settings of 0.000 through 1.000	0.05 μs	0.01 μs	50 nanosecond
	0.1 μs	0.01 μs	0.1 microsecond
	0.2 μs	0.02 μs	0.2 microsecond
	0.5 μs	0.05 μs	0.5 microsecond
Exclude dial settings of 0.000 through 0.050	1 μs	0.1 μs	1 microsecond
	2 μs	0.2 μs	2 microsecond
	5 μs	0.5 μs	5 microsecond
	10 μs	1 μs	10 microsecond
	20 μs	2 μs	20 microsecond
	50 μs	5 μs	50 microsecond
	0.1 ms	10 μs	0.1 millisecond
	0.2 ms	20 μs	0.2 millisecond
	0.5 ms	50 μs	0.5 millisecond
	1 ms	0.1 ms	1 millisecond
	2 ms	0.2 ms	2 millisecond
	5 ms	0.5 ms	5 millisecond
	10 ms	1 ms	10 millisecond
	20 ms	2 ms	20 millisecond
	50 ms	5 ms	50 millisecond
	0.1 s	10 ms	0.1 second
	0.2 s	20 ms	0.2 second
	0.5 s	50 ms	0.5 second

[1]**If the time-mark generator being used does not have a 1-2-5 sequence, set for 1 or more time marks per division on DELAY TIME POSITION dial.**

77. Check Delay Time Jitter

a. Set DLY'D SWP to 0.2 μs, set A TIME/DIV to 1 ms and set time-mark generator for 1 millisecond time marks.

b. Set DELAY TIME POSITION to 1.000 on dial and position nearest time mark to graticule center.

c. CHECK—That jitter on the leading edge of the time mark does not exceed 1 division (60 Hertz line) or 2.5 division (50 Hertz line).

d. Set DELAY TIME POSITION to view each time mark from 2.000 to 9.000 on dial and check delay time jitter for limits stated in part c.

78. Check MIX (Mixed Sweep) Timing Accuracy

a. Set DLY'D SWP to 0.02 μs, A TIME/DIV to 0.05 μs, HORIZ DISPLAY to MIX and DELAY TIME POSITION fully clockwise.

b. Set time-mark generator for 50 nanosecond time marks.

c. CHECK—A TIME/DIV settings from 0.02 μs to 0.5 s/division for accuracy at 2nd and 10th graticule lines, (8 division timing), within 3%. Exclude the first 0.5 division from start of sweep when checking A sweep. Set DLY'D SWP at least 1 sweep setting faster than A sweep setting on all ranges. Set time-mark generator to maintain appropriate time marks.

d. Set DELAY TIME POSITION fully counterclockwise, DLY'D SWP to 0.05 μs, A TIME/DIV to 0.1 μs and set time-mark generator for 50 nanosecond time marks.

e. CHECK—DLY'D SWP settings from 0.05 μs to 0.5 s/division for accuracy at 2nd and 10th graticule lines, (8 division timing), within 3%. Exclude the first 0.2 division or 0.1 microsecond (whichever is greater) after the transition of A to B. Set DLY'D SWP at least 1 sweep setting faster than A sweep setting on all ranges. Set time-mark generator to maintain appropriate time marks.

f. Disconnect all test equipment.

79. Adjust X Gain

a. Set TRIG MODE to AUTO, set DLY'D SWP to lock knobs and set TIME/DIV to X-Y. Set VERT MODE to CH 2, set X (CH 1) VOLTS/DIV to 5 mV, and set X (CH 1) AC-GND-DC switch to DC.

b. Set amplitude calibrator to 20 millivolts and connect to X (CH 1) input through a 42-inch 50-ohm BNC cable.

c. Set X and Y POSITION controls to set the 2-dot display at graticule center.

d. CHECK—The deflection between the 2 displayed dots for 4 divisions within 3%.

e. ADJUST—X Gain, R1102, for 4 divisions of deflection between the 2 displayed dots. See ADJUSTMENT LOCATIONS 4-B.

f. Adjust X VAR VOLTS/DIV and X POSITION for exactly 2 divisions between the displayed dots at graticule center.

g. Position right dot of display to extreme right graticule line.

h. CHECK—The display for 0.2 division or less of compression or expansion.

i. Position left dot of display to extreme left graticule line.

j. CHECK—The display for 0.2 divisions or less of compression or expansion.

k. Disconnect all test equipment.

80. Adjust X-Y Phase Difference

a. Return X VAR VOLTS/DIV to calibrated detent and set X AC-GND-DC switch to GND.

b. Set Y VOLTS/DIV to 5 mV.

@

NOTE

See test equipment required, Table 6-1, for selection of sine-wave generator with an output of 100 megahertz and below.

c. Connect the sine-wave generator output cable to a BNC female-to-BNC female adapter, to a BNC T-connector, to two 18-inch 50-ohm BNC cables. Connect the 18-inch cables through 50-ohm terminations to X and Y inputs.

d. Set the sine-wave generator for an 8 division display of reference frequency, then set X AC-GND-DC switch to DC.

e. Center the lissajous display on graticule with X and Y POSITION controls.

f. CHECK—For 0.14 division or less of opening at center of the lissajous display. (Measure horizontally).

g. ADJUST—L1103 for minimum opening of the lissajous display. See ADJUSTMENT LOCATIONS 4-B.

h. Increase the frequency of the sine-wave generator to 2 megahertz.

i. CHECK—For 0.42 division or less of opening at center of the lissajous display. (Measure horizontally).

j. Disconnect all test equipment.

81. Check X Bandwidth

a. Connect the sine-wave generator output cable to a 50-ohm termination, to X input.

b. Set the sine-wave generator for a 4 division horizontal display of reference frequency.

c. Increase the frequency of the sine-wave generator until the display is reduced to 2.8 divisions.

d. CHECK—The sine-wave generator for a reading of 3 megahertz or higher.

e. Disconnect all test equipment.

82. Check B ENDS A Operation

a. Set TIME/DIV to 1 ms, pull and unlock DLY'D SWP knob and set to 0.1 ms, set VERT MODE to CH 1, set HORIZ DISPLAY to A INTEN and set A TRIG HOLDOFF to B ends A detent.

b. Increase INTENSITY until A sweep is visible.

c. Turn DELAY TIME POSITION through its range.

d. CHECK—That A sweep ends after the intensified portion at all settings of DELAY TIME POSITION dial.

83. Check A TRIG HOLDOFF Operation

a. Set HORIZ DISPLAY to A, set A TRIG HOLDOFF to NORM and set DLY'D SWP (B TIME/DIV) to 1 ms (lock knobs).

b. Connect A +GATE (output connector on rear panel) to channel 1 of test oscilloscope through a 42-inch 50-ohm BNC cable.

c. Set test oscilloscope: time/division to 1 millisecond, X10 magnifier to off, channel 1 volts/division to 2 volts and trigger slope to negative.

d. Adjust A TRIG HOLDOFF for maximum time of negative pulse on test oscilloscope display. (Avoid setting near B ENDS A detent where negative portion decreases).

e. CHECK—That maximum holdoff time is 9 or more times the TIME/DIV setting on the 475A.

f. CHECK—475A TIME/DIV settings from 0.01 μs to 0.5 s for maximum holdoff time of 9 or more times the TIME/DIV setting on the 475A.

GATE OUTPUTS, EXTERNAL Z AXIS AND CALIBRATOR

Equipment Required

1. Test Oscilloscope With 10X Probe
2. Digital Voltmeter
3. Amplitude Calibrator
4. 42-inch 50-ohm BNC Cable

Before you begin, see ADJUSTMENT LOCATIONS 4 *in the pullout pages.*

Control Settings

POWER	ON

Display

INTENSITY	Midrange
FOCUS	Midrange
SCALE ILLUM	Midrange

Vertical (CH 1 and CH 2)

POSITION	Midrange
VOLTS/DIV	5 mV
VAR VOLTS/DIV	Calibrated detent
AC-GND-DC	DC
INVERT	Off (button out)
VERT MODE	CH 1
100 OR 20 MHz BW	**20 (new setting)**

Trigger (A and B)

COUPLING	AC
LEVEL	0
SLOPE	+
A TRIGGER SOURCE	NORM
B TRIGGER SOURCE	STARTS AFTER DELAY
TRIG MODE	AUTO
A TRIG HOLDOFF	**NORM (new setting)**

Sweep

A TIME/DIV	**0.2 ms (new setting)**
B TIME/DIV	**0.2 ms (new setting)**
VAR TIME/DIV	Calibrated detent
DELAY TIME POSITION	**Fully counterclockwise (new setting)**
HORIZ DISPLAY	A
X10 MAG	Off (button out)
POSITION (Horiz)	Midrange
FINE	Midrange

84. Check A and B +GATE Outputs

a. Connect A +GATE (output connector on rear panel) to channel 1 of test oscilloscope through a 42-inch 50-ohm BNC cable.

b. Set test oscilloscope: time/div to 1 millisecond, channel 1 for 2 volts/division and trigger slope to positive.

c. CHECK—Test oscilloscope display for a positive pulse amplitude of approximately 5 volts.

d. Set HORIZ DISPLAY to A INTEN and move cable from A +GATE connector to B +GATE connector.

e. CHECK—Repeat part c.

f. Disconnect all test equipment.

85. Check EXT Z-Axis Operation

a. Set HORIZ DISPLAY to A and set TIME/DIV to 1 ms.

b. Set amplitude calibrator for a 5 volt output and connect to EXT Z-AXIS (input connector on rear panel) through a 50-ohm BNC cable.

c. CHECK—For noticeable modulation at normal intensity. Adjust VAR TIME/DIV, if necessary, to observe modulation, then return to calibrated detent.

d. Disconnect all test equipment.

86. Adjust CALIBRATOR Output Amplitude

a. Connect the digital voltmeter between the CALIBRATOR current loop and ground test point. See ADJUSTMENT LOCATIONS 4-B.

b. Apply a short circuit between the calibrator test points, TP1503 and TP1504. See ADJUSTMENT LOCATIONS 4-B.

c. CHECK—For a reading of 0.3 volts, within 3 millivolts, from 0%°C to +40°C; within 4.5 millivolts, from −15°C to +55°C.

d. ADJUST—Calibrator Amplitude, R1515, for a reading of 0.3 volt. See ADJUSTMENT LOCATIONS 4-B.

e. Remove the short circuit between calibrator test points and disconnect all test equipment.

87. Check CALIBRATOR Frequency

a. Set CH 1 VOLTS/DIV to 10 mV and set TIME/DIV to 1 ms.

b. Connect a 10X probe from CALIBRATOR current loop to CH 1 input.

c. CHECK—For approximately 1 cycle/division.

This completes the calibration procedure for the 475A. Disconnect all test equipment, replace the vertical output circuit board cover and replace the cabinet. See Cabinet Installation instructions in the Maintenance Section of this manual for important installation information.

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.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

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

ACTR	ACTUATOR	PLSTC	PLASTIC
ASSY	ASSEMBLY	QTZ	QUARTZ
CAP	CAPACITOR	RECP	RECEPTACLE
CER	CERAMIC	RES	RESISTOR
CKT	CIRCUIT	RF	RADIO FREQUENCY
COMP	COMPOSITION	SEL	SELECTED
CONN	CONNECTOR	SEMICOND	SEMICONDUCTOR
ELCTLT	ELECTROLYTIC	SENS	SENSITIVE
ELEC	ELECTRICAL	VAR	VARIABLE
INCAND	INCANDESCENT	WW	WIREWOUND
LED	LIGHT EMITTING DIODE	XFMR	TRANSFORMER
NONWIR	NON WIREWOUND	XTAL	CRYSTAL

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
00853	SANGAMO ELECTRIC CO., S. CAROLINA DIV.	P O BOX 128	PICKENS, SC 29671
01121	ALLEN-BRADLEY COMPANY	1201 2ND STREET SOUTH	MILWAUKEE, WI 53204
01281	TRW ELECTRONIC COMPONENTS, SEMICONDUCTOR OPERATIONS	14520 AVIATION BLVD.	LAWNDALE, CA 90260
01295	TEXAS INSTRUMENTS, INC., SEMICONDUCTOR GROUP	P O BOX 5012, 13500 N CENTRAL EXPRESSWAY	DALLAS, TX 75222
01963	CHERRY ELECTRICAL PRODUCTS CORPORATION	3600 SUNSET AVENUE	WAUKEGAN, IL 60085
02735	RCA CORPORATION, SOLID STATE DIVISION	ROUTE 202	SOMERVILLE, NY 08876
03508	GENERAL ELECTRIC COMPANY, SEMI-CONDUCTOR PRODUCTS DEPARTMENT	ELECTRONICS PARK	SYRACUSE, NUY 13201
04222	AVX CERAMICS., DIVISION OF AVX CORP.	P O BOX 867, 19TH AVE. SOUTH	MURTLE 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 94040
07910	TELEDYNE SEMICONDUCTOR	12515 CHADRON AVE.	HAWTHORNE, CA 90250
08806	GENERAL ELECTRIC CO., MINIATURE LAMP PRODUCTS DEPT.	NELA PK.	CLEVELAND, OH 44112
09353	C AND K COMPONENTS, INC.	103 MORSE STREET	WATERTOWN, MA 02172
12637	FLEET PRODUCTS COMPANY, INC.	1920 E POMONA STREET	SANTA ANA, CA 92705
12697	CLAROSTAT MFG. CO., INC.	LOWER WASHINGTON ST.	DOVER, NH 03820
12969	UNITRODE CORP.	580 PLEASANT ST.	WATERTOWN, MA 02172
14099	SEMTECH CORP.	652 MITCHELL RD.	NEWBURY PARK, CA 91320
15454	RODAN INDUSTRIES, INC.	2905 BLUE STAR ST.	ANAHEIM, CA 92806
15818	TELEDYNE SEMICONDUCTOR	1300 TERRA BELLA AVE.	MOUNTAIN VIEW, CA 94040
24211	GRIGSBY-BARTON INC.	3800 INDUSTRIAL DRIVE	ROLLING MEADOWS, IL 60008
24931	SPECIALTY CONNECTOR CO., INC.	3560 MADISON AVE.	INDIANAPOLIS, IN 46227
25088	SIEMENS CORP.	186 WOOD AVE. S	ISELIN, NJ 08830
27014	NATIONAL SEMI-CONDUCTOR CORP.	2900 SAN YSIDRO WAY	SANTA CLARA, CA 95051
28480	HEWLETT-PACKARD CO., CORPORATE HQ.	1501 PAGE MILL RD.	PALO ALTO, CA 94304
32997	BOURNS, INC., TRIMPOT PRODUCTS DIV.	1200 COLUMBIA AVE.	RIVERSIDE, CA 92507
50157	N. L. INDUSTRIES, INC., ELECTRONICS DEPT.	P. O. BOX 787	MUSKEGON, MI 49443
56289	SPRAGUE ELECTRIC CO.		NORTH ADAMS, MA 01247
71400	BUSSMAN MFG., DIVISION OF MCGRAW EDISON CO.	2536 W. UNIVERSITY ST.	ST. LOUIS, MO 63107
72136	ELECTRO MOTIVE MFG. CO., INC., THE	SOUTH PARK AND JOHN STREETS	WILLIMANTIC, CT 06226
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.	P. O. BOX 5825	COMPTON, CA 90224
78488	STACKPOLE CARBON CO.		ST. MARYS, PA 15857
80009	TEKTRONIX, INC.	P. O. BOX 500	BEAVERTON, OR 97005
80740	BECKMAN INSTRUMENTS, INC.	2500 HARBOR BlVD.	FULLERTON, CA 92634
81483	INTERNATIONAL RECTIFIER CORP.	9220 SUNSET BlVD.	LOS ANGELES, CA 90069
82389	SWITCHCRAFT, INC.	5555 N. ELSTON AVE.	CHICAGO, IL 60630
90201	MALLORY CAPACITOR CO., DIV. OF P. R. MALLORY CO., INC.	3029 E. WASHINGTON ST.	INDIANAPOLIS, IN 46206
91637	DALE ELECTRONICS, INC.	P. O. BOX 609	COLUMBUS, NB 68601
93410	ESSEX INTERNATIONAL, INC., CONTROLS DIV. MANSFIELD PLANT	P. O. BOX 1007	MANSFIELD, OH 44903

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A1	670-3120-01			CKT CARD ASSY:CH 1 ATTENUATOR	80009	670-3120-01
A2	670-3120-01			CKT CARD ASSY:CH 2 ATTENUATOR	80009	670-3120-01
A3	670-2240-03			CKT CARD ASSY:VERT PERAMPL	80009	670-2240-03
A3[1]	670-2240-04			CKT CARD ASSY:VERT PREAMPL	80009	670-2240-04
A4	670-2243-01			CKT CARD ASSY:VERT MODE GAIN SW	80009	670-2243-01
A5	670-2242-02			CKT CARD ASSY:VERT OUTPUT	80009	670-2242-02
A6	670-2245-00			CKT CARD ASSY:FAN MOTOR	80009	670-2245-00
A7	670-3468-01			CKT CARD ASSY:TIMING	80009	670-3468-01
A8	670-2241-02			CKT CARD ASSY:TRIGGER GEN AND Z-AXIS LOGIC	80009	670-2241-02
A9	670-2239-04			CKT CARD ASSY:INTERFACE	80009	670-2239-04
A10	670-2279-00			CKT CARD ASSY:GRATICULE ILLUM	80009	670-2279-00
B1690	147-0035-00			MOTOR,DC:BRUSHLESS,10-15VDC,145MA	25088	1AD3001-0A
C10	281-0064-00			CAP.,VAR,PLSTC:0.25-1.5PF,600V	72982	530-002
C11	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C12	285-0816-01			CAP.,FXD,PLSTC:0.019UF,10%,600V	80009	285-0816-01
C13	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C30(2)	307-1014-01			ATTENUATOR,FXD:100X	80009	307-1014-01
C31						
C32(2)	307-1013-01			ATTENUATOR,FXD:10X	80009	307-1013-01
C33						
C34(2)	307-1012-00			ATTENUATOR,FXD:5X	80009	307-1012-00
C35						
C36(2)	307-1010-01			ATTENUATOR,FXD:2X	80009	307-1010-01
C37						
C41	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111B213Z5U0102Z
C50	281-0064-00			CAP.,VAR,PLSTC:0.25-1.5PF,600V	72982	530-002
C51	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C52	285-0816-01			CAP.,FXD,PLSTC:0.019UF,10%,600V	80009	285-0816-01
C53	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C61	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111B213Z5U0102Z
C104	281-0064-00			CAP.,VAR,PLSTC:0.25-1.5PF,600V	72982	530-002
C105	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C107	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C109	283-0191-00			CAP.,FXD,CER DI:0.022UF,20%,50V	72982	8121N063 E223M
C112	281-0122-00			CAP.,VAR,CER DI:2.5-9PF,100V	72982	518-000A2.5-9
C113	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111B213Z5U0102Z
C119	283-0191-00			CAP.,FXD,CER DI:0.022UF,20%,50V	72982	8121N063 E223M
C123	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C127	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C133	281-0123-00			CAP.,VAR,CER DI:5-25PF,100V	72982	518-000A5-25
C136	283-0213-00			CAP.,FXD,CER DI:300PF,5%,100V	72982	8121N130 A 301J
C137	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145 E 104Z
C138	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039 E 105Z
C139	283-0238-00			CAP.,FXD,CER DI:0.01UF,10%,50V	72982	8121N071WR5103K
C142[2]						
C144	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C147[2]						
C151[2]						
C152[2]						
C157	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C158	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111B213Z5U0102Z

[1]Option 7 only.
[2]Part of Circuit Card.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C172	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C175	281-0123-00			CAP.,VAR,CER DI:5-25PF,100V	72982	518-000A5-25
C182	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C204	281-0064-00			CAP.,VAR,PLSTC:0.25-1.5PF,600V	72982	530-002
C205	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C207	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C209	283-0191-00			CAP.,FXD,CER DI:0.022UF,20%,50V	72982	8121N063 E223M
C212	281-0122-00			CAP.,VAR,CER DI:2.5-9PF,100V	72982	518-000A2.5-9
C213	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111B213Z5U0102Z
C219	283-0191-00			CAP.,FXD,CER DI:0.022UF,20%,50V	72982	8121N063 E223M
C223	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C227	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C233	281-0123-00			CAP.,VAR,CER DI:5-25PF,100V	72982	518-000A5-25
C236	283-0213-00			CAP.,FXD,CER DI:300PF,5%,100V	72982	8121N130 A 301J
C237	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145 E 104Z
C238	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039 E 105Z
C239	283-0238-00			CAP.,FXD,CER DI:0.01UF,10%,50V	72982	8121N071WR5103K
C242[1]						
C244	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C247[1]						
C251[1]						
C252[1]						
C257	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C258	283-0156-00			CAP.,FXD,CER DI:1000PF,+100-0%,200V	72982	8111B213Z5U0102Z
C272	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C275	281-0123-00			CAP.,VAR,CER DI:5-25PF,100V	72982	518-000A5-25
C282	283-0103-00			CAP.,FXD,CER DI:180PF,5%,500V	56289	40C638
C291	290-0525-00			CAP.,FXD,ELCTLT:4.7UF,20%,50V	56289	196D475X0050KA1
C292	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C297	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C310	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C320	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C329	283-0024-00			CAP.,FXD,CER DI:0.1UF,+80-20%,30V	72982	8131N039Z5U-104Z
C335	283-0677-00			CAP.,FXD,MICA D:82PF,1%,500V	00853	D155E820F0
C336	283-0677-00			CAP.,FXD,MICA D:82PF,1%,500V	00853	D155E820F0
C338[2]	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-055C0G0100F
C343	281-0549-00			CAP.,FXD,CER DI:68PF,10%,500V	72982	301-000U2J0680K
C346	281-0543-00			CAP.,FXD,CER DI:270PF,10%,500V	72982	301055X5P271K
C377	281-0564-00			CAP.,FXD,CER DI:24PF,5%,500V	72982	301-000C0G0240J
C378	283-0640-00			CAP.,FXD,MICA D:160PF,1%,100V	00853	D151E161F0
C393	281-0659-00			CAP.,FXD,CER DI:4.3PF,+/-0.25PF,500V	72982	301-000C0H0439C
C394	281-0547-00			CAP.,FXD,CER DI:2.7PF,10%,500V	72982	301-000C0J0279C
C396	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C398	281-0628-00			CAP.,FXD,CER DI:15PF,5%,500V	72982	301-000C0G0150J
C399	281-0508-00			CAP.,FXD,CER DI:12PF,+/-0.6PF,500V	72982	301-000C0G0120J
C403	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C420	281-0547-00			CAP.,FXD,CER DI:2.7PF,10%,500V	72982	301-000C0J0279C
C430	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C436	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C437	283-0080-00			CAP.,FXD,CER DI:0.022UF,+80-20%,25V	56289	19C611
C438	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C439	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1

[1]Part of Circuit Board.
[2]Option 7 only.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C441[1]						
C445[1]						
C450	281-0122-00			CAP.,VAR,CER DI:2.5-9PF,100V	72982	518-000A2.5-9
C454	283-0058-00			CAP.,FXD,CER DI:0.027UF,10%,100V	72982	8131N147W5R273K
C455	283-0180-00			CAP.,FXD,CER DI:5600PF,20%,200V	72982	8121N204 E 562M
C460	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C466	281-0122-00			CAP.,VAR,CER DI:2.5-9PF,100V	72982	518-000A2.5-9
C470	281-0122-00			CAP.,VAR,CER DI:2.5-9PF,100V	72982	518-000A2.5-9
C471	281-0097-00			CAP.,VAR,CER DI:9-35PF,200V	72982	538-006E2P094R
C472	281-0613-00			CAP.,FXD,CER DI:10PF,+/-1PF,200V	72982	374-001C0G0100F
C475	283-0116-00			CAP.,FXD,CER DI:820PF,5%,500V	72982	801-547B821J
C476	283-0139-00			CAP.,FXD,CER DI:150PF,20%,50V	72982	8101A058B 151M
C477	281-0123-00			CAP.,VAR,CER DI:5-25PF,100V	72982	518-000A5-25
C485	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C486	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C491	283-0067-00			CAP.,FXD,CER DI:0.001UF,10%,200V	72982	835-515B102K
C494A	283-0198-00			CAP.,FXD,CER DI:0.22UF,20%,50V	72982	8131N075 E224M
C494B[1]	283-0341-00			CAP.,FXD,CER DI:0.047UF,10%,100V	72982	8131N145W5R473K
C498	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C499	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C500	281-0511-00			CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000C0G0220K
C504	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C506	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C507	281-0546-00			CAP.,FXD,CER DI:330PF,10%,500V	04222	7001-1380
C508	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C509	281-0511-00			CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000C0G0220K
C510	281-0505-00			CAP.,FXD,CER DI:12PF,+/-1.2PF,500V	72982	301-012C0G0120K
C511	281-0662-00			CAP.,FXD,CER DI:10PF,+/-0.5PF,500V	72982	301-000H3M0100D
C513[2]						
C515	281-0605-00			CAP.,FXD,CER DI:200PF,10%,500V	04222	7001-1375
C516	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C519	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C520	281-0511-00			CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000C0G0220K
C521	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C524	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C525	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C526	281-0601-00			CAP.,FXD,CER DI:7.5PF,500V	72982	301-000C0H0759D
C543	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C546	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C554	281-0508-00			CAP.,FXD,CER DI:12PF,+/-0.6PF,500V	72982	301-000C0G0120J
C555	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C556	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C557	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C562	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C565	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C570	290-0525-00			CAP.,FXD,ELCTLT:4.7UF,20%,50V	56289	196D475X0050KA1
C571	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C583	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C584	281-0617-00			CAP.,FXD,CER DI:15PF,10%,200V	72982	374-001C0G0150K
C593	281-0524-00			CAP.,FXD,CER DI:150PF,+/-30PF,500V	04222	7001-1381
C596	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C599	281-0519-00			CAP.,FXD,CER DI:47PF,+/-4.7PF,500V	72982	308-000C0G0470K
C600	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL

[1]Selected and added if necessary.
[2]Short adjustable wire.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C606	290-0526-00			CAP.,FXD,ELCTLT:6.8UF,20%,6V	90201	TDC685M006EL
C607	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C608	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C609	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C610	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C611	281-0592-00			CAP.,FXD,CER DI:4.7PF,+/-0.5PF,500V	72982	301-023C0H0479D
C622	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C627	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C644	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C647	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C668	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C669	SELECTED					
C670	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C673	281-0632-00			CAP.,FXD,CER DI:35PF,1%,500V	72982	308-000C0G0350F
C675	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C679	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C683	281-0629-00			CAP.,FXD,CER DI:33PF,5%,600V	72982	308-000C0G0330J
C684	281-0519-00			CAP.,FXD,CER DI:47PF,+/-4.7PF,500V	72982	308-000C0G0470K
C693	281-0528-00			CAP.,FXD,CER DI:82PF,+/-8.2PF,500V	72982	301-000U2M0820K
C695	281-0503-00			CAP.,FXD,CER DI:8PF,+/-0.5PF,500V	72982	301-000C0H0809D
C698	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C711	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C712	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C713	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C714	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C715	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C717	281-0511-00			CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000C0G0220K
C718	281-0511-00			CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000C0G0220K
C719	281-0511-00			CAP.,FXD,CER DI:22PF,+/-2.2PF,500V	72982	301-000C0G0220K
C721	281-0505-00			CAP.,FXD,CER DI:12PF,+/-1.2PF,500V	72982	301-012C0G0120K
C722	281-0662-00			CAP.,FXD,CER DI:10PF,+/-0.5PF,500V	72982	301-000H3M0100D
C729	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C735	281-0605-00			CAP.,FXD,CER DI:200PF,10%,500V	04222	7001-1375
C736	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C739	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C741	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C744	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C745	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C746	281-0601-00			CAP.,FXD,CER DI:7.5PF,500V	72982	301-000C0H0759D
C752	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C763	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C764	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C766	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C771	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C774	281-0508-00			CAP.,FXD,CER DI:12PF,+/-0.6PF,500V	72982	301-000C0G0120J
C775	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C776	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C777	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C783	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C785	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C795	283-0001-00			CAP.,FXD,CER DI:0.005UF,+100-0%,500V	72982	831-559E502P
C798	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C799	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C803	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C811	281-0509-00			CAP.,FXD,CER DI:15PF,+/-1.5PF,500V	72982	301-000C0G0150K
C819	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C823	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C824	281-0617-00			CAP.,FXD,CER DI:15PF,10%,200V	72982	374-001C0G0150K
C825	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C826	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C905	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C913	290-0525-00			CAP.,FXD,ELCTLT:4.7UF,20%,50V	56289	196D475X0050KA1
C917	281-0525-00			CAP.,FXD,CER DI:470PF,+/-94PF,500V	04222	7001-1364
C922	281-0509-00			CAP.,FXD,CER DI:15PF,+/-1.5PF,500V	72982	301-000C0G0150K
C923	283-0059-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8141N037Z5U0105Z
C933	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C947	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C961	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C963	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C965	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C967	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C969	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C976	281-0579-00			CAP.,FXD,CER DI:21PF,5%,500V	72982	301-050C0G0210J
C984	281-0658-00			CAP.,FXD,CER DI:6.2PF,+/-0.25PF,500V	72982	301-000C0H0629C
C1007	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C1008	283-0157-00			CAP.,FXD,CER DI:7PF,5%,500V	72982	8111B064C0H0709J
C1009	281-0168-00			CAP.,VAR,AIR DI:1.3-5.4PF,250V	74970	187-0103-035
C1010	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C1023	281-0096-00			CAP.,VAR,AIR DI:5.5-18PF,350V	72982	538-006D9-35
C1025	281-0096-00			CAP.,VAR,AIR DI:5.5-18PF,350V	72982	538-006D9-35
C1033	281-0549-00			CAP.,FXD,CER DI:68PF,10%,500V	72982	301-000U2J0680K
C1045	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C1050	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C1052	281-0589-00			CAP.,FXD,CER DI:170PF,5%,500V	72982	301000Z5D171J
C1054	290-0525-00			CAP.,FXD,ELCTLT:4.7UF,20%,50V	56289	196D475X0050KA1
C1056	283-0341-00			CAP.,FXD,CER DI:0.047UF,10%,100V	72982	8131N145W5R473K
C1058	281-0543-00			CAP.,FXD,CER DI:270PF,10%,500V	72982	301055X5P271K
C1059	290-0392-00			CAP.,FXD,ELCTLT:3.6UF,10%,125V	90201	TLS365K125B1A
C1062	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C1064	281-0096-00			CAP.,VAR,AIR DI:5.5-18PF,350V	72982	538-006D9-35
C1071 [1]				CAP.,MATCHED:10UF		
C1072 [1]	295-0163-00			CAP.,MATCHED:10UF,0.1UF,0.001UF	80009	295-0163-00
C1073 [1]				CAP.,MATCHED:985PF		
C1075	283-0144-00			CAP.,FXD,CER DI:33PF,1%,500V	72982	801-457P2G330F
C1081	281-0523-00			CAP.,FXD,CER DI:100PF,+/-20PF,500V	72982	301-000U2M0101M
C1082 [1]				CAP.,MATCHED:10UF		
C1083 [1]	295-0163-00			CAP.,MATCHED:10UF,0.1UF,0.001UF	80009	295-0163-00
C1085 [1]				CAP.,MATCHED:985PF		
C1091	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C1093	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C1103	283-0670-00			CAP.,FXD,MICA D:375PF,1%,500V	00853	D155F3750F0
C1107 [2]	281-0547-00			CAP.,FXD,CER DI:2.7PF,10%,500V	72982	301-000C0J0279C
C1114	283-0010-00			CAP.,FXD,CER DI:0.05UF,+100-20%,50V	56289	79688-001
C1124	283-0116-00			CAP.,FXD,CER DI:820PF,5%,500V	72982	801-547B821J
C1134	283-0116-00			CAP.,FXD,CER DI:820PF,5%,500V	72982	801-547B821J
C1140	283-0010-00			CAP.,FXD,CER DI:0.05UF,+100-20%,50V	56289	79688-001

[1]Individual timing capacitors in this assembly must be ordered by the 9-digit part number, letter suffix and tolerance printed on the timing capacitor to be replaced. The letter suffix and the tolerance should be the same for all of the timing capacitors in the assembly.
EXAMPLE: 285-XXXX-XX F-

[2]Selected and added if necessary.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C1142	283-0111-00			CAP.,FXD,CER DI:0.1UF,20%,50V	72982	8131N075651104M
C1152	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C1162	283-0003-00			CAP.,FXD,CER DI:0.01UF,+80-20%,150V	72982	855558Z5U0103Z
C1178	283-0644-00			CAP.,FXD,MICA D:150PF,1%,500V	00853	D151E151F0
C1179	281-0118-00			CAP.,VAR,MICA D:8-90PF,750V	72136	T50417-6
C1187	283-0010-00			CAP.,FXD,CER DI:0.05UF,+100-20%,50V	56289	79688-001
C1201	283-0005-00			CAP.,FXD,CER DI:0.01UF,+100-0%,250V	72982	8131N300Z5U0103P
C1205	283-0005-00			CAP.,FXD,CER DI:0.01UF,+100-0%,250V	72982	8131N300Z5U0103P
C1211	283-0005-00			CAP.,FXD,CER DI:0.01UF,+100-0%,250V	72982	8131N300Z5U0103P
C1212	283-0005-00			CAP.,FXD,CER DI:0.01UF,+100-0%,250V	72982	8131N300Z5U0103P
C1216	283-0010-00			CAP.,FXD,CER DI:0.05UF,+100-20%,50V	56289	79688-001
C1231	283-0638-00			CAP.,FXD,MICA D:130PF,1%,100V	00853	D151E131F0
C1233	281-0153-00			CAP.,VAR,AIR DI:1.7-10PF,250V	74970	187-0106-005
C1235[1]						
C1251	283-0638-00			CAP.,FXD,MICA D:130PF,1%,100V	00853	D151E131F0
C1253	281-0153-00			CAP.,VAR,AIR DI:1.7-10PF,250V	74970	187-0106-005
C1255[1]						
C1261	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C1263	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C1265	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C1267	283-0092-00			CAP.,FXD,CER DI:0.03UF,+80-20%,200V	72982	845-534E303Z
C1302	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C1304	290-0573-00			CAP.,FXD,ELCTLT:2.7UF,20%,50V	56289	196D275X0050JA1
C1305	290-0572-00			CAP.,FXD,ELCTLT:0.1UF,20%,50V	56289	196D104X0050HA1
C1316	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C1317	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C1318	290-0312-00			CAP.,FXD,ELCTLT:47UF,10%,35V	56289	150D476X9035S2
C1320	283-0011-00			CAP.,FXD,CER DI:0.01UF,2000V	72982	3878012Z5U0103Z
C1322	283-0071-00			CAP.,FXD,CER DI:0.0068UF,+80-30%,5000V	56289	45C10A1
C1323	283-0071-00			CAP.,FXD,CER DI:0.0068UF,+80-30%,5000V	56289	45C10A1
C1326	281-0519-00			CAP.,FXD,CER DI:47PF,+/-4.7PF,500V	72982	308-000C0G0470K
C1328	283-0071-00			CAP.,FXD,CER DI:0.0068UF,+80-30%,5000V	56289	45C10A1
C1329	283-0002-00			CAP.,FXD,CER DI:0.01UF,+80-20%,500V	72982	811-546E103Z
C1330	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C1335	283-0078-00			CAP.,FXD,CER DI:0.001UF,20%,500V	56289	20C114A8
C1336	283-0078-00			CAP.,FXD,CER DI:0.001UF,20%,500V	56289	20C114A8
C1346	283-0002-00			CAP.,FXD,CER DI:0.01UF,+80-20%,500V	72982	811-546E103Z
C1348	283-0005-00			CAP.,FXD,CER DI:0.01UF,+100-0%,250V	72982	8131N300Z5U0103P
C1352	281-0064-00			CAP.,VAR,PLSTC:0.25-1.5PF,600V	72982	530-002
C1354	283-0005-00			CAP.,FXD,CER DI:0.01UF,+100-0%,250V	72982	8131N300Z5U0103P
C1358	283-0057-00			CAP.,FXD,CER DI:0.1UF,+80-20%,200V	56289	274C10
C1363	283-0057-00			CAP.,FXD,CER DI:0.1UF,+80-20%,200V	56289	274C10
C1366	281-0627-00			CAP.,FXD,CER DI:1PF,+/-0.25PF,500V	72982	301-000C0K0109C
C1371	285-1040-00			CAP.,FXD,PLSTC:0.0012UF,10%,4000V	56289	430P522
C1372	285-1040-00			CAP.,FXD,PLSTC:0.0012UF,10%,4000V	56289	430P522
C1373	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145 E 104Z
C1374	290-0164-00			CAP.,FXD,ELCTLT:1UF,+50-10%,150V	56289	30D105F150BA2
C1380	285-1040-00			CAP.,FXD,PLSTC:0.0012UF,10%,4000V	56289	430P522
C1387	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C1388	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C1390	283-0001-00			CAP.,FXD,CER DI:0.005UF,+100-0%,500V	72982	831-559E502P
C1394	283-0001-00			CAP.,FXD,CER DI:0.005UF,+100-0%,500V	72982	831-559E502P
C1397	283-0001-00			CAP.,FXD,CER DI:0.005UF,+100-0%,500V	72982	831-559E502P

[1]Part of Circuit Card.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C1399	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145 E 104Z
C1412	290-0585-00			CAP.,FXD,ELCTLT:350UF,+75-10%,75V	90201	20-36095
C1414	290-0586-00			CAP.,FXD,ELCTLT:1000UF,+75-10%,75V	90201	20-36096
C1416	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C1428	290-0525-00			CAP.,FXD,ELCTLT:4.7UF,20%,50V	56289	196D475X0050KA1
C1431	281-0546-00			CAP.,FXD,CER DI:330PF,10%,500V	04222	7001-1380
C1442	290-0584-00			CAP.,FXD,ELCTLT:5500UF,+100-10%,30V	90201	20-36094
C1448	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C1452	290-0571-00			CAP.,FXD,ELCTLT:5000UF,+100-0%,25V	90201	PFP20-36043
C1455	283-0004-00			CAP.,FXD,CER DI:0.02UF,+80-20%,150V	72982	855-558-Z5V0203Z
C1458	290-0535-00			CAP.,FXD,ELCTLT:33UF,20%,10V	56289	196D336X0010KA1
C1462	290-0584-00			CAP.,FXD,ELCTLT:5500UF,+100-10%,30V	90201	20-36094
C1468	290-0535-00			CAP.,FXD,ELCTLT:33UF,20%,10V	56289	196D336X0010KA1
C1472	290-0583-00			CAP.,FXD,ELCTLT:3000UF,+100-10%,35V	56289	68D10490
C1478	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
C1483	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145 E 104Z
C1489	283-0092-00			CAP.,FXD,CER DI:0.03UF,+80-20%,200V	72982	845-534E303Z
C1492	290-0523-00			CAP.,FXD,ELCTLT:2.2UF,20%,20V	56289	196D225X0025HA1
C1504	281-0551-00			CAP.,FXD,CER DI:390PF,10%,500V	04222	7001-1363
C1505	285-0686-00			CAP.,FXD,PLSTC:0.068UF,10%,100V	56289	410P108
C1511	290-0532-00			CAP.,FXD,ELCTLT:150UF,20%,6V	90201	TDC157M006CL
C1512	281-0512-00			CAP.,FXD,CER DI:27PF,+/-2.7PF,500V	72982	308-000C0G0270K
C1698	290-0536-00			CAP.,FXD,ELCTLT:10UF,20%,25V	90201	TDC106M025FL
CR103	152-0323-01			SEMICOND DEVICE:SILICON,35V,100MA	80009	152-0323-01
CR104	152-0323-01			SEMICOND DEVICE:SILICON,35V,100MA	80009	152-0323-01
CR105	152-0323-01			SEMICOND DEVICE:SILICON,35V,100MA	80009	152-0323-01
CR107	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR170	152-0422-00			SEMICOND DEVICE:SILICON,4V,7PF	01281	PG1084
CR174	152-0422-00			SEMICOND DEVICE:SILICON,4V,7PF	01281	PG1084
CR182	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR203	152-0323-01			SEMICOND DEVICE:SILICON,35V,100MA	80009	152-0323-01
CR204	152-0323-01			SEMICOND DEVICE:SILICON,35V,100MA	80009	152-0323-01
CR205	152-0323-01			SEMICOND DEVICE:SILICON,35V,100MA	80009	152-0323-01
CR207	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR270	152-0422-00			SEMICOND DEVICE:SILICON,4V,7PF	01281	PG1084
CR274	152-0422-00			SEMICOND DEVICE:SILICON,4V,7PF	01281	PG1084
CR282	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR290	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR301	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR306	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR312	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR322	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR336	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR351	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR352	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR359	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR361	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR368	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR369	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR422	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR480	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR519	152-0246-00			SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR556	152-0140-01			SEMICOND DEVICE:TUNNEL,10MA,8PF	03508	SMTD995

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
CR566	152-0140-01			SEMICOND DEVICE:TUNNEL,10MA,8PF	03508	SMTD995
CR582	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR584	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR592	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR601	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR647	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR604	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR605	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR680	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR681	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR682	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR683	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR685	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR689	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR693	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR694	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR699	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR701	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR703	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR705	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR739	152-0246-00			SEMICOND DEVICE:SILICON,400PIV,200MA	07910	CD12676
CR776	152-0140-01			SEMICOND DEVICE:TUNNEL,10MA,8PF	03508	SMTD995
CR786	152-0140-01			SEMICOND DEVICE:TUNNEL,10MA,8PF	03508	SMTD995
CR787	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR788	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR792	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR793	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR794	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR795	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR796	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR797	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR799	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR801	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR802	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR806	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR811	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR812	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR814	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR822	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR824	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR903	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR907	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR910	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR914	152-0501-00			SEMICOND DEVICE:SILICON,70V,200MA	04713	MSD6150
CR922	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR923	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR926	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	28480	5082-2672
CR927	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	28480	5082-2672
CR940	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR943	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR944	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR945	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR952	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
CR955	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR956	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR971	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR976	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR985	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR987	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR988	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR996	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1001	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1006	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1015	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1017	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1018	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1023	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1026	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1028	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1029	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1034	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1036	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1037	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1044	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1046	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1049	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1052	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1054	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1056	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1058	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1060	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1061	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1062	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1102	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1103	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1104	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1111	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1121	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	28480	5082-2672
CR1122	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	28480	5082-2672
CR1140	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1164	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1173	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	28480	5082-2672
CR1183	152-0322-00			SEMICOND DEVICE:SILICON,15V,HOT CARRIER	28480	5082-2672
CR1237	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1304	152-0333-00			SEMICOND DEVICE:SILICON,55V,200MA	80009	152-0333-00
CR1310	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1312	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1314	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1316	152-0333-00			SEMICOND DEVICE:SILICON,55V,200MA	80009	152-0333-00
CR1317	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1320	152-0429-00			SEMICOND DEVICE:SILICON,5000V,10MA	14099	SA3282
CR1321	152-0429-00			SEMICOND DEVICE:SILICON,5000V,10MA	14099	SA3282
CR1329	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
CR1331	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	07263	FD7003
CR1337	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1341	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	07263	FD7003

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
CR1342	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1343	152-0153-00			SEMICOND DEVICE:SILICON,15V,50MA	07263	FD7003
CR1344	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1345	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1352	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1353	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1354	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1358	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1360	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
CR1366	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1367	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1368	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1371	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1373	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1377	152-0242-00			SEMICOND DEVICE:SILICON,225V,200MA	12969	NDP341
CR1379	152-0242-00			SEMICOND DEVICE:SILICON,225V,200MA	12969	NDP341
CR1412	152-0488-00			SEMICOND DEVICE:SILICON,200V,1500MA	80009	152-0488-00
CR1415	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
CR1421	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1422	152-0061-00			SEMICOND DEVICE:SILICON,175V,100MA	80009	152-0061-00
CR1424	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1426	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	80009	152-0066-00
CR1428	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	80009	152-0066-00
CR1432	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1442	152-0556-00			SEMICOND DEVICE:BRIDGE,50V,2.5A	04713	MDA960-1
CR1448	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	80009	152-0066-00
CR1452	152-0488-00			SEMICOND DEVICE:SILICON,200V,1500MA	80009	152-0488-00
CR1456	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1458	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	80009	152-0066-00
CR1462	152-0462-00			SEMICOND DEVICE:SILICON,200V,2.5A	04713	SDA10228
CR1466	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1468	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	80009	152-0066-00
CR1472	152-0488-00			SEMICOND DEVICE:SILICON,200V,1500MA	80009	152-0488-00
CR1478	152-0066-00			SEMICOND DEVICE:SILICON,400V,750MA	80009	152-0066-00
CR1489	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
CR1502	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1512	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1691	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1692	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1694	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1696	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR1698	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
DL380	119-0388-00			DELAY LINE,ELEC:	80009	119-0388-00
DS128	150-0035-00			LAMP,GLOW:90V,0.3MA	08806	A1D-T
DS228	150-0035-00			LAMP,GLOW:90V,0.3MA	08806	A1D-T
DS312	150-0130-00			LAMP,INCAND:5V,60MA	08806	2200DX
DS314	150-0130-00			LAMP,INCAND:5V,60MA	08806	2200DX
DS322	150-0130-00			LAMP,INCAND:5V,60MA	08806	2200DX
DS324	150-0130-00			LAMP,INCAND:5V,60MA	08806	2200DX
DS608	150-0130-00			LAMP,INCAND:5V,60MA	08806	2200DX
DS610	150-0130-00			LAMP,INCAND:5V,60MA	08806	2200DX
DS1091	150-0035-00			LAMP,GLOW:90V,0.3MA	08806	A1D-T

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
DS1110	150-0035-00			LAMP,GLOW:90V,0.3MA	08806	A1D-T
DS1382	150-0002-00			LAMP,GLOW:0.5 MA 60/125V	08806	NE2T-A1AT
DS1383	150-0002-00			LAMP,GLOW:0.5 MA 60/125V	08806	NE2T-A1AT
DS1482	150-0129-00			LAMP,INCAND:6.3V,200MA	08806	2112D
DS1483	150-0129-00			LAMP,INCAND:6.3V,200MA	08806	2112D
DS1492	150-0130-00			LAMP,INCAND:5V,60MA	08806	2200DX
F1318	159-0016-00			FUSE,CARTRIDGE:3AG,1.5A,250V,FAST-BLOW	71400	AGC 1 1/2
F1401[1]	159-0016-00			FUSE,CARTRIDGE:3AG,1.5A,250V,FAST-BLOW	71400	AGC 1 1/2
F1401[2]	159-0042-00			FUSE,CARTRIDGE:3AG,0.75A,250V,FAST-BLOW	71400	AGC 3/4
J10	131-0679-02			CONNECTOR,RCPT,:BNC W/HARDWARE	24931	28JR270-1
J50	131-0679-02			CONNECTOR,RCPT,:BNC W/HARDWARE	24931	28JR270-1
J349	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J380	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J385	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J399	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J400	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J405	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J410	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J430	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J435	131-0955-00			CONNECTOR,RCPT:BNC,FEMALE	24931	28JR200-1
J510	131-0955-00			CONNECTOR,RCPT:BNC,FEMALE	24931	28JR200-1
J584	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J589	131-0955-00			CONNECTOR,RCPT:BNC,FEMALE	24931	28JR200-1
J664	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J674	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J694	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J702	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J704	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J706	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J720	131-0955-00			CONNECTOR,RCPT:BNC,FEMALE	24931	28JR200-1
J824	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J829	131-0955-00			CONNECTOR,RCPT:BNC,FEMALE	24931	28JR200-1
J1101	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J1302	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J1330	131-0955-00			CONNECTOR,RCPT:BNC,FEMALE	24931	28JR200-1
J1333	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J1334	131-1003-00			CONNECTOR BODY,:CKT BD MT,3 PRONG	80009	131-1003-00
J1478	131-0771-00			CONNECTOR,RCPT,:4 CONT,QUICK DISCONNECT	80009	131-0771-00
J1479	131-0771-00			CONNECTOR,RCPT,:4 CONT,QUICK DISCONNECT	80009	131-0771-00
K1103	148-0076-00			RELAY,REED:1 FORM A,5V,0.25A,100V	24211	GB831A-22
L141[3]						
L142[3]						
L147[3]						
L148[3]						
L151[4]						
L152[4]						
L170	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L171	276-0528-00			SHIELDING BEAD,:0.1UH	80009	276-0528-00
L172	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L174	276-0528-00			SHIELDING BEAD,:0.1UH	80009	276-0528-00
L178[5]	276-0543-00			SHIELDING BEAD,:	80009	276-0543-00
L180	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L182	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B

[1]For use at 115V operation.
[2]For use at 230V operation.
[3]Part of Circuit Card.
[4]#26 Wire acting as inductance.
[5]Selected.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
L188[1]	276-0543-00			SHIELDING BEAD,:	80009	276-0543-00
L241[2]						
L242[2]						
L247[2]						
L248[2]						
L251[3]						
L252[3]						
L270	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L271	276-0528-00			SHIELDING BEAD,:0.1UH	80009	276-0528-00
L272	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L274	276-0528-00			SHIELDING BEAD,:0.1UH	80009	276-0528-00
L278[1]	276-0543-00			SHIELDING BEAD,:	80009	276-0543-00
L280	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L282	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L288[1]	276-0543-00			SHIELDING BEAD,:	80009	276-0543-00
L291	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L292	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L297	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L375	108-0182-00			COIL,RF:0.3UH	80009	108-0182-00
L376	108-0182-00			COIL,RF:0.3UH	80009	108-0182-00
L435	276-0588-00			CORE,FERRITE:	78488	57-3114
L439	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L441[2]						
L442[2]						
L444[2]						
L445[2]						
L480	276-0528-00			SHIELDING BEAD,:0.1UH	80009	276-0528-00
L498	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L499	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L506[4]	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L546	108-0433-00			COIL,RF:0.09UH	80009	108-0433-00
L551	108-0433-00			COIL,RF:0.09UH	80009	108-0433-00
L572	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L574	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L588	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L600	120-0402-00			XFMR,TOROID:3 TURNS SINGLE	80009	120-0402-00
L669[4]	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L716[4]	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L746[4]	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L771	108-0433-00			COIL,RF:0.09UH	80009	108-0433-00
L772	276-0528-00			SHIELDING BEAD,:0.1UH	80009	276-0528-00
L781	108-0433-00			COIL,RF:0.09UH	80009	108-0433-00
L782	276-0528-00			SHIELDING BEAD,:0.1UH	80009	276-0528-00
L802	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L804	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L826	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L917	108-0750-00			COIL,RF:9.3UH	80009	108-0750-00
L922	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L984	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L1018	120-0407-00			XFMR,TOROID:5 TURNS SINGLE	80009	120-0407-00
L1091	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L1093	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L1102	108-0538-00			COIL,RF:2.7UH	76493	70F276A1
L1103	114-0278-00			COIL,RF:4.6-16.7UH,CORE 276-0568-00	80009	114-0278-00
L1231	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B

[1]Selected.
[2]Part of Circuit Card.
[3]#26 Wire acting as inductance.
[4]Selected and added if necessary.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
L1232[1]	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L1251	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L1252[1]	276-0507-00			SHIELDING BEAD,:0.6UH	78488	57-0180-7D 500B
L1261	108-0245-00			COIL,RF:3.9UH	80009	108-0245-00
L1263	108-0245-00			COIL,RF:3.9UH	80009	108-0245-00
L1265	108-0245-00			COIL,RF:3.9UH	80009	108-0245-00
L1318	108-0422-00			COIL,RF:82UH	80009	108-0422-00
L1330	108-0440-00			COIL,RF:8UH,TOROIDAL INDUCTOR	80009	108-0440-00
L1385	108-0714-00			COIL,TUBE DEFLE:Y AXIS ALIGNMENT	80009	108-0714-00
L1386	108-0713-00			COIL,TUBE DEFLE:TRACE ROTATION	80009	108-0713-00
L1387	108-0245-00			COIL,RF:3.9UH	80009	108-0245-00
L1388	108-0245-00			COIL,RF:3.9UH	80009	108-0245-00
L1394	276-0541-00			SHIELDING BEAD,:	80009	276-0541-00
L1511	108-0245-00			COIL,RF:3.9UH	80009	108-0245-00
LR377	108-0760-00			COIL,RF:67MH	80009	108-0760-00
LR378	108-0760-00			COIL,RF:67MH	80009	108-0760-00
LR467	108-0328-00			COIL,RF:0.3UH	80009	108-0328-00
LR496	108-0685-00			COIL,RF:80NH	80009	108-0685-00
LR497	108-0685-00			COIL,RF:80NH	80009	108-0685-00
LR1335	108-0537-00			COIL,RF:200UH	80009	108-0537-00
LR1336	108-0537-00			COIL,RF:200UH	80009	108-0537-00
Q172	151-0271-00			TRANSISTOR:SILICON,PNP	80009	151-0271-00
Q178	151-0434-00			TRANSISTOR:SILICON,PNP	80009	151-0434-00
Q182	151-0271-00			TRANSISTOR:SILICON,PNP	80009	151-0271-00
Q184	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q188	151-0434-00			TRANSISTOR:SILICON,PNP	80009	151-0434-00
Q272	151-0271-00			TRANSISTOR:SILICON,PNP	80009	151-0271-00
Q278	151-0434-00			TRANSISTOR:SILICON,PNP	80009	151-0434-00
Q282	151-0271-00			TRANSISTOR:SILICON,PNP	80009	151-0271-00
Q284	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q288	151-0434-00			TRANSISTOR:SILICON,PNP	80009	151-0434-00
Q312	151-0435-00			TRANSISTOR:SILICON,PNP	04713	MPS-A65
Q314	151-0435-00			TRANSISTOR:SILICON,PNP	04713	MPS-A65
Q322	151-0435-00			TRANSISTOR:SILICON,PNP	04713	MPS-A65
Q324	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q338	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q348	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q390	151-0441-00			TRANSISTOR:SILICON,NPN	80009	151-0441-00
Q396	151-0271-00			TRANSISTOR:SILICON,PNP	80009	151-0271-00
Q420	151-0223-00			TRANSISTOR:SILICON,NPN	80009	151-0223-00
Q430	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q444	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q502	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q504	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q506	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q522 Q524	151-1042-00			SEMICOND DVC SE:MATCHED PAIR FET	80009	151-1042-00
Q526	151-0221-00			TRANSISTOR:SILICON,PNP	80009	151-0221-00
Q532	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q552	151-0434-00			TRANSISTOR:SILICON,PNP	80009	151-0434-00
Q556	151-0221-00			TRANSISTOR:SILICON,PNP	80009	151-0221-00
Q562	151-0434-00			TRANSISTOR:SILICON,PNP	80009	151-0434-00

[1]Selected and added if necessary.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
Q566	151-0221-00			TRANSISTOR:SILICON,PNP	80009	151-0221-00
Q572	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q574	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q584	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q588	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q594	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q596	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q612	151-0223-00			TRANSISTOR:SILICON,NPN	80009	151-0223-00
Q628	151-0223-00			TRANSISTOR:SILICON,NPN	80009	151-0223-00
Q644	151-0350-00			TRANSISTOR:SILICON,PNP	07263	S036521
Q662	151-0221-00			TRANSISTOR:SILICON,PNP	80009	151-0221-00
Q664	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q672	151-0221-00			TRANSISTOR:SILICON,PNP	80009	151-0221-00
Q674	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q680	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q688	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q698	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q712	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q714	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q716	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q742 Q744	151-1042-00			SEMICOND DVC SE:MATCHED PAIR FET	80009	151-1042-00
Q746	151-0221-00			TRANSISTOR:SILICON,PNP	80009	151-0221-00
Q752	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q772	151-0434-00			TRANSISTOR:SILICON,PNP	80009	151-0434-00
Q776	151-0221-00			TRANSISTOR:SILICON,PNP	80009	151-0221-00
Q782	151-0434-00			TRANSISTOR:SILICON,PNP	80009	151-0434-00
Q786	151-0221-00			TRANSISTOR:SILICON,PNP	80009	151-0221-00
Q788	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q790	151-0223-00			TRANSISTOR:SILICON,NPN	80009	151-0223-00
Q792	151-0223-00			TRANSISTOR:SILICON,NPN	80009	151-0223-00
Q794	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q796	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q798	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q802	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q804	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q824	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q826	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q902	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q904	151-0190-01			TRANSISTOR:SILICON,NPN	07910	TE23652
Q914	151-0261-00			TRANSISTOR:SILICON,PNP,DUAL	04713	SD441
Q920	151-1025-00			TRANSISTOR:SILICON,JFE,N-CHANNEL	80009	151-1025-00
Q922	151-0127-00			TRANSISTOR:SILICON,NPN	07263	S6075
Q926A,B	151-1036-00			TRANSISTOR:SILICON,JFE,N-CHANNEL,DUAL	80009	151-1036-00
Q928	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q938	151-0261-00			TRANSISTOR:SILICON,PNP,DUAL	04713	SD441
Q940	151-0223-00			TRANSISTOR:SILICON,NPN	80009	151-0223-00
Q944	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q946	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q956	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q972	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q974	151-0190-01			TRANSISTOR:SILICON,NPN	07910	TE23652
Q980	151-1025-00			TRANSISTOR:SILICON,JFE,N-CHANNEL	80009	151-1025-00

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
Q984	151-0127-00			TRANSISTOR:SILICON,NPN	07263	S6075
Q988	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q992	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q996	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q1002	151-0347-00			TRANSISTOR:SILICON,NPN	80009	151-0347-00
Q1004	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q1008	151-0347-00			TRANSISTOR:SILICON,NPN	80009	151-0347-00
Q1010	151-1025-00			TRANSISTOR:SILICON,JFE,N-CHANNEL	80009	151-1025-00
Q1014	151-0127-00			TRANSISTOR:SILICON,NPN	07263	S6075
Q1018	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1022	151-0223-00			TRANSISTOR:SILICON,NPN	80009	151-0223-00
Q1026	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1034	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q1044	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q1052	151-0350-00			TRANSISTOR:SILICON,PNP	07263	S036521
Q1054	151-0350-00			TRANSISTOR:SILICON,PNP	07263	S036521
Q1056	151-0350-00			TRANSISTOR:SILICON,PNP	07263	S036521
Q1058	151-0350-00			TRANSISTOR:SILICON,PNP	07263	S036521
Q1062	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1066	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1086	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q1099	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q1112	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1114	151-0127-00			TRANSISTOR:SILICON,NPN	07263	S6075
Q1124	151-0212-00			TRANSISTOR:SILICON,NPN	80009	151-0212-00
Q1134	151-0212-00			TRANSISTOR:SILICON,NPN	80009	151-0212-00
Q1140	151-0223-00			TRANSISTOR:SILICON,NPN	80009	151-0223-00
Q1152	151-0325-00			TRANSISTOR:SILICON,PNP,SEL FROM 2N4258	80009	151-0325-00
Q1162	151-0325-00			TRANSISTOR:SILICON,PNP,SEL FROM 2N4258	80009	151-0325-00
Q1164	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1172	151-0325-00			TRANSISTOR:SILICON,PNP,SEL FROM 2N4258	80009	151-0325-00
Q1174	151-0325-00			TRANSISTOR:SILICON,PNP,SEL FROM 2N4258	80009	151-0325-00
Q1182	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q1184	151-0127-00			TRANSISTOR:SILICON,NPN	07263	S6075
Q1188	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1202	151-0270-00			TRANSISTOR:SILICON,PNP,SEL FROM 2N3495	80009	151-0270-00
Q1204	151-0124-00			TRANSISTOR:SILICON,NPN,SEL FROM 2N3501	80009	151-0124-00
Q1212	151-0270-00			TRANSISTOR:SILICON,PNP,SEL FROM 2N3495	80009	151-0270-00
Q1214	151-0124-00			TRANSISTOR:SILICON,NPN,SEL FROM 2N3501	80009	151-0124-00
Q1234	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1254	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1306	151-0126-00			TRANSISTOR:SILICON,NPN	15818	2N2484
Q1308	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q1310	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q1312	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1316	151-0136-00			TRANSISTOR:SILICON,NPN	02735	35495
Q1318	151-0140-00			TRANSISTOR:SILICON,NPN	80009	151-0140-00
Q1332	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640
Q1338	151-0367-00			TRANSISTOR:SILICON,NPN,SEL FROM 3571TP	80009	151-0367-00
Q1344	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1352	151-0407-00			TRANSISTOR:SILICON,NPN	80009	151-0407-00
Q1354	151-0406-00			TRANSISTOR:SILICON,PNP	07263	S037880
Q1358	151-0199-00			TRANSISTOR:SILICON,PNP	27014	MPS3640

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
Q1362	151-0188-00			TRANSISTOR:SILICON,PNP	01295	2N3906
Q1424	151-0347-00			TRANSISTOR:SILICON,NPN	80009	151-0347-00
Q1426	151-0349-00			TRANSISTOR:SILICON,NPN,SEL FROM MJE2801	80009	151-0349-00
Q1432	151-0347-00			TRANSISTOR:SILICON,NPN	80009	151-0347-00
Q1444	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1446	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1448	151-0349-00			TRANSISTOR:SILICON,NPN,SEL FROM MJE2801	80009	151-0349-00
Q1454	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1456	151-0390-00			TRANSISTOR:SILICON,NPN	80009	151-0390-00
Q1464	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1466	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1468	151-0349-00			TRANSISTOR:SILICON,NPN,SEL FROM MJE2801	80009	151-0349-00
Q1474	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1478	151-0260-02			TRANSISTOR:SILICON,NPN	04713	2N5859
Q1482	151-0390-00			TRANSISTOR:SILICON,NPN	80009	151-0390-00
Q1490	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q1492	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1494	151-0347-00			TRANSISTOR:SILICON,NPN	80009	151-0347-00
Q1496	151-0280-00			TRANSISTOR:SILICON,PNP	80009	151-0280-00
Q1497	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q1498	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1502	151-0342-00			TRANSISTOR:SILICON,PNP	80009	151-0342-00
Q1504	151-0342-00			TRANSISTOR:SILICON,PNP	80009	151-0342-00
Q1512	151-0164-00			TRANSISTOR:SILICON,PNP	80009	151-0164-00
Q1698	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
R10	315-0430-00			RES.,FXD,CMPSN:43 OHM,5%,0.25W	01121	CB4305
R13	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R22(2)	316-0105-00			RES.,FXD,CMPSN:1M OHM,10%,0.25W	01121	CB1051
R24(2)	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
R31(2)[1]						
R32(2)	317-0082-00			RES.,FXD,CMPSN:8.2 OHM,(NOM VALUE),SEL	01121	BB82G5
R33(2)	315-0360-00			RES.,FXD,CMPSN:36 OHM,5%,0.25W	01121	CB3605
R34(2)	317-0300-00			RES.,FXD,CMPSN:30 OHM,(NOM VALUE),SEL	01121	BB3005
R35(2)	317-0390-00			RES.,FXD,CMPSN:39 OHM,5%,0.125W	01121	BB3905
R36(2)	317-0330-00			RES.,FXD,CMPSN:33 OHM,(NOM VALUE),SEL	01121	BB3305
R37(2)[1]						
R39(2)	321-0481-00			RES.,FXD,FILM:1M OHM,1%,0.125W	91637	MFF1816G10003F
R41	317-0474-00			RES.,FXD,CMPSN:470K OHM,5%,0.125W	01121	BB4745
R42	315-0510-00			RES.,FXD,CMPSN:51 OHM,(NOM VALUE),SEL	01121	BB5105
R61	317-0474-00			RES.,FXD,CMPSN:470K OHM,5%,0.125W	01121	BB4745
R62	315-0510-00			RES.,FXD,CMPSN:51 OHM,(NOM VALUE),SEL	01121	BB5105
R103[2]	317-0120-00			RES.,FXD,CMPSN:12 OHM,5%,0.125W	01121	BB1205
R104	317-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.125W	01121	BB3915
R105	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R107	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R108	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R109	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	32997	3329P-L58-103
R110	311-1228-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	32997	3386F-T04-103
R111	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R112	311-1259-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	32997	3329P-L58-101
R113	317-0681-00			RES.,FXD,CMPSN:680 OHM,5%,0.125W	01121	BB6815
R114	315-0151-00			RES.,FXD,CMPSN:150 OHM,5%,0.25W	01121	CB1515
R119	315-0300-00			RES.,FXD,CMPSN:30 OHM,5%,0.25W	01121	CB3005
R120	315-0154-00			RES.,FXD,CMPSN:150K OHM,5%,0.25W	01121	CB1545
R122	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F

[1]Selected.
[2]Added if necessary.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R123	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R124	321-0307-00			RES.,FXD,FILM:15.4K OHM,1%,0.125W	91637	MFF1816G15401F
R125	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R126	321-0277-00			RES.,FXD,FILM:7.5K OHM,1%,0.125W	91637	MFF1816G75000F
R127	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R128[1]	311-1403-00			RES.,VAR,NONWIR:5K OHM,20%,0.50W	01121	10M922
R129	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
R130	321-0133-00			RES.,FXD,FILM:237 OHM,1%,0.125W	91637	MFF1816G237R0F
R131	321-0133-00			RES.,FXD,FILM:237 OHM,1%,0.125W	91637	MFF1816G237R0F
R132	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R133	311-1259-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	32997	3329P-L58-101
R134	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R135	311-1222-00			RES.,VAR,NONWIR:100 OHM,20%,0.50W	32997	3386F-T04-101
R136	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R137	317-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.125W	01121	BB2425
R138	317-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.125W	01121	BB2025
R139	311-0635-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	80740	62-56-3
R141	317-0120-00			RES.,FXD,CMPSN:12 OHM,(NOM VALUE),SEL	01121	BB1205
R142	321-0072-00			RES.,FXD,FILM:54.9 OHM,(NOM VALUE),SEL	91637	MFF1816G54R90F
R143	321-0072-00			RES.,FXD,FILM:54.9 OHM,(NOM VALUE),SEL	91637	MFF1816G54R90F
R144	317-0120-00			RES.,FXD,CMPSN:12 OHM,(NOM VALUE),SEL	01121	BB1205
R145	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
R151	321-0076-00			RES.,FXD,FILM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F
R152	321-0076-00			RES.,FXD,FILM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F
R153	317-0220-00			RES.,FXD,CMPSN:22 OHM,(NOM VALUE),SEL	01121	BB2205
R154	321-0076-00			RES.,FXD,FILM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F
R155	321-0076-00			RES.,FXD,FILM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F
R156	321-0081-00			RES.,FXD,FILM:68.1 OHM,1%,0.125W	91637	MFF1816G68R10F
R157	321-0018-00			RES.,FXD,FILM:15 OHM,1%,0.125W	91637	MFF1816G15R00F
R158	317-0220-00			RES.,FXD,CMPSN:22 OHM,(NOM VALUE),SEL	01121	BB2205
R161	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R162	321-0172-00			RES.,FXD,FILM:604 OHM,1%,0.125W	91637	MFF1816G604R0F
R163	321-0201-00			RES.,FXD,FILM:1.21K OHM,1%,0.125W	91637	MFF1816G12100F
R164	321-0179-00			RES.,FXD,FILM:715 OHM,1%,0.125W	91637	MFF1816G715R0F
R165	311-1225-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W	32997	3386F-T04-102
R168	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R170	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
R172	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
R173	321-0053-00			RES.,FXD,FILM:34.8 OHM,1%,0.125W	91637	MFF1816G34R80F
R174	315-0154-00			RES.,FXD,CMPSN:150K OHM,5%,0.25W	01121	CB1545
R175	311-1260-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	32997	3329P-L58-251
R176	311-1226-00			RES.,VAR,NONWIR:2.5K OHM,20%,0.50W	32997	3386F-T04-252
R177	317-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.125W	01121	BB1005
R178	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
R179	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R180	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
R181	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R182	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
R183	321-0053-00			RES.,FXD,FILM:34.8 OHM,1%,0.125W	91637	MFF1816G34R80F
R184	321-0051-00			RES.,FXD,FILM:33.2 OHM,1%,0.125W	75042	CEAT0-33R20F
R185	311-1397-00			RES.,VAR,NONWIR:2 X 5K OHM,20%,0.50W	01121	12M940
R186	321-0127-00			RES.,FXD,FILM:205 OHM,1%,0.125W	91637	MFF1816G205R0F

[1]Furnished as a unit with S128.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R187	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
R188	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
R189	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R193	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R194	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R195	311-1225-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W	32997	3386F-T04-102
R196	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R198	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R203	317-0120-00			RES.,FXD,CMPSN:12 OHM,5%,0.125W	01121	BB1205
R204	317-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.125W	01121	BB3915
R205	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R207	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R208[1]	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R209	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	32997	3329P-L58-103
R210	311-1228-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	32997	3386F-T04-103
R211	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R212	311-1259-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	32997	3329P-L58-101
R213	317-0681-00			RES.,FXD,CMPSN:680 OHM,5%,0.125W	01121	BB6815
R214	315-0151-00			RES.,FXD,CMPSN:150 OHM,5%,0.25W	01121	CB1515
R215	311-1268-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	32997	3329P-L58-103
R216	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R217	321-0277-00			RES.,FXD,FILM:7.5K OHM,1%,0.125W	91637	MFF1816G75000F
R218	321-0277-00			RES.,FXD,FILM:7.5K OHM,1%,0.125W	91637	MFF1816G75000F
R219	315-0300-00			RES.,FXD,CMPSN:30 OHM,5%,0.25W	01121	CB3005
R220	315-0154-00			RES.,FXD,CMPSN:150K OHM,5%,0.25W	01121	CB1545
R221	321-0307-00			RES.,FXD,FILM:15.4K OHM,1%,0.125W	91637	MFF1816G15401F
R222	321-0253-00			RES.,FXD,FILM:4.22K OHM,1%,0.125W	91637	MFF1816G42200F
R223	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R224	321-0307-00			RES.,FXD,FILM:15.4K OHM,1%,0.125W	91637	MFF1816G15401F
R225	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R226	321-0253-00			RES.,FXD,FILM:4.22K OHM,1%,0.125W	91637	MFF1816G42200F
R227	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R228[2]	311-1403-00			RES.,VAR,NONWIR:5K OHM,20%,0.50W	01121	10M922
R229	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
R230	321-0133-00			RES.,FXD,FILM:237 OHM,1%,0.125W	91637	MFF1816G237R0F
R231	321-0133-00			RES.,FXD,FILM:237 OHM,1%,0.125W	91637	MFF1816G237R0F
R232	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R233	311-1259-00			RES.,VAR,NONWIR:100 OHM,10%,0.50W	32997	3329P-L58-101
R234	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R235	311-1222-00			RES.,VAR,NONWIR:100 OHM,20%,0.50W	32997	3386F-T04-101
R236	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R237	317-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.125W	01121	BB2425
R238	317-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.125W	01121	BB2025
R239	311-0635-00			RES.,VAR,NONWIR:1K OHM,10%,0.50W	80740	62-56-3
R241	317-0120-00			RES.,FXD,CMPSN:12 OHM,(NOM VALUE),SEL	01121	BB1205
R242	321-0072-00			RES.,FXD,FIIM:54.9 OHM,(NOM VALUE),SEL	91637	MFF1816G54R90F
R243	321-0072-00			RES.,FXD,FILM:54.9 OHM,(NOM VALUE),SEL	91637	MFF1816G54R90F
R244	317-0120-00			RES.,FXD,CMPSN:12 OHM,(NOM VALUE),SEL	01121	BB1205
R245	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
R251	321-0076-00			RES.,FXD,FILM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F
R252	321-0076-00			RES.,FXD,FIIM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F
R253	317-0220-00			RES.,FXD,CMPSN:22 OHM,(NOM VALUE),SEL	01121	BB2205
R254	321-0076-00			RES.,FXD,FILM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F

[1]Added if necessary.
[2]Furnished as a unit with S228.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R255	321-0076-00			RES.,FXD,FILM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F
R256	321-0081-00			RES.,FXD,FILM:68.1 OHM,1%,0.125W	91637	MFF1816G68R10F
R257	321-0018-00			RES.,FXD,FILM:15 OHM,1%,0.125W	91637	MFF1816G15R00F
R258	317-0220-00			RES.,FXD,CMPSN:22 OHM,(NOM VALUE),SEL	01121	BB2205
R261	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R262	321-0172-00			RES.,FXD,FILM:604 OHM,1%,0.125W	91637	MFF1816G604R0F
R263	321-0201-00			RES.,FXD,FILM:1.21K OHM,1%,0.125W	91637	MFF1816G12100F
R264	321-0179-00			RES.,FXD,FILM:715 OHM,1%,0.125W	91637	MFF1816G715R0F
R265	311-1225-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W	32997	3386F-T04-102
R268	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R270	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
R272	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
R273	321-0053-00			RES.,FXD,FILM:34.8 OHM,1%,0.125W	91637	MFF1816G34R80F
R274	315-0154-00			RES.,FXD,CMPSN:150K OHM,5%,0.25W	01121	CB1545
R275	311-1260-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	32997	3329P-L58-251
R276	311-1226-00			RES.,VAR,NONWIR:2.5K OHM,20%,0.50W	32997	3386F-T04-252
R277	317-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.125W	01121	BB1005
R278	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
R279	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R280	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
R281	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R282	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
R283	321-0053-00			RES.,FXD,FILM:34.8 OHM,1%,0.125W	91637	MFF1816G34R80F
R284	321-0051-00			RES.,FXD,FILM:33.2 OHM,1%,0.125W	75042	CEAT0-33R20F
R285	311-1397-00			RES.,VAR,NONWIR:2 X 5K OHM,20%,0.50W	01121	12M940
R286	321-0127-00			RES.,FXD,FILM:205 OHM,1%,0.125W	91637	MFF1816G205R0F
R287	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
R288	315-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.25W	01121	CB3915
R289	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R291	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R292	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R293	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R294	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R295	311-1225-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W	32997	3386F-T04-102
R296	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R297	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R298	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R301	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R302	321-0131-00			RES.,FXD,FILM:226 OHM,1%,0.125W	91637	MFF1816G226R0F
R304	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R306	315-0121-00			RES.,FXD,CMPSN:120 OHM,5%,0.25W	01121	CB1215
R310	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R311	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R312	315-0120-00			RES.,FXD,CMPSN:12 OHM,5%,0.25W	01121	CB1205
R313	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R314	315-0822-00			RES.,FXD,CMPSN:8.2K OHM,5%,0.25W	01121	CB8225
R315	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R320	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R321	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R322	315-0120-00			RES.,FXD,CMPSN:12 OHM,5%,0.25W	01121	CB1205
R323	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R324	315-0822-00			RES.,FXD,CMPSN:8.2K OHM,5%,0.25W	01121	CB8225

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R325	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R331	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R332	315-0123-00			RES.,FXD,CMPSN:12K OHM,5%,0.25W	01121	CB1235
R333	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R335	315-0123-00			RES.,FXD,CMPSN:12K OHM,5%,0.25W	01121	CB1235
R336	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R338	315-0203-00			RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
R339	315-0222-00			RES.,FXD,CMPSN:2.2K OHM,5%,0.25W	01121	CB2225
R341	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R342	315-0132-00			RES.,FXD,CMPSN:1.3K OHM,5%,0.25W	01121	CB1325
R343	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R346	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R347	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R348	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
R351	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R353	321-0152-00			RES.,FXD,FILM:374 OHM,1%,0.125W	91637	MFF1816G374ROF
R354	321-0114-00			RES.,FXD,FILM:150 OHM,1%,0.125W	91637	MFF1816G150ROF
R355	321-0174-00			RES.,FXD,FILM:634 OHM,1%,0.125W	91637	MFF1816G634ROF
R356	321-0114-00			RES.,FXD,FILM:150 OHM,1%,0.125W	91637	MFF1816G150ROF
R357	321-0174-00			RES.,FXD,FILM:634 OHM,1%,0.125W	91637	MFF1816G634ROF
R358	321-0152-00			RES.,FXD,FILM:374 OHM,1%,0.125W	91637	MFF1816G374ROF
R359	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R361	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R363	321-0152-00			RES.,FXD,FILM:374 OHM,1%,0.125W	91637	MFF1816G374ROF
R364	321-0114-00			RES.,FXD,FILM:150 OHM,1%,0.125W	91637	MFF1816G150ROF
R365	321-0174-00			RES.,FXD,FILM:634 OHM,1%,0.125W	91637	MFF1816G634ROF
R366	321-0114-00			RES.,FXD,FILM:150 OHM,1%,0.125W	91637	MFF1816G150ROF
R367	321-0174-00			RES.,FXD,FILM:634 OHM,1%,0.125W	91637	MFF1816G634ROF
R368	321-0152-00			RES.,FXD,FILM:374 OHM,1%,0.125W	91637	MFF1816G374ROF
R369	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R371	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R372	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R373	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R374	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R380	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R381	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R382	323-0130-00			RES.,FXD,FILM:221 OHM,1%,0.50W	91637	MFF1226G221ROF
R383	323-0130-00			RES.,FXD,FILM:221 OHM,1%,0.50W	91637	MFF1226G221ROF
R384	322-0107-00			RES.,FXD,FILM:127 OHM,1%,0.25W	75042	CEBT0-1270F
R385	311-1221-00			RES.,VAR,NONWIR:50 OHM,20%,0.50W	32997	3386F-T04-500
R388	315-0270-00			RES.,FXD,CMPSN:27 OHM,5%,0.25W	01121	CB2705
R391A	321-0163-00			RES.,FXD,FILM:487 OHM,1%,0.125W	91637	MFF1816G487ROF
R391B	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R392	321-0122-00			RES.,FXD,FILM:182 OHM,1%,0.125W	91637	MFF1816G182ROF
R393	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R394	321-0146-00			RES.,FXD,FILM:324 OHM,1%,0.125W	91637	MFF1816G324ROF
R395	322-0156-00			RES.,FXD,FILM:412 OHM,1%,0.25W	75042	CEBT0-4120F
R396	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R397	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R398	317-0430-00			RES.,FXD,CMPSN:43 OHM,5%,0.125W	01121	BB4305
R399	315-0330-00			RES.,FXD,CMPSN:33 OHM,5%,0.25W	01121	CB3305
R401	321-0132-00			RES.,FXD,FILM:232 OHM,1%,0.125W	91637	MFF1816G232ROF
R402	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F

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R403	311-1221-00			RES.,VAR,NONWIR:50 OHM,20%,0.50W	32997	3386F-T04-500
R404	321-0132-00			RES.,FXD,FILM:232 OHM,1%,0.125W	91637	MFF1816G232R0F
R405	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R411	321-0132-00			RES.,FXD,FILM:232 OHM,1%,0.125W	91637	MFF1816G232R0F
R412	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R414	321-0132-00			RES.,FXD,FILM:232 OHM,1%,0.125W	91637	MFF1816G232R0F
R415	321-0078-00			RES.,FXD,FILM:63.4 OHM,1%,0.125W	91637	MFF1816G63R40F
R419	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
R420	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
R421	321-0151-00			RES.,FXD,FILM:365 OHM,1%,0.125W	91637	MFF1816G365R0F
R422	321-0210-00			RES.,FXD,FILM:1.5K OHM,1%,0.125W	91637	MFF1816G15000F
R423	321-0076-00			RES.,FXD,FILM:60.4 OHM,1%,0.125W	91637	MFF1816G60R40F
R425	311-1227-00			RES.,VAR,NONWIR:5K OHM,20%,0.50W	32997	3386F-T04-502
R426	322-0161-00			RES.,FXD,FILM:464 OHM,1%,0.25W	75042	CEBT0-4640F
R427	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R430	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R431	321-0071-00			RES.,FXD,FILM:53.6 OHM,1%,0.125W	91637	MFF1816G53R60F
R432	321-0184-00			RES.,FXD,FILM:806 OHM,1%,0.125W	91637	MFF1816G806R0F
R436	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R437	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R438	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R441	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
R443	317-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.125W	01121	BB5105
R445	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
R446	317-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.125W	01121	BB5105
R447	321-0201-00			RES.,FXD,FILM:1.21K OHM,1%,0.125W	91637	MFF1816G12100F
R448	321-0135-00			RES.,FXD,FILM:249 OHM,1%,0.125W	91637	MFF1816G249R0F
R449	311-1238-00			RES.,VAR,NONWIR:5K OHM,10%,0.50W	73138	72X-27-0.502K
R450	311-1260-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	32997	3329P-L58-251
R451	317-0750-00			RES.,FXD,COMP:75 OHM,5%,0.125W	01121	BB7555
R452	317-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.125W	01121	BB2005
R453	317-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.125W	01121	BB2005
R454	317-0681-00			RES.,FXD,CMPSN:680 OHM,5%,0.125W	01121	BB6815
R455	317-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.125W	01121	BB1025
R456	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R457	321-0163-00			RES.,FXD,FILM:487 OHM,1%,0.125W	91637	MFF1816G487R0F
R458	321-0163-00			RES.,FXD,FILM:487 OHM,1%,0.125W	91637	MFF1816G487R0F
R459	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R460	315-0270-00			RES.,FXD,CMPSN:27 OHM,5%,0.25W	01121	CB2705
R461	321-0198-00			RES.,FXD,FILM:1.13K OHM,1%,0.125W	91637	MFF1816G11300F
R462	323-0147-00			RES.,FXD,FILM:332 OHM,1%,0.50W	75042	CECT0-3320F
R463	315-0561-00			RES.,FXD,CMPSN:560 OHM,5%,0.25W	01121	CB5615
R464	323-0147-00			RES.,FXD,FILM:332 OHM,1%,0.50W	75042	CECT0-3320F
R465	315-0561-00			RES.,FXD,CMPSN:560 OHM,5%,0.25W	01121	CB5615
R466	311-1278-00			RES.,VAR,NONWIR:250 OHM,10%,0.5W	32997	3329W-L58-251
R467	317-0240-00			RES.,FXD,CMPSN:24 OHM,5%,0.125W	01121	BB2405
R468	321-0061-00			RES.,FXD,FILM:42.2 OHM,1%,0.125W	91637	MFF1816G42R20F
R469	321-0061-00			RES.,FXD,FILM:42.2 OHM,1%,0.125W	91637	MFF1816G42R20F
R470	311-1279-00			RES.,VAR,NONWIR:500 OHM,10%,0.50W	32997	3329W-L58-501
R471	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R472	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
R473	315-0200-00			RES.,FXD,CMPSN:20 OHM,5%,0.25W	01121	CB2005
R474	317-0240-00			RES.,FXD,CMPSN:24 OHM,5%,0.125W	01121	BB2405

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R475	311-1245-00			RES.,VAR,NONWIR:10K OHM,10%,0.50W	73138	72X-28-0-103K
R476	317-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.125W	01121	BB1825
R477	315-0821-00			RES.,FXD,CMPSN:820 OHM,5%,0.25W	01121	CB8215
R478	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R479	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R481	321-0039-00			RES.,FXD,FILM:24.9 OHM,1%,0.125W	91637	MFF1816G24R90F
R482	321-0039-00			RES.,FXD,FILM:24.9 OHM,1%,0.125W	91637	MFF1816G24R90F
R483	322-0157-00			RES.,FXD,FILM:422 OHM,1%,0.25W	75042	CEBT0-4220F
R484	322-0157-00			RES.,FXD,FILM:422 OHM,1%,0.25W	75042	CEBT0-4220F
R485	315-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.25W	01121	CB5605
R486	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R487	315-0301-00			RES.,FXD,CMPSN:300 OHM,5%,0.25W	01121	CB3015
R488	311-1236-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	73138	72X-22-0-251K
R489	315-0911-00			RES.,FXD,CMPSN:910 OHM,5%,0.25W	01121	CB9115
R490	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R491	301-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.50W	01121	EB1005
R492	323-0134-00			RES.,FXD,FILM:243 OHM,1%,0.50W	91637	MFF1226G243R0F
R493	323-0134-00			RES.,FXD,FILM:243 OHM,1%,0.50W	91637	MFF1226G243R0F
R494A	317-0621-00			RES.,FXD,CMPSN:620 OHM,5%,0.125W	01121	BB6215
R494B[1]	311-0633-00			RES.,VAR,NONWIR:5K OHM,10%,0.50W	80740	62-58-3
R495	323-0134-00			RES.,FXD,FILM:243 OHM,1%,0.50W	91637	MFF1226G243R0F
R496	323-0134-00			RES.,FXD,FILM:243 OHM,1%,0.50W	91637	MFF1226G243R0F
R497	307-0292-00			RES.,FXD,FILM:182.5 OHM	80009	307-0292-00
R498	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R499	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R500	315-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.25W	01121	CB5605
R501	316-0221-00			RES.,FXD,CMPSN:220 OHM,10%,0.25W	01121	CB2211
R502	316-0152-00			RES.,FXD,CMPSN:1.5K OHM,10%,0.25W	01121	CB1521
R503	316-0221-00			RES.,FXD,CMPSN:220 OHM,10%,0.25W	01121	CB2211
R504	316-0152-00			RES.,FXD,CMPSN:1.5K OHM,10%,0.25W	01121	CB1521
R505	316-0470-00			RES.,FXD,CMPSN:47 OHM,10%,0.25W	01121	CB4701
R506	316-0152-00			RES.,FXD,CMPSN:1.5K OHM,10%,0.25W	01121	CB1521
R507	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R508	316-0274-00			RES.,FXD,CMPSN:270K OHM,10%,0.25W	01121	CB2741
R509	315-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.25W	01121	CB5605
R510	316-0330-00			RES.,FXD,CMPSN:33 OHM,10%,0.25W	01121	CB3301
R511	315-0824-00			RES.,FXD,CMPSN:820K OHM,5%,0.25W	01121	CB8245
R512	315-0514-00			RES.,FXD,CMPSN:510K OHM,5%,0.25W	01121	CB5145
R513	315-0475-00			RES.,FXD,CMPSN:4.7M OHM,5%,0.25W	01121	CB4755
R514	315-0184-00			RES.,FXD,CMPSN:180K OHM,5%,0.25W	01121	CB1845
R515	316-0104-00			RES.,FXD,CMPSN:100K OHM,10%,0.25W	01121	CB1041
R516	316-0563-00			RES.,FXD,CMPSN:56K OHM,10%,0.25W	01121	CB5631
R517	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
R518	316-0100-00			RES.,FXD,CMPSN:10 OHM,10%,0.25W	01121	CB1001
R519	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R520	315-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.25W	01121	CB5605
R521	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R522	316-0150-00			RES.,FXD,CMPSN:15 OHM,10%,0.25W	01121	CB1501
R523	316-0150-00			RES.,FXD,CMPSN:15 OHM,10%,0.25W	01121	CB1501
R524	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R525	316-0821-00			RES.,FXD,CMPSN:820 OHM,10%,0.25W	01121	CB8211
R526	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R527	322-0178-00			RES.,FXD,FILM:698 OHM,1%,0.25W	75042	CEBT0-6980F

[1]Added if necessary.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R528	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R529	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R530[1]	311-1192-00			RES.,VAR,NONWIR:10K OHM,20%,1W	12637	381-CM39695
R532	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
R533	316-0821-00			RES.,FXD,CMPSN:820 OHM,10%,0.25W	01121	CB8211
R534	311-1230-00			RES.,VAR,NONWIR:20K OHM,20%,0.50W	32997	3386F-T04-203
R535	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R536	315-0131-00			RES.,FXD,CMPSN:130 OHM,5%,0.25W	01121	CB1315
R537	316-0152-00			RES.,FXD,CMPSN:1.5K OHM,10%,0.25W	01121	CB1521
R538	316-0332-00			RES.,FXD,CMPSN:3.3K OHM,10%,0.25W	01121	CB3321
R541	316-0682-00			RES.,FXD,CMPSN:6.8K OHM,10%,0.25W	01121	CB6821
R542	316-0392-00			RES.,FXD,CMPSN:3.9K OHM,10%,025W	01121	CB3921
R543	316-0221-00			RES.,FXD,CMPSN:220 OHM,10%,0.25W	01121	CB2211
R544	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R545	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R546	316-0470-00			RES.,FXD,CMPSN:47 OHM,10%,0.25W	01121	CB4701
R547	311-1230-00			RES.,VAR,NONWIR:20K OHM,20%,0.50W	32997	3386F-T04-203
R550	317-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.125W	01121	BB5605
R551	321-0082-00			RES.,FXD,FILM:69.8 OHM,1%,0.125W	91637	MFF1816G69R80F
R552	322-0283-00			RES.,FXD,FILM:8.66K OHM,1%,0.25W	75042	CEBT0-8661F
R553	321-0082-00			RES.,FXD,FILM:69.8 OHM,1%,0.125W	91637	MFF1816G69R80F
R554	321-0059-00			RES.,FXD,FILM:40.2 OHM,1%,0.125W	91637	MFF1816G40R20F
R555	321-0185-00			RES.,FXD,FILM:825 OHM,1%,0.125W	91637	MFF1816G825R0F
R556	321-0047-00			RES.,FXD,FILM:30.1 OHM,1%,0.125W	91637	MFF1816G30R10F
R557	321-0224-00			RES.,FXD,FILM:2.1K OHM,1%,0.125W	91637	MFF1816G21000F
R558	321-0044-00			RES.,FXD,FILM:28 OHM,1%,0.125W	91637	MFF1816G28R00F
R559	321-0259-00			RES.,FXD,FILM:4.87K OHM,1%,0.125W	91637	MFF1816G48700F
R560	317-0560-00			RES.,FXD,CMPSN:56 OHM,5%,0.125W	01121	BB5605
R561	321-0082-00			RES.,FXD,FILM:69.8 OHM,1%,0.125W	91637	MFF1816G69R80F
R562	322-0283-00			RES.,FXD,FILM:8.66K OHM,1%,0.25W	75042	CEBT0-8661F
R563	321-0082-00			RES.,FXD,FILM:69.8 OHM,1%,0.125W	91637	MFF1816G69R80F
R564	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R565	311-1228-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	32997	3386F-T04-103
R566	321-0044-00			RES.,FXD,FILM:28 OHM,1%,0.125W	91637	MFF1816G28R00F
R567	321-0224-00			RES.,FXD,FILM:2.1K OHM,1%,0.125W	91637	MFF1816G21000F
R568	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R569	321-0279-00			RES.,FXD,FILM:7.87K OHM,1%,0.125W	91637	MFF1816G78700F
R570	301-0181-00			RES.,FXD,CMPSN:180 OHM,5%,0.50W	01121	EB1815
R571	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R572	321-0187-00			RES.,FXD,FILM:866 OHM,1%,0.125W	91637	MFF1816G866R0F
R574	315-0432-00			RES.,FXD,CMPSN:4.3K OHM,5%,0.25W	01121	CB4325
R575	315-0151-00			RES.,FXD,CMPSN:150 OHM,5%,0.25W	01121	CB1515
R577	321-0246-00			RES.,FXD,FILM:3.57K OHM,1%,0.125W	91637	MFF1816G35700F
R578	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R579	301-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.50W	01121	EB2015
R580	316-0220-00			RES.,FXD,CMPSN:22 OHM,10%,0.25W	01121	CB2201
R581	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R582	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R583	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
R584	316-0220-00			RES.,FXD,CMPSN:22 OHM,10%,0.25W	01121	CB2201
R588	301-0121-00			RES.,FXD,CMPSN:120 OHM,5%,0.50W	01121	EB1215
R590	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R591	321-0242-00			RES.,FXD,FILM:3.24K OHM,1%,0.125W	91637	MFF1816G32400F

[1]Furnished as a unit with S530.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R592	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
R593	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R594	315-0162-00			RES.,FXD,CMPSN:1.6K OHM,5%,0.25W	01121	CB1625
R595	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R596	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R597	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R598	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R599	321-0318-00			RES.,FXD,FILM:20K OHM,1%,0.125W	91637	MFF1816G20001F
R600	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R601	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R602	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R603	315-0241-00			RES.,FXD,CMPSN:240 OHM,5%,0.25W	01121	CB2415
R604	316-0393-00			RES.,FXD,CMPSN:39K OHM,10%,0.25W	01121	CB3931
R607	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R608	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R609	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R610	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R611	321-0174-00			RES.,FXD,FILM:634 OHM,1%,0.125W	91637	MFF1816G634R0F
R612	321-0190-00			RES.,FXD,FILM:931 OHM,1%,0.125W	91637	MFF1816G931R0F
R613	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R622	307-0103-00			RES.,FXD,CMPSN:2.7 OHM,5%,0.25W	01121	CB27G5
R626	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
R627	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R628	321-0184-00			RES.,FXD,FILM:806 OHM,1%,0.125W	91637	MFF1816G806R0F
R629	321-0205-00			RES.,FXD,FILM:1.33K OHM,1%,0.125W	91637	MFF1816G13300F
R641	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
R642	321-0275-00			RES.,FXD,FILM:7.15K OHM,1%,0.125W	91637	MFF1816G71500F
R644 [1]	311-1401-00			RES.,VAR,NONWIR:100K OHM,20%,0.50W	01121	10M920
R647	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R661	315-0430-00			RES.,FXD,CMPSN:43 OHM,5%,0.25W	01121	CB4305
R662	315-0150-00			RES.,FXD,CMPSN:15 OHM,5%,0.25W	01121	CB1505
R663	322-0207-00			RES.,FXD,FILM:1.4K OHM,1%,0.25W	75042	CEBT0-1401F
R664	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
R665	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R666	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R667	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
R668	321-0178-00			RES.,FXD,FILM:698 OHM,1%,0.125W	91637	MFF1816G698R0F
R669	315-0160-00			RES.,FXD,CMPSN:16 OHM,5%,0.25W	01121	CB1605
R670	316-0470-00			RES.,FXD,CMPSN:47 OHM,10%,0.25W	01121	CB4701
R671	315-0430-00			RES.,FXD,CMPSN:43 OHM,5%,0.25W	01121	CB4305
R672	315-0150-00			RES.,FXD,CMPSN:15 OHM,5%,0.25W	01121	CB1505
R673	311-1223-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	32997	3386F-T04-251
R674	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
R675	321-0155-00			RES.,FXD,FILM:402 OHM,1%,0.125W	91637	MFF1816G402R0F
R676	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R677	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
R678	321-0178-00			RES.,FXD,FILM:698 OHM,1%,0.125W	91637	MFF1816G698R0F
R679	316-0220-00			RES.,FXD,CMPSN:22 OHM,10%,0.25W	01121	CB2201
R680	321-0225-00			RES.,FXD,FILM:2.15K OHM,1%,0.125W	91637	MFF1816G21500F
R681	321-0209-00			RES.,FXD,FILM:1.47K OHM,1%,0.125W	91637	MFF1816G14700F
R682	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R683	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R684	321-0248-00			RES.,FXD,FILM:3.74K OHM,1%,0.125W	91637	MFF1816G37400F

[1]Furnished as a unit with S644.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R685	321-0248-00			RES.,FXD,FILM:3.74K OHM,1%,0.125W	91637	MFF1816G37400F
R686	321-0210-00			RES.,FXD,FILM:1.5K OHM,1%,0.125W	91637	MFF1816G15000F
R687	321-0209-00			RES.,FXD,FILM:1.47K OHM,1%,0.125W	91637	MFF1816G14700F
R688	321-0141-00			RES.,FXD,FILM:287 OHM,1%,0.125W	91637	MFF1816G287R0F
R689	315-0432-00			RES.,FXD,CMPSN:4.3K OHM,5%,0.25W	01121	CB4325
R692	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R693	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R694	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R695	321-0204-00			RES.,FXD,FILM:1.3K OHM,1%,0.125W	91637	MFF1816G13000F
R696	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
R697	321-0178-00			RES.,FXD,FILM:698 OHM,1%,0.125W	91637	MFF1816G698R0F
R698	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R699	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R701	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R702	315-0162-00			RES.,FXD,CMPSN:1.6K OHM,5%,0.25W	01121	CB1625
R703	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R704	315-0162-00			RES.,FXD,CMPSN:1.6K OHM,5%,0.25W	01121	CB1625
R705	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	01121	CB1525
R706	315-0162-00			RES.,FXD,CMPSN:1.6K OHM,5%,0.25W	01121	CB1625
R711	316-0152-00			RES.,FXD,CMPSN:1.5K OHM,10%,0.25W	01121	CB1521
R712	316-0221-00			RES.,FXD,CMPSN:220 OHM,10%,0.25W	01121	CB2211
R713	316-0152-00			RES.,FXD,CMPSN:1.5K OHM,10%,0.25W	01121	CB1521
R714	316-0221-00			RES.,FXD,CMPSN:220 OHM,10%,0.25W	01121	CB2211
R715	316-0151-00			RES.,FXD,CMPSN:150 OHM,10%,0.25W	01121	CB1511
R716	316-0152-00			RES.,FXD,CMPSN:1.5K OHM,10%,0.25W	01121	CB1521
R717	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
R718	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
R719	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
R721	316-0330-00			RES.,FXD,CMPSN:33 OHM,10%,0.25W	01121	CB3301
R722	315-0684-00			RES.,FXD,CMPSN:680K OHM,5%,0.25W	01121	CB6845
R723	315-0474-00			RES.,FXD,CMPSN:470K OHM,5%,0.25W	01121	CB4745
R729	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R731	316-0332-00			RES.,FXD,CMPSN:3.3K OHM,10%,0.25W	01121	CB3321
R735	316-0104-00			RES.,FXD,CMPSN:100K OHM,10%,0.25W	01121	CB1041
R736	316-0563-00			RES.,FXD,CMPSN:56K OHM,10%,0.25W	01121	CB5631
R737	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
R738	316-0100-00			RES.,FXD,CMPSN:10 OHM,10%,0.25W	01121	CB1001
R739	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R741	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R742	316-0150-00			RES.,FXD,CMPSN:15 OHM,10%,0.25W	01121	CB1501
R743	316-0150-00			RES.,FXD,CMPSN:15 OHM,10%,0.25W	01121	CB1501
R744	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R745	316-0821-00			RES.,FXD,CMPSN:820 OHM,10%,0.25W	01121	CB8211
R746	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R747	322-0178-00			RES.,FXD,FILM:698 OHM,1%,0.25W	75042	CEBT0-6980F
R748	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R750[1]	311-1192-00			RES.,VAR,NONWIR:10K OHM,20%,1W	12637	381-CM39695
R752	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
R753	316-0821-00			RES.,FXD,CMPSN:820 OHM,10%,0.25W	01121	CB8211
R754	311-1230-00			RES.,VAR,NONWIR:20K OHM,20%,0.50W	32997	3386F-T04-203
R755	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R756	315-0131-00			RES.,FXD,CMPSN:130 OHM,5%,0.25W	01121	CB1315
R758	316-0152-00			RES.,FXD,CMPSN:1.5K OHM,10%,0.25W	01121	CB1521

[1]Furnished as a unit with S750.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R759	321-0259-00			RES.,FXD,FILM:4.87K OHM,1%,0.125W	91637	MFF1816G48700F
R761	316-0682-00			RES.,FXD,CMPSN:6.8K OHM,10%,0.25W	01121	CB6821
R762	316-0392-00			RES.,FXD,CMPSN:3.9K OHM,10%,025W	01121	CB3921
R763	316-0221-00			RES.,FXD,CMPSN:220 OHM,10%,0.25W	01121	CB2211
R764	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R765	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R766	316-0470-00			RES.,FXD,CMPSN:47 OHM,10%,0.25W	01121	CB4701
R767	311-1230-00			RES.,VAR,NONWIR:20K OHM,20%,0.50W	32997	3386F-T04-203
R769	321-0279-00			RES.,FXD,FILM:7.87K OHM,1%,0.125W	91637	MFF1816G78700F
R771	321-0082-00			RES.,FXD,FILM:69.8 OHM,1%,0.125W	91637	MFF1816G69R80F
R772	322-0283-00			RES.,FXD,FILM:8.66K OHM,1%,0.25W	75042	CEBT0-8661F
R773	321-0082-00			RES.,FXD,FILM:69.8 OHM,1%,0.125W	91637	MFF1816G69R80F
R774	321-0059-00			RES.,FXD,FILM:40.2 OHM,1%,0.125W	91637	MFF1816G40R20F
R775	321-0185-00			RES.,FXD,FILM:825 OHM,1%,0.125W	91637	MFF1816G825R0F
R776	321-0047-00			RES.,FXD,FILM:30.1 OHM,1%,0.125W	91637	MFF1816G30R10F
R777	321-0224-00			RES.,FXD,FILM:2.1K OHM,1%,0.125W	91637	MFF1816G21000F
R778	321-0044-00			RES.,FXD,FILM:28 OHM,1%,0.125W	91637	MFF1816G28R00F
R781	321-0082-00			RES.,FXD,FILM:69.8 OHM,1%,0.125W	91637	MFF1816G69R80F
R782	322-0283-00			RES.,FXD,FILM:8.66K OHM,1%,0.25W	75042	CEBT0-8661F
R783	321-0082-00			RES.,FXD,FILM:69.8 OHM,1%,0.125W	91637	MFF1816G69R80F
R784	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R785	311-1228-00			RES.,VAR,NONWIR:10K OHM,20%,0.50W	32997	3386F-T04-103
R786	321-0044-00			RES.,FXD,FILM:28 OHM,1%,0.125W	91637	MFF1816G28R00F
R787	321-0224-00			RES.,FXD,FILM:2.1K OHM,1%,0.125W	91637	MFF1816G21000F
R788	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R789	316-0221-00			RES.,FXD,CMPSN:220 OHM,10%,0.25W	01121	CB2211
R792	316-0220-00			RES.,FXD,CMPSN:22 OHM,10%,0.25W	01121	CB2201
R793	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R794	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R795	321-0225-00			RES.,FXD,FILM:2.15K OHM,1%,0.125W	91637	MFF1816G21500F
R796	321-0227-00			RES.,FXD,FILM:2.26K OHM,1%,0.125W	91637	MFF1816G22600F
R797	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R798	321-0249-00			RES.,FXD,FILM:3.83K OHM,1%,0.125W	91637	MFF1816G38300F
R799	316-0102-00			RES.,FXD,CMPSN:1K OHM,10%,0.25W	01121	CB1021
R801	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
R802	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R803	307-0103-00			RES.,FXD,CMPSN:2.7 OHM,5%,0.25W	01121	CB27G5
R804	321-0166-00			RES.,FXD,FILM:523 OHM,1%,0.125W	91637	MFF1816G523R0F
R805	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R806	315-0681-00			RES.,FXD,CMPSN:680 OHM,5%,0.25W	01121	CB6815
R807	321-0254-00			RES.,FXD,FILM:4.32K OHM,1%,0.125W	91637	MFF1816G43200F
R808	321-0250-00			RES.,FXD,FILM:3.92K OHM,1%,0.125W	91637	MFF1816G39200F
R809	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R810	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
R811	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R812	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
R813	315-0151-00			RES.,FXD,CMPSN:150 OHM,5%,0.25W	01121	CB1515
R814	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R815	321-0232-00			RES.,FXD,FILM:2.55K OHM,1%,0.125W	91637	MFF1816G25500F
R816	321-0155-00			RES.,FXD,FILM:402 OHM,1%,0.125W	91637	MFF1816G402R0F
R817	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R818	321-0187-00			RES.,FXD,FILM:866 OHM,1%,0.125W	91637	MFF1816G866R0F
R819	316-0100-00			RES.,FXD,CMPSN:10 OHM,10%,0.25W	01121	CB1001

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R821	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R822	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R823	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
R824	316-0220-00			RES.,FXD,CMPSN:22 OHM,10%,0.25W	01121	CB2201
R825	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R826	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R900	321-0225-00			RES.,FXD,FILM:2.15K OHM,1%,0.125W	91637	MFF1816G21500F
R902	321-0155-00			RES.,FXD,FILM:402 OHM,1%,0.125W	91637	MFF1816G402R0F
R903	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R904	321-0168-00			RES.,FXD,FILM:549 OHM,1%,0.125W	91637	MFF1816G549R0F
R905	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R906	321-0268-00			RES.,FXD,FILM:6.04K OHM,1%,0.125W	91637	MFF1816G60400F
R907	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R908	321-0294-00			RES.,FXD,FILM:11.3K OHM,1%,0.125W	91637	MFF1816G11301F
R910	321-0220-00			RES.,FXD,FILM:1.91K OHM,1%,0.125W	91637	MFF1816G19100F
R911	321-0314-00			RES.,FXD,FILM:18.2K OHM,1%,0.125W	91637	MFF1816G18201F
R912	321-0261-00			RES.,FXD,FILM:5.11K OHM,1%,0.125W	91637	MFF1816G51100F
R913	316-0100-00			RES.,FXD,CMPSN:10 OHM,10%,0.25W	01121	CB1001
R916	308-0539-00			RES.,FXD,WW:2.25K OHM,0.5%,3W	91637	RS2B-B22500D
R917	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R918	316-0220-00			RES.,FXD,CMPSN:22 OHM,10%,0.25W	01121	CB2201
R921	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R922	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R923	316-0100-00			RES.,FXD,CMPSN:10 OHM,10%,0.25W	01121	CB1001
R924	301-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.50W	01121	EB6825
R925	321-0218-00			RES.,FXD,FILM:1.82K OHM,1%,0.125W	91637	MFF1816G18200F
R926	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R927	321-0238-00			RES.,FXD,FILM:2.94K OHM,1%,0.125W	91637	MFF1816G29400F
R928	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R929	316-0123-00			RES.,FXD,CMPSN:12K OHM,10%,0.25W	01121	CB1231
R930	311-1458-00			RES.,VAR,WW:50K OHM,5%	73138	7266-322-0
R930 [1]	311-1709-00			RES.,VAR,WW:20K OHM,10%,2W	73138	8136-22-0
R931	316-0392-00			RES.,FXD,CMPSN:3.9K OHM,10%,025W	01121	CB3921
R932	316-0102-00			RES.,FXD,CMPSN:1K OHM,10%,0.25W	01121	CB1021
R933	321-0338-00			RES.,FXD,FILM:32.4K OHM,1%,0.125W	91637	MFF1816G32401F
R934	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R935	321-0274-00			RES.,FXD,FILM:6.98K OHM,1%,0.125W	91637	MFF1816G69800F
R936	311-1226-00			RES.,VAR,NONWIR:2.5K OHM,20%,0.50W	32997	3386F-T04-252
R937	321-0196-00			RES.,FXD,FILM:1.07K OHM,1%,0.125W	91637	MFF1816G10700F
R938	311-1225-00			RES.,VAR,NONWIR:1K OHM,20%,0.50W	32997	3386F-T04-102
R939	321-0258-00			RES.,FXD,FILM:4.75K OHM,1%,0.125W	91637	MFF1816G47500F
R940	315-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
R941	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R942	321-0145-00			RES.,FXD,FILM:316 OHM,1%,0.125W	91637	MFF1816G316R0F
R943	321-0152-00			RES.,FXD,FILM:374 OHM,1%,0.125W	91637	MFF1816G374R0F
R944	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
R946	321-0216-00			RES.,FXD,FILM:1.74K OHM,1%,0.125W	91637	MFF1816G17400F
R947	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R948	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
R949	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R950	311-1222-00			RES.,VAR,NONWIR:100 OHM,20%,0.50W	32997	3386F-T04-101
R951	321-0183-00			RES.,FXD,FILM:787 OHM,1%,0.125W	91637	MFF1816G787R0F
R952	321-0198-00			RES.,FXD,FILM:1.13K OHM,1%,0.125W	91637	MFF1816G11300F

[1] DM43-DM40 version only.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R955	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R956	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R961	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R963	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R965	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R967	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R969	307-0106-00			RES.,FXD,CMPSN:4.7 OHM,5%,0.25W	01121	CB47G5
R971	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R972	321-0287-00			RES.,FXD,FILM:9.53K OHM,1%,0.125W	91637	MFF1816G95300F
R973	321-0155-00			RES.,FXD,FILM:402 OHM,1%,0.125W	91637	MFF1816G402R0F
R974	321-0268-00			RES.,FXD,FILM:6.04K OHM,1%,0.125W	91637	MFF1816G60400F
R975	321-0354-00			RES.,FXD,FILM:47.5K OHM,1%,0.125W	91637	MFF1816G47501F
R976	315-0562-00			RES.,FXD,CMPSN:5.6K OHM,5%,0.25W	01121	CB5625
R981	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R982	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R985	301-0622-00			RES.,FXD,CMPSN:6.2K OHM,5%,0.50W	01121	EB6225
R986	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R987	316-0332-00			RES.,FXD,CMPSN:3.3K OHM,10%,0.25W	01121	CB3321
R988	315-0680-00			RES.,FXD,CMPSN:68 OHM,5%,0.25W	01121	CB6805
R994	321-0225-00			RES.,FXD,FILM:2.15K OHM,1%,0.125W	91637	MFF1816G21500F
R995	321-0155-00			RES.,FXD,FILM:402 OHM,1%,0.125W	91637	MFF1816G402R0F
R996	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R1001	315-0392-00			RES.,FXD,CMPSN:3.9K OHM,5%,0.25W	01121	CB3925
R1002	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
R1004	321-0268-00			RES.,FXD,FILM:6.04K OHM,1%,0.125W	91637	MFF1816G60400F
R1005	321-0354-00			RES.,FXD,FILM:47.5K OHM,1%,0.125W	91637	MFF1816G47501F
R1006	321-0287-00			RES.,FXD,FILM:9.53K OHM,1%,0.125W	91637	MFF1816G95300F
R1007	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R1010	321-0414-00			RES.,FXD,FILM:200K OHM,1%,0.125W	91637	MFF1816G20002F
R1011	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R1012[1]	SELECTED					
R1015	301-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.50W	01121	EB6825
R1016	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R1017	316-0332-00			RES.,FXD,CMPSN:3.3K OHM,10%,0.25W	01121	CB3321
R1018	315-0330-00			RES.,FXD,CMPSN:33 OHM,5%,0.25W	01121	CB3305
R1022	315-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
R1023	321-0185-00			RES.,FXD,FILM:825 OHM,1%,0.125W	91637	MFF1816G825R0F
R1024	321-0197-00			RES.,FXD,FILM:1.1K OHM,1%,0.125W	91637	MFF1816G11000F
R1028	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R1029	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R1031	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R1032	321-0145-00			RES.,FXD,FILM:316 OHM,1%,0.125W	91637	MFF1816G316R0F
R1033	321-0149-00			RES.,FXD,FILM:348 OHM,1%,0.125W	91637	MFF1816G348R0F
R1036	321-0222-00			RES.,FXD,FILM:2K OHM,1%,0.125W	91637	MFF1816G20000F
R1042	321-0208-00			RES.,FXD,FILM:1.43K OHM,1%,0.125W	91637	MFF1816G14300F
R1045	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R1046	321-0239-00			RES.,FXD,FILM:3.01K OHM,1%,0.125W	91637	MFF1816G30100F
R1047	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R1049	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1050	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R1051	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R1052	315-0563-00			RES.,FXD,CMPSN:56K OHM,5%,0.25W	01121	CB5635
R1053	315-0432-00			RES.,FXD,CMPSN:4.3K OHM,5%,0.25W	01121	CB4325

[1]Added if necessary.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R1056	321-0352-00			RES.,FXD,FILM:45.3K OHM,1%,0.125W	91637	MFF1816G45301F
R1057	315-0204-00			RES.,FXD,CMPSN:200K OHM,5%,0.25W	01121	CB2045
R1058	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
R1059	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R1060	315-0561-00			RES.,FXD,CMPSN:560 OHM,5%,0.25W	01121	CB5615
R1061	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1062	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R1064	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R1066	315-0432-00			RES.,FXD,CMPSN:4.3K OHM,5%,0.25W	01121	CB4325
R1067	315-0133-00			RES.,FXD,CMPSN:13K OHM,5%,0.25W	01121	CB1335
R1070[1]	311-1702-00			RES.,VAR,NONWIR:20K OHM,20%,1W	01121	13M214
R1071	321-0472-04			RES.,FXD,FILM:806K OHM,0.1%,0.125W	91637	MFF1816D80602B
R1072	321-0481-04			RES.,FXD,FILM:1M OHM,0.1%,0.125W	91637	MFF1816D10003B
R1073	321-0976-04			RES.,FXD,FILM:602 OHM,0.1%,0.125W	91637	MFF1816D60202B
R1074	321-0431-04			RES.,FXD,FILM:301K OHM,0.1%,0.125W	91637	MFF1816D30102B
R1075	311-1246-00			RES.,VAR,NONWIR:5K OHM,10%,0.5W	73138	72X-31-0-503K
R1076	321-0973-04			RES.,FXD,FILM:60.2K OHM,0.1%,0.125W	91637	MFF1816D60201B
R1077	321-0977-04			RES.,FXD,FILM:120.4K OHM,0.1%,0.125W	91637	MFF1816D12042B
R1078	321-0973-04			RES.,FXD,FILM:60.2K OHM,0.1%,0.125W	91637	MFF1816D60201B
R1079	321-0973-04			RES.,FXD,FILM:60.2K OHM,0.1%,0.125W	91637	MFF1816D60201B
R1081	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R1082	321-0973-04			RES.,FXD,FILM:60.2K OHM,0.1%,0.125W	91637	MFF1816D60201B
R1083	321-0472-04			RES.,FXD,FILM:806K OHM,0.1%,0.125W	91637	MFF1816D80602B
R1084	321-0481-04			RES.,FXD,FILM:1M OHM,0.1%,0.125W	91637	MFF1816D10003B
R1085	321-0976-04			RES.,FXD,FILM:602 OHM,0.1%,0.125W	91637	MFF1816D60202B
R1086	321-0431-04			RES.,FXD,FILM:301K OHM,0.1%,0.125W	91637	MFF1816D30102B
R1087	321-0975-04			RES.,FXD,FILM:180.6K OHM,0.1%,0.125W	91637	MFF1816D18062B
R1088	321-0973-04			RES.,FXD,FILM:60.2K OHM,0.1%,0.125W	91637	MFF1816D60201B
R1089	321-0973-04			RES.,FXD,FILM:60.2K OHM,0.1%,0.125W	91637	MFF1816D60201B
R1090	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R1091	316-0105-00			RES.,FXD,CMPSN:1M OHM,10%,0.25W	01121	CB1051
R1092	316-0154-00			RES.,FXD,CMPSN:150K OHM,10%,0.25W	01121	CB1541
R1093	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R1094	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R1095	321-0274-00			RES.,FXD,FILM:6.98K OHM,1%,0.125W	91637	MFF1816G69800F
R1096	316-0220-00			RES.,FXD,CMPSN:22 OHM,10%,0.25W	01121	CB2201
R1098	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R1099	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R1101	321-0068-00			RES.,FXD,FILM:49.9 OHM,1%,0.125W	91637	MFF1816G49R90F
R1102	311-1223-00			RES.,VAR,NONWIR:250 OHM,10%,0.50W	32997	3386F-T04-251
R1103	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R1104	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R1105	315-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.25W	01121	CB5105
R1106	321-0118-04			RES.,FXD,FILM:165 OHM,0.1%,0.125W	91637	MFF1816D165R0B
R1107	321-0738-04			RES.,FXD,FILM:1.485K OHM,0.1%,0.125W	91637	MFF1816D14850B
R1108	321-0118-04			RES.,FXD,FILM:165 OHM,0.1%,0.125W	91637	MFF1816D165R0B
R1109	316-0154-00			RES.,FXD,CMPSN:150K OHM,10%,0.25W	01121	CB1541
R1110	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
R1111	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
R1112A	316-0100-00			RES.,FXD,CMPSN:10 OHM,10%,0.25W	01121	CB1001
R1112B	321-0212-00			RES.,FXD,FILM:1.58K OHM,1%,0.125W	91637	MFF1816G15800F
R1113A	316-0100-00			RES.,FXD,CMPSN:10 OHM,10%,0.25W	01121	CB1001
R1113B	321-0300-00			RES.,FXD,FILM:13K OHM,1%,0.125W	91637	MFF1816G13001F

[1]Furnished as a unit with S1070A,B.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R1114	321-0126-00			RES.,FXD,FILM:200 OHM,1%,0.125W	91637	MFF1816G200R0F
R1116	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R1117	315-0303-00			RES.,FXD,CMPSN:30K OHM,5%,0.25W	01121	CB3035
R1118	315-0151-00			RES.,FXD,CMPSN:150 OHM,5%,0.25W	01121	CB1515
R1119A,B	311-1411-00			RES.,VAR,NONWIR:1K OHM X 10K OHM,20%,0.50W	01121	10M924
R1120[1]	315-0433-00			RES.,FXD,CMPSN:43K OHM,5%,0.25W	01121	CB4335
R1124	315-0361-00			RES.,FXD,CMPSN:360 OHM,5%,0.25W	01121	CB3615
R1125	321-0134-00			RES.,FXD,FILM:243 OHM,1%,0.125W	91637	MFF1816G243R0F
R1126	321-0108-00			RES.,FXD,FILM:130 OHM,1%,0.125W	91637	MFF1816G130R0F
R1128	321-0045-00			RES.,FXD,FILM:28.7 OHM,1%,0.125W	75042	CEAT0-28R7F
R1130	311-1230-00			RES.,VAR,NONWIR:20K OHM,20%,0.50W	32997	3386F-T04-203
R1131	315-0273-00			RES.,FXD,CMPSN:27K OHM,5%,0.25W	01121	CB2735
R1132	315-0151-00			RES.,FXD,CMPSN:150 OHM,5%,0.25W	01121	CB1515
R1133	321-0193-07			RES.,FXD,FILM:1K OHM,0.1%,0.125W	91637	MFF1816C10000B
R1134	315-0431-00			RES.,FXD,CMPSN:430 OHM,5%,0.25W	01121	CB4315
R1135	321-0134-00			RES.,FXD,FILM:243 OHM,1%,0.125W	91637	MFF1816G243R0F
R1136	321-0222-07			RES.,FXD,FILM:2K OHM,0.1%,0.125W	91637	MFF1816C20000B
R1137	321-0193-07			RES.,FXD,FILM:1K OHM,0.1%,0.125W	91637	MFF1816C10000B
R1138	321-0045-00			RES.,FXD,FILM:28.7 OHM,1%,0.125W	75042	CEAT0-28R7F
R1140	321-0097-00			RES.,FXD,FILM:100 OHM,1%,0.125W	91637	MFF1816G100R0F
R1141	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R1142	321-0164-00			RES.,FXD,FILM:499 OHM,1%,0.125W	91637	MFF1816G499R0F
R1152	315-0121-00			RES.,FXD,CMPSN:120 OHM,5%,0.25W	01121	CB1215
R1153	321-0147-00			RES.,FXD,FILM:332 OHM,1%,0.125W	91637	MFF1816G332R0F
R1154	321-0106-00			RES.,FXD,FILM:124 OHM,1%,0.125W	91637	MFF1816G124R0F
R1155	311-1258-00			RES.,VAR,NONWIR:50 OHM,10%,0.50W	32997	3329P-L58-500
R1156	321-0159-00			RES.,FXD,FILM:442 OHM,1%,0.125W	91637	MFF1816G442R0F
R1159	321-0159-00			RES.,FXD,FILM:442 OHM,1%,0.125W	91637	MFF1816G442R0F
R1162	315-0121-00			RES.,FXD,CMPSN:120 OHM,5%,0.25W	01121	CB1215
R1163	321-0147-00			RES.,FXD,FILM:332 OHM,1%,0.125W	91637	MFF1816G332R0F
R1164	315-0223-00			RES.,FXD,CMPSN:22K OHM,5%,0.25W	01121	CB2235
R1165	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R1166	315-0513-00			RES.,FXD,CMPSN:51K OHM,5%,0.25W	01121	CB5135
R1167	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R1168	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1169	315-0161-00			RES.,FXD,CMPSN:160 OHM,5%,0.25W	01121	CB1615
R1172	321-0157-00			RES.,FXD,FILM:422 OHM,1%,0.125W	91637	MFF1816G422R0F
R1173	321-0157-00			RES.,FXD,FILM:422 OHM,1%,0.125W	91637	MFF1816G422R0F
R1174	315-0751-00			RES.,FXD,CMPSN:750 OHM,5%,0.25W	01121	CB7515
R1175	311-1258-00			RES.,VAR,NONWIR:50 OHM,10%,0.50W	32997	3329P-L58-500
R1182	321-0145-00			RES.,FXD,FILM:316 OHM,1%,0.125W	91637	MFF1816G316R0F
R1183	321-0131-00			RES.,FXD,FILM:226 OHM,1%,0.125W	91637	MFF1816G226R0F
R1184	315-0751-00			RES.,FXD,CMPSN:750 OHM,5%,0.25W	01121	CB7515
R1185	311-1258-00			RES.,VAR,NONWIR:50 OHM,10%,0.50W	32997	3329P-L58-500
R1186	321-0182-00			RES.,FXD,FILM:768 OHM,1%,0.125W	91637	MFF1816G768R0F
R1187	321-0162-00			RES.,FXD,FILM:475 OHM,1%,0.125W	91637	MFF1816G475R0F
R1188	321-0114-00			RES.,FXD,FILM:150 OHM,1%,0.125W	91637	MFF1816G150R0F
R1189	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1201	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1202	321-0218-00			RES.,FXD,FILM:1.82K OHM,1%,0.125W	91637	MFF1816G18200F
R1203	321-0234-00			RES.,FXD,FILM:2.67K OHM,1%,0.125W	91637	MFF1816G26700F
R1204	321-0213-00			RES.,FXD,FILM:1.62K OHM,1%,0.125W	91637	MFF1816G16200F
R1209	321-0121-00			RES.,FXD,FILM:178 OHM,1%,0.125W	91637	MFF1816G178R0F

[1]Added if necessary.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R1211	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1212	321-0218-00			RES.,FXD,FILM:1.82K OHM,1%,0.125W	91637	MFF1816G18200F
R1216	321-0153-00			RES.,FXD,FILM:383 OHM,1%,0.125W	91637	MFF1816G383R0F
R1232	317-0621-00			RES.,FXD,CMPSN:620 OHM,5%,0.125W	01121	BB6215
R1233	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R1234	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R1235	321-0385-00			RES.,FXD,FILM:100K OHM,1%,0.125W	91637	MFF1816G10002F
R1237	321-0193-00			RES.,FXD,FILM:1K OHM,1%,0.125W	91637	MFF1816G10000F
R1239	321-0365-00			RES.,FXD,FILM:61.9K OHM,1%,0.125W	91637	MFF1816G61901F
R1252	317-0621-00			RES.,FXD,CMPSN:620 OHM,5%,0.125W	01121	BB6215
R1253	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R1254	315-0100-00			RES.,FXD,CMPSN:10 OHM,5%,0.25W	01121	CB1005
R1255	321-0385-00			RES.,FXD,FILM:100K OHM,1%,0.125W	91637	MFF1816G10002F
R1256	311-1230-00			RES.,VAR,NONWIR:20K OHM,20%,0.50W	32997	3386F-T04-203
R1257	321-0385-00			RES.,FXD,FILM:100K OHM,1%,0.125W	91637	MFF1816G10002F
R1258	321-0202-00			RES.,FXD,FILM:1.24K OHM,1%,0.125W	91637	MFF1816G12400F
R1259	321-0287-00			RES.,FXD,FILM:9.53K OHM,1%,0.125W	91637	MFF1816G95300F
R1267	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R1268	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R1302	315-0203-00			RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
R1303A				RES.,FXD,FILM:24.5M OHM		
R1303B				RES.,FXD,FILM:500K OHM		
R1303C	307-0290-03			RES.,FXD,FILM:23.4M OHM	80009	307-0290-03
R1303D				RES.,FXD,FILM:6.57M OHM		
R1304	315-0244-00			RES.,FXD,CMPSN:240K OHM,5%,0.25W	01121	CB2445
R1305	315-0822-00			RES.,FXD,CMPSN:8.2K OHM,5%,0.25W	01121	CB8225
R1306	315-0123-00			RES.,FXD,CMPSN:12K OHM,5%,0.25W	01121	CB1235
R1307	315-0683-00			RES.,FXD,CMPSN:68K OHM,5%,0.25W	01121	CB6835
R1308	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1310	316-0392-00			RES.,FXD,CMPSN:3.9K OHM,10%,025W	01121	CB3921
R1312	315-0242-00			RES.,FXD,CMPSN:2.4K OHM,5%,0.25W	01121	CB2425
R1313	321-0327-00			RES.,FXD,FILM:24.9K OHM,1%,0.125W	91637	MFF1816G24901F
R1314	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R1315	316-0473-00			RES.,FXD,CMPSN:47K OHM,10%,0.25W	01121	CB4731
R1316	316-0472-00			RES.,FXD,CMPSN:4.7K OHM,10%,0.25W	01121	CB4721
R1317	321-0329-00			RES.,FXD,FILM:26.1K OHM,1%,0.125W	91637	MFF1816G26101F
R1322	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R1326	315-0394-00			RES.,FXD,CMPSN:390K OHM,5%,0.25W	01121	CB3945
R1328	321-0157-00			RES.,FXD,FILM:422 OHM,1%,0.125W	91637	MFF1816G422R0F
R1329	316-0106-00			RES.,FXD,CMPSN:10M OHM,10%,0.25W	01121	CB1061
R1330	315-0182-00			RES.,FXD,CMPSN:1.8K OHM,5%,0.25W	01121	CB1825
R1331	301-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.50W	01121	EB1535
R1133	321-0193-07			RES.,FXD,FILM:1K OHM,0.1%,0.125W	91637	MFF1816C10000B
R1333	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R1335A,B	311-1533-00			RES.,VAR,NONWIR:5K OHM X 2.5M OHM,10%	01121	12M701
R1136	321-0222-07			RES.,FXD,FILM:2K OHM,0.1%,0.125W	91637	MFF1816C20000B
R1137	321-0193-07			RES.,FXD,FILM:1K OHM,0.1%,0.125W	91637	MFF1816C10000B
R1336	321-0206-00			RES.,FXD,FILM:1.37K OHM,1%,0.125W	91637	MFF1816G13700F
R1337	321-0206-00			RES.,FXD,FILM:1.37K OHM,1%,0.125W	91637	MFF1816G13700F
R1339	321-0174-00			RES.,FXD,FILM:634 OHM,1%,0.125W	91637	MFF1816G634R0F
R1340	321-0120-00			RES.,FXD,FILM:174 OHM,1%,0.125W	91637	MFF1816G174R0F
R1341	322-0197-00			RES.,FXD,FILM:1.1K OHM,1%,0.25W	75042	CEBT0-1101F
R1342	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R1343	321-0322-00			RES.,FXD,FILM:22.1K OHM,1%,0.125W	91637	MFF1816G22101F
R1344	316-0102-00			RES.,FXD,CMPSN:1K OHM,10%,0.25W	01121	CB1021
R1345	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
R1346	315-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.25W	01121	CB6825
R1352	315-0911-00			RES.,FXD,CMPSN:910 OHM,5%,0.25W	01121	CB9115
R1354	301-0752-00			RES.,FXD,CMPSN:7.5K OHM,5%,0.50W	01121	EB7525
R1355	302-0273-00			RES.,FXD,CMPSN:27K OHM,10%,0.50W	01121	EB2731
R1356	301-0752-00			RES.,FXD,CMPSN:7.5K OHM,5%,0.50W	01121	EB7525
R1358	315-0241-00			RES.,FXD,CMPSN:240 OHM,5%,0.25W	01121	CB2415
R1362	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
R1363	315-0332-00			RES.,FXD,CMPSN:3.3K OHM,5%,0.25W	01121	CB3325
R1364	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R1368	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
R1369	323-0307-00			RES.,FXD,FILM:15.4K OHM,1%,0.50W	75042	CECT0-1542F
R1371	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1372	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1373	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1375	311-1231-00			RES.,VAR,NONWIR:25K OHM,20%,0.50W	32997	3386F-T04-253
R1376	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R1378	315-0226-00			RES.,FXD,CMPSN:22M OHM,5%,0.25W	01121	CB2265
R1379	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R1380	311-0075-00			RES.,VAR,NONWIR:5M OHM,20%	12697	381-CM16993
R1384	302-0121-00			RES.,FXD,CMPSN:120 OHM,10%,0.50W	01121	EB1211
R1385	311-1227-00			RES.,VAR,NONWIR:5K OHM,20%,0.50W	32997	3386F-T04-502
R1386	311-1373-00			RES.,VAR,NONWIR:5K OHM,20%,1W	01121	10M836
R1390	311-1235-00			RES.,VAR,NONWIR:100K OHM,20%,0.50W	32997	3386F-T04-104
R1391	316-0470-00			RES.,FXD,CMPSN:47 OHM,10%,0.25W	01121	CB4701
R1393	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
R1394	321-0248-00			RES.,FXD,FILM:3.74K OHM,1%,0.125W	91637	MFF1816G37400F
R1395	311-1226-00			RES.,VAR,NONWIR:2.5K OHM,20%,0.50W	32997	3386F-T04-252
R1396	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R1397	311-1372-00			RES.,VAR,NONWIR:100K OHM,20%,1W	01121	10M835
R1398	316-0100-00			RES.,FXD,CMPSN:10 OHM,10%,0.25W	01121	CB1001
R1399	316-0470-00			RES.,FXD,CMPSN:47 OHM,10%,0.25W	01121	CB4701
R1416	323-0265-00			RES.,FXD,FILM:5.62K OHM,1%,0.50W	75042	CECT0-5621F
R1417	321-0282-00			RES.,FXD,FILM:8.45K OHM,1%,0.125W	91637	MFF1816G84500F
R1418	315-0181-00			RES.,FXD,CMPSN:180 OHM,5%,0.25W	01121	CB1815
R1422	315-0682-00			RES.,FXD,CMPSN:6.8K OHM,5%,0.25W	01121	CB6825
R1423	303-0822-00			RES.,FXD,CMPSN:8.2K OHM,5%,1W	01121	GB8225
R1424	315-0122-00			RES.,FXD,CMPSN:1.2K OHM,5%,0.25W	01121	CB1225
R1425	315-0563-00			RES.,FXD,CMPSN:56K OHM,5%,0.25W	01121	CB5635
R1426	307-0052-00			RES.,FXD,CMPSN:3 OHM,5%,0.50W	01121	EB30G5
R1430	311-1226-00			RES.,VAR,NONWIR:2.5K OHM,20%,0.50W	32997	3386F-T04-252
R1431	321-0351-00			RES.,FXD,FILM:44.2K OHM,1%,0.125W	91637	MFF1816G44201F
R1432	321-0284-00			RES.,FXD,FILM:8.87K OHM,1%,0.125W	91637	MFF1816G88700F
R1444	321-0761-03			RES.,FXD,FILM:35K OHM,0.25%,0.125W	75042	CEAT2-3502C
R1445	321-0684-00			RES.,FXD,FILM:15K OHM,0.5%,0.125W	91637	MFF1816D15001D
R1446	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R1447	315-0622-00			RES.,FXD,CMPSN:6.2K OHM,5%,0.25W	01121	CB6225
R1448	308-0245-00			RES.,FXD,WW:0.6 OHM,5%,2W	91637	RS2B162ER6000J
R1454	321-0775-03			RES.,FXD,FILM:45K OHM,0.25%,0.125W	91637	MFF1816D45001C
R1455	321-0816-03			RES.,FXD,FILM:5K OHM,0.25%,0.125W	91637	MFF1816D50001C
R1456	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315

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R1457	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R1458	308-0245-00			RES.,FXD,WW:0.6 OHM,5%,2W	91637	RS2B162ER6000J
R1463	321-0273-00			RES.,FXD,FILM:6.81K OHM,1%,0.125W	91637	MFF1816G68100F
R1464	321-0756-03			RES.,FXD,FILM:50K OHM,0.25%,0.125W	75042	CEAT2-5002C
R1465	321-0962-03			RES.,FXD,FILM:8K OHM,0.25%,0.125W	91637	MFF1816D80000C
R1466	315-0561-00			RES.,FXD,CMPSN:560 OHM,5%,0.25W	01121	CB5615
R1467	315-0432-00			RES.,FXD,CMPSN:4.3K OHM,5%,0.25W	01121	CB4325
R1468	308-0245-00			RES.,FXD,WW:0.6 OHM,5%,2W	91637	RS2B162ER6000J
R1473	321-0287-00			RES.,FXD,FILM:9.53K OHM,1%,0.125W	91637	MFF1816G95300F
R1474	321-0756-03			RES.,FXD,FILM:50K OHM,0.25%,0.125W	75042	CEAT2-5002C
R1475	321-0684-00			RES.,FXD,FILM:15K OHM,0.5%,0.125W	91637	MFF1816D15001D
R1476	315-0331-00			RES.,FXD,CMPSN:330 OHM,5%,0.25W	01121	CB3315
R1477	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R1478	307-0052-00			RES.,FXD,CMPSN:3 OHM,5%,0.50W	01121	EB30G5
R1480	311-1373-00			RES.,VAR,NONWIR:5K OHM,20%,1W	01121	10M836
R1481	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R1483	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R1484	315-0203-00			RES.,FXD,CMPSN:20K OHM,5%,0.25W	01121	CB2035
R1485	315-0273-00			RES.,FXD,CMPSN:27K OHM,5%,0.25W	01121	CB2735
R1486	321-0364-00			RES.,FXD,FILM:60.4K OHM,1%,0.125W	91637	MFF1816G60401F
R1487	321-0356-00			RES.,FXD,FILM:49.9K OHM,1%,0.125W	91637	MFF1816G49901F
R1488	308-0127-00			RES.,FXD,WW:2.5K OHM,5%,5W	91637	RS5-B25000J
R1489	315-0180-00			RES.,FXD,CMPSN:18 OHM,5%,0.25W	01121	CB1805
R1493	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R1494	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	01121	CB1045
R1495	316-0221-00			RES.,FXD,CMPSN:220 OHM,10%,0.25W	01121	CB2211
R1496	321-0357-00			RES.,FXD,FILM:51.1K OHM,1%,0.125W	91637	MFF1816G51101F
R1497	321-0280-00			RES.,FXD,FILM:8.06K OHM,1%,0.125W	91637	MFF1816G80600F
R1498	315-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
R1499	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1501	315-0912-00			RES.,FXD,CMPSN:9.1K OHM,5%,0.25W	01121	CB9125
R1502	315-0433-00			RES.,FXD,CMPSN:43K OHM,5%,0.25W	01121	CB4335
R1503	315-0822-00			RES.,FXD,CMPSN:8.2K OHM,5%,0.25W	01121	CB8225
R1504	315-0473-00			RES.,FXD,CMPSN:47K OHM,5%,0.25W	01121	CB4735
R1506	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	01121	CB5125
R1515	311-1221-00			RES.,VAR,NONWIR:50 OHM,20%,0.50W	32997	3386F-T04-500
R1516	321-0107-00			RES.,FXD,FILM:127 OHM,1%,0.125W	91637	MFF1816G127R0F
R1517	321-0001-00			RES.,FXD,FILM:10 OHM,1%,0.125W	75042	CEAT0-10R00F
R1691	303-0150-00			RES.,FXD,CMPSN:15 OHM,5%,1W	01121	GB1505
R1692	321-0062-00			RES.,FXD,FILM:43.2 OHM,1%,0.125W	91637	MFF1816G43R20F
R1693	323-0140-00			RES.,FXD,FILM:280 OHM,1%,0.50W	75042	CECT0-2800F
R1694	323-0140-00			RES.,FXD,FILM:280 OHM,1%,0.50W	75042	CECT0-2800F
R1695	321-0228-00			RES.,FXD,FILM:2.32K OHM,1%,0.125W	91637	MFF1816G23200F
R1697	321-0201-00			RES.,FXD,FILM:1.21K OHM,1%,0.125W	91637	MFF1816G12100F
R1698	315-0363-00			RES.,FXD,CMPSN:36K OHM,5%,0.25W	01121	CB3635
RT170	307-0181-00			RES.,THERMAL:100K OHM,10%,4MW/DEG C	15454	1DE104-K-220EC
RT270	307-0181-00			RES.,THERMAL:100K OHM,10%,4MW/DEG C	15454	1DE104-K-220EC
RT452	307-0125-00			RES.,THERMAL:500 OHM,10%,25 DEG C	50157	2D1595
RT559	307-0124-00			RES.,THERMAL:5K OHM,10%	50157	1D1618
RT759	307-0124-00			RES.,THERMAL:5K OHM,10%	50157	1D1618
RT1103	307-0125-00			RES.,THERMAL:500 OHM,10%,25 DEG C	50157	2D1595
RT1696	307-0124-00			RES.,THERMAL:5K OHM,10%	50157	1D1618

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
S20A(2)	105-0282-01			DRUM,CAM SWITCH:	80009	105-0282-01
S20B(2)	105-0343-01			DRUM,CAM SWITCH:	80009	105-0343-01
S128[1]						
S225	260-1208-00			SWITCH,PUSH:DPDT	80009	260-1208-00
S228[2]						
S300	260-1424-00			SWITCH,PUSH:	80009	260-1424-00
S375A	263-1019-00			DRUM ASSY,CAM S:	80009	263-1019-00
S375B,C	105-0421-00			ACTUATOR,SWITCH:	80009	105-0421-00
S450A,B	260-1310-01			SWITCH,PUSH:	80009	260-1310-01
S505	105-0400-00			ACTUATOR,SWITCH:	80009	105-0400-00
S508	105-0399-00			ACTUATOR,SWITCH:	80009	105-0399-00
S530[3]						
S600	260-1422-00			SWITCH,PUSH:	80009	260-1422-00
S644[4]						
S705	105-0401-00			ACTUATOR,SWITCH:	80009	105-0401-00
S708	105-0399-00			ACTUATOR,SWITCH:	80009	105-0399-00
S750[5]						
S1050	263-1091-00			DRUM ASSY,CAM S:	80009	263-1091-00
S1070A,B[6]						
S1090	260-1423-00			SWITCH,PUSH:	80009	260-1423-00
S1099	260-1309-00			SWITCH,PUSH:4PDT	01963	E63-10H
S1110A,B	260-1209-00			SWITCH,PUSH:4PDT	80009	260-1209-00
S1401	260-0834-00			SWITCH,TOGGLE:DPDT,5A,125VAC,0.25-40 THD	09353	7201SN260-834-1B
S1402	260-0638-00			SW,THERMOSTATIC:10A,240V,OPEN 75 DEG C	93410	110-364
S1403	260-1300-01			SWITCH,SLIDE:DPDT,3A,125V	82389	11A-1354
T178	120-0469-00			XFMR,TOROID:3 TURNS BIFILAR	80009	120-0469-00
T278	120-0469-00			XFMR,TOROID:3 TURNS BIFILAR	80009	120-0469-00
T1320	120-0815-01			XFMR,PWR,SDN &:HV(MOLDED)	80009	120-0815-01
T1400	120-0799-01			XFMR,PWR,STPDN:LV	80009	120-0799-01
U120	155-0085-01			MICROCIRCUIT,LI:HYB,DUAL FET INPUT/AMPL,SEL	80009	155-0085-01
U140	155-0078-07			MICROCIRCUIT,LI:ML,VERT AMPL,SEL	80009	155-0078-07
U220	155-0085-01			MICROCIRCUIT,LI:HYB,DUAL FET INPUT/AMPL,SEL	80009	155-0085-01
U240	155-0078-07			MICROCIRCUIT,LI:ML,VERT AMPL,SEL	80009	155-0078-07
U330	156-0030-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U340	156-0030-00			MICROCIRCUIT,DI:QUAD 2-INPUT POS NAND GATE	01295	SN7400N
U350	156-0041-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	27014	DM7474N
U370	155-0091-00			MICROCIRCUIT,LI:ML,CHANNEL SWITCH	80009	155-0091-00
U450	155-0078-05			MICROCIRCUIT,LI:ML,VERT AMPL,SEL	80009	155-0078-05
U470	155-0082-00			MICROCIRCUIT,LI:HYBRID,VERT OUTPUT AMPL	80009	155-0082-00
U520	155-0032-01			MICROCIRCUIT,LI:MONOLITHIC,INPUT PRE-AMPL	80009	155-0032-01
U600	155-0049-01			MICROCIRCUIT,DI:MONOLITHIC,SWEEP CONTROL	80009	155-0049-01
U720	155-0032-01			MICROCIRCUIT,LI:MONOLITHIC,INPUT PRE-AMPL	80009	155-0032-01
U930	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	80009	156-0158-00
U1321	152-0552-00			SEMICOND DEVICE:V MULTR,5KV IN,15KV OUT	80009	152-0552-00
U1418	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	80009	156-0158-00
U1454	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	80009	156-0158-00
U1464	156-0158-00			MICROCIRCUIT,LI:DUAL OPERATIONAL AMPLIFIER	80009	156-0158-00
U1690	156-0281-00			MICROCIRCUIT,LI:4 TRANSISTOR ARRAY	80009	156-0281-00
V1380	154-0677-10			ELECTRON TUBE:CRT	80009	154-0677-10
VR144	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035
VR161	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035
VR244	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035

[1]Furnished as a unit with R128.
[2]Furnished as a unit with R228.
[3]Furnished as a unit with R530.
[4]Furnished as a unit with R644.
[5]Furnished as a unit with R750.
[6]Furnished as a unit with R1070.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
VR261	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035
VR290	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035
VR396	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035
VR462	152-0195-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	81483	6965112
VR464	152-0195-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	81483	6965112
VR465	152-0149-00			SEMICOND DEVICE:ZENER,0.4W,10V,5%	04713	1N961B
VR467	152-0278-00			SEMICOND DEVICE:ZENER,0.4W,3V,5%	07910	1N4372A
VR482	152-0195-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	81483	6965112
VR570	152-0217-00			SEMICOND DEVICE:ZENER,0.4W,8.2V,5%	07910	1N756A
VR608	152-0278-00			SEMICOND DEVICE:ZENER,0.4W,3V,5%	07910	1N4372A
VR647	152-0195-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	81483	6965112
VR796	152-0226-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	81483	69-6584
VR798	152-0278-00			SEMICOND DEVICE:ZENER,0.4W,3V,5%	07910	1N4372A
VR930	152-0265-00			SEMICOND DEVICE:ZENER,0.4W,24V,5%	04713	1N970B
VR938	152-0304-00			SEMICOND DEVICE:ZENER,0.4W,20V,5%	04713	1N968B
VR956	152-0278-00			SEMICOND DEVICE:ZENER,0.4W,3V,5%	07910	1N4372A
VR1026	152-0278-00			SEMICOND DEVICE:ZENER,0.4W,3V,5%	07910	1N4372A
VR1124	152-0175-00			SEMICOND DEVICE:ZENER,0.4W,5.6V,5%	04713	1N752A
VR1134	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035
VR1216	152-0055-00			SEMICOND DEVICE:ZENER,0.4W,11V,5%	04713	1N962B
VR1267	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035
VR1329	152-0289-00			SEMICOND DEVICE:ZENER,0.4W,180V,5%	04713	1N991B
VR1362	152-0166-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	81483	69-9035
VR1374	152-0357-00			SEMICOND DEVICE:ZENER,0.4W,82V,5%	04713	1N983B
VR1416	152-0411-00			SEMICOND DEVICE:ZENER,0.25W,9V,5%	04713	1N937
VR1418	152-0022-00			SEMICOND DEVICE:ZENER,1W,25V,5%	80009	152-0022-00
VR1422	152-0283-00			SEMICOND DEVICE:ZENER,0.4W,43V,5%	04713	1N976B
VR1423	152-0304-00			SEMICOND DEVICE:ZENER,0.4W,20V,5%	04713	1N968B
VR1480	152-0127-00			SEMICOND DEVICE:ZENER,0.4W,7.5V,5%	04713	1N755A

OPTION 4

This section describes the features of Option 4 as it pertains to the 475A Oscilloscope. This circuitry modifies the instrument to meet conducted and radiated interference requirements over the frequency range of 150 kHz to 25 MHz (conducted) and 150 kHz to 1 GHz (radiated).

The following additions and changes were made to the standard circuitry to meet the specification requirements:

EMI filter (FL1401) added in series with the input power cord.

Cathode ray tube mesh filter installed to minimize crt faceplate radiation.

Four signal-output bnc connectors on the rear plenum chamber changed to a type that improves shielding of the connected signal leads.

Capacitors added across the transformer secondary windings.

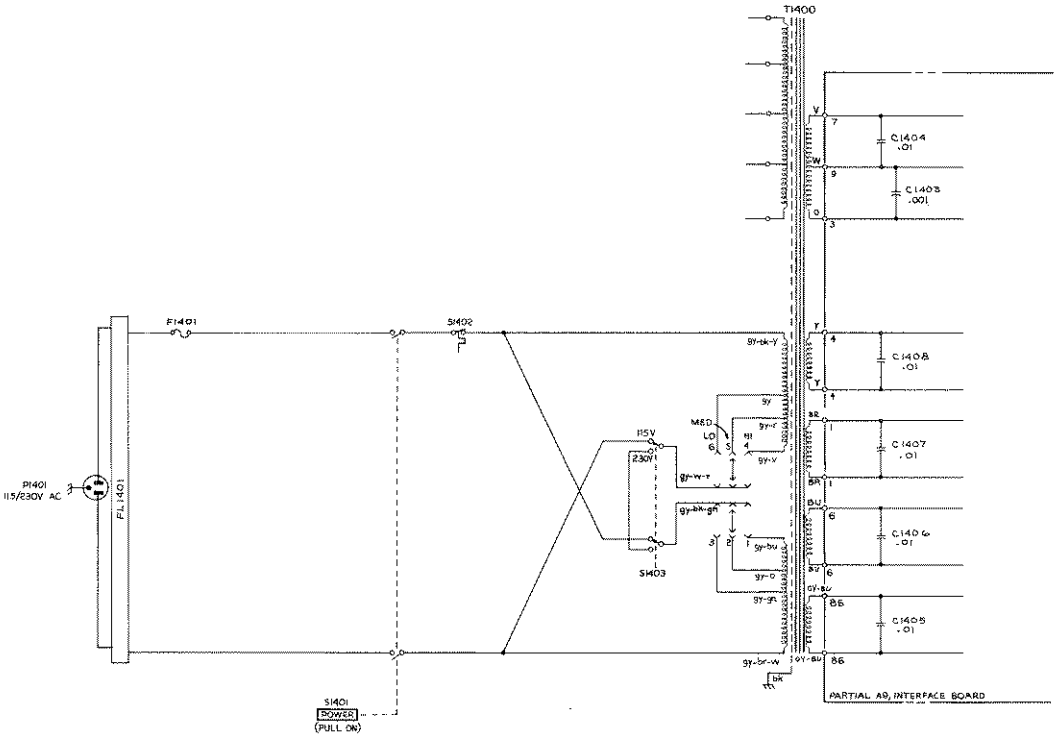


Fig. Option 4-1. 475A Option 4 primary winding with power-line filter.

OPTION 4

REPLACEABLE PARTS LIST

ELECTRICAL

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C1403	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C1404	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	196241
C1405	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	196241
C1406	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	196241
C1407	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	196241
C1408	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	196241
FL1401	119-0376-01			FILTER,RAD INT:2 X 3A,250V,400 HZ	80009	119-0376-01
J430	131-1315-00			CONNECTOR,RCPT,:BNC,FEMALE	80009	131-1315-00
J584	131-1315-00			CONNECTOR,RCPT,:BNC,FEMALE	80009	131-1315-00
J829	131-1315-00			CONNECTOR,RCPT,:BNC,FEMALE	80009	131-1315-00
J1330	131-1315-00			CONNECTOR,RCPT,:BNC,FEMALE	80009	131-1315-00

MECHANICAL

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5 Name & Description	Mfr Code	Mfr Part Number
	119-0376-01			1	FILTER,RAD INT:(SEE FL1401 EPL)	80009	119-0376-01
					(ATTACHING PARTS)		
	211-0038-00			1	SCREW,MACHINE:4-40 X 0.312"100 DEG,FLH STL	83385	OBD
	210-0586-00			1	NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL	78189	OBD
					- - - * - - -		
	131-0707-00			1	CONTACT,ELEC:0.48"L,22-26 AWG WIRE	22526	47439
	131-0708-00			1	CONTACT,ELEC:0.48"L,28-32 AWG WIRE	22526	47437
	131-1310-00			1	CONTACT,ELEC:MESH FILTER GROUND	80009	131-1310-00
	----- -----			4	CONNECTOR,RCPT:(SEE J430,J584,J829,J1330 EPL)		
	179-2162-00			1	WIRING,HARNESS:	80009	179-2162-00
	210-0774-00			2	EYELET,METALLIC:0.152 OD X 0.245 INCH L,BRS	80009	210-0774-00
	210-0775-00			2	EYELET,METALLIC:0.126 OD X 0.23 INCH L,BRS	80009	210-0775-00
	378-0726-00			1	FILTER,MESH,CRT:	80009	378-0726-00

OPTION 7

Option 7 is a dc to ac inverter that permits Tektronix Oscilloscopes to operate on 12 or 24 V dc with no performance deterioration. Circuitry is provided to protect against damage due to connection of 24 V when in the 12 V mode of operation.

The 24-volt external input permits use with conventional dc power (marine and aircraft).

Option 7 is an integral part of the oscilloscope. The modified oscilloscope has a three-position voltage input selection slide switch (visible through the right-hand side panel) at the rear of the line voltage selector switch. A dc input connector is located below the fan cover on the rear panel.

SPECIFICATIONS

AC Requirements

No increase in ac requirements over those of oscilloscopes not having Option 7.

DC Requirements

11.5 to 14 volts or 22 to 28 volts. 11.5-volt operation excludes graticule light operation and Option 5. Operating range may be extended to 15 volts or 30 volts with a series dropping resistor. Maximum elevation for + or − power lead is 60 V with respect to oscilloscope chassis ground.

Temperature

The same operating and non-operating range as the oscilloscope without Option 7.

SAFETY CONSIDERATIONS

Option 7 becomes a part of the modified instrument. The safety considerations for the unmodified instrument apply.

FUNCTION OF CONTROLS AND CONNECTORS

Mode Switch[1]

AC — Applies ac power to the oscilloscope power switch.

DC 12 — Permits 12 V operation of the instrument from an external 12 V source.

DC 24 — Permits 24 V operation of the instrument from either an external 24 V power source or from the 1106 Power Supply, which may be mechanically attached to the oscilloscope.

Dc Input Connector

Option 7 mode switch and dc input connector are located on the modified oscilloscope.

OPERATION AND INSPECTION

Set the oscilloscope and Option 7 for the power source available as listed.

TABLE 1

Power Source	Oscilloscope Line Selector	Option 7 Mode Switch
115 V AC	115	AC
230 V AC	230	AC
12 V DC		12
24 V DC		24
1106[1]		24

Turn the oscilloscope on. Check that the oscilloscope operates properly on any of the listed power sources that may be available.

Connect the oscilloscope frame to a ground (earth) reference before using.

CIRCUIT DESCRIPTION

Option 7 is a dc to ac inverter. It operates on 12 or 24 V dc. The circuit description is for 24 V operation unless noted otherwise. Refer to the schematic diagrams (Figs. Option 7-2 and 7-3) throughout the detailed circuit description.

The operating frequency of the inverter is approximately 400 Hz.

[1] **Be sure that the 1106 Line Selector switch is set to the correct line voltage for proper battery charging.**

Simplified Block Diagram

See Fig. Option 7-1. The dc source is applied to the turn-off level circuit, the start circuit and the primary of T1400. If the dc source is above the level set by Turn-Off Level Adjustment R1613, the turn-off circuit does not operate.

The start circuit provides a large current surge through T1631 secondary to the bases of Q1652, Q1662, Q1654 and Q1664. This starts the inverter.

The turn-off circuit is activated in two ways. In 24 V operation, Q1622 is turned on by the source voltage dropping below 22 V. In 12 V mode of operation, Q1626 is turned on by the accidental application of 24 V dc.

Turn-Off Level Circuit

For the following description, refer to Fig. Option 7-2.

The voltage reference for the base of Q1606 is set by R1604, VR1604 and VR1605 for about 9.1 V. This establishes the junction of R1607 and the emitters of Q1606 and Q1608 at about 9.7 V. C1605 helps to hold the 9.1 V level, preventing inverter transients from activating the turn-off circuit and prevents Q1608 from turning on when the inverter is started. This allows the power source time to recover after providing the initial-start surge.

Source voltages higher than 22 V dc cause increased current through R1607, Q1606 and R1609. Q1608 is kept cut off by the increased voltage across R1609 and the resulting change across divider R1611-R1613-R1614. This permits no current through R1617. Since R1617 furnishes bias to Q1622, the transistor is cut off. This permits the collector of Q1622 and the rest of the turn-off circuit to rise to a voltage determined by the inverter circuit and the dc source voltage. The collector of Q1622 may be about 24 V (with respect to minus dc) with a 12 V dc source and about 36 V with a 24 V dc source.

If the dc source voltage drops to less than 22 V, the current through divider R1609, R1611, R1613 and R1614 is decreased. Q1608 conducts, taking current from Q1606, and causing less drop across R1609. This makes Q1608 conduct more and Q1606 is cut off. Current flow through R1617 turns Q1622 on. Q1622 saturates, dropping its collector voltage to about 0.2 V. R1618 limits the maximum base current of Q1622.

During 12 V dc operation, there is no current flow through VR1604 and VR1605, since their series rating, about 18 volts, exceeds the applied voltage. The base current of Q1606, through R1605, turns Q1606 on enough to take all the current through R1607, which causes Q1608 to be cut off.

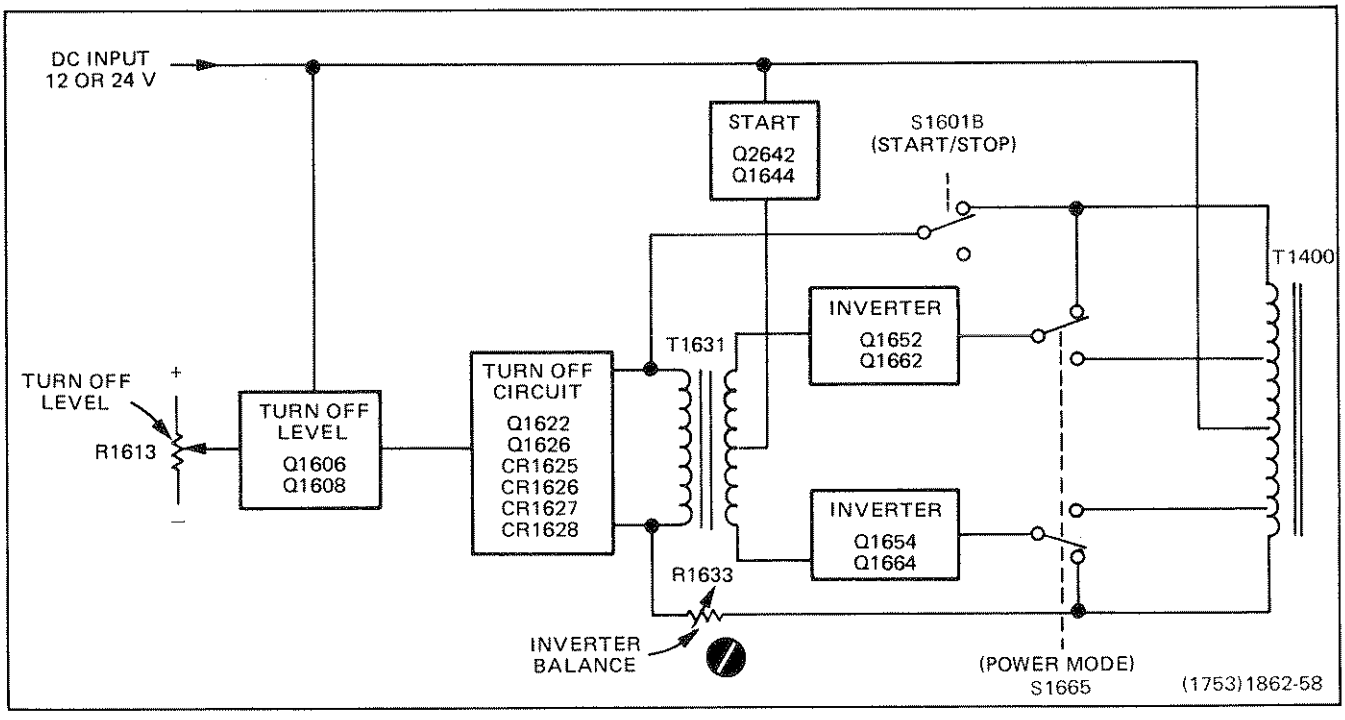


Fig. Option 7-1. Option 7 simplified block diagram.

Turn-Off Circuit

Q1622 is off under normal operating conditions until the dc source drops below 22 V and causes Q1622 to conduct. Q1622 does not conduct during 12 V dc operation, since the turn-off level circuit is disabled, CR1625, CR1626, CR1627, and CR1628 form a bridge rectifier. The inverter waveform is rectified to provide operating power for the turn-off circuit. C1626 filters the inverter spikes to keep them from firing Q1626 (scr). R1623 prevents C1626 from charging to the peak-to-peak inverter spikes.

Q1622 saturates when it is turned on. C1622 provides the high current path for feedback current via CR1625 or CR1626. Once the inverter is shut down, R1622 establishes a path to discharge C1622.

If 24 V dc is accidentally applied when the mode switch is in the 12 V position, tranformer T1400 attempts to produce two times the correct feedback. This is sufficient to cause VR1622 to conduct. VR1622 provides the firing current for the scr, Q1626. Scr Q1626 fires and shorts out the bridge rectifier and the primary of T1631, stopping the inverter. R1625 prevents Q1626 from being fired by inverter noise. R1624 and C1626 provide holding current for Q1626, keeping it conducting until the surge current created by the over-voltage conditions have terminated. CR1624 permits rapid charging of C1626.

Start Circuit

When S1601 is closed, the external dc source is applied to C1614, VR1641, and R1645. The initial surge is coupled to Q1642 through C1614, VR1639, and R1641. Transistor Q1642 saturates until C1614 charges through R1639 to the value determined by VR1639 and the base-emitter junction of Q1642 (about 5.7 volts), then Q1642 is cut off. R1641 limits the base current in Q1642. Zender diode VR1639, once C1614 is charged, makes Q1642 insensitive to input variations. R1642 limits Q1642 collector current. Q1644, R1645, and VR1641 provide a constant current during the time Q1642 is saturated, regardless of the dc source voltage. CR1643 is reverse biased by this starting current. The starting current is applied to the inverter transistors through T1631.

Inverter Circuit

The starting surge is applied to the bases of Q1652, Q1662, Q1654, and Q1664 trough T1631, R1652, R1662, R1654, and R1664. Since the transistors do not have identical parameters, one pair will conduct before the other, and start the inverter. Operating base current is provided through CR1643.

R1626, R1631, and T1631 primary and secondary are the main frequency-determining components for the inverter. Four base resistors, R1652, R1662, R1654, and

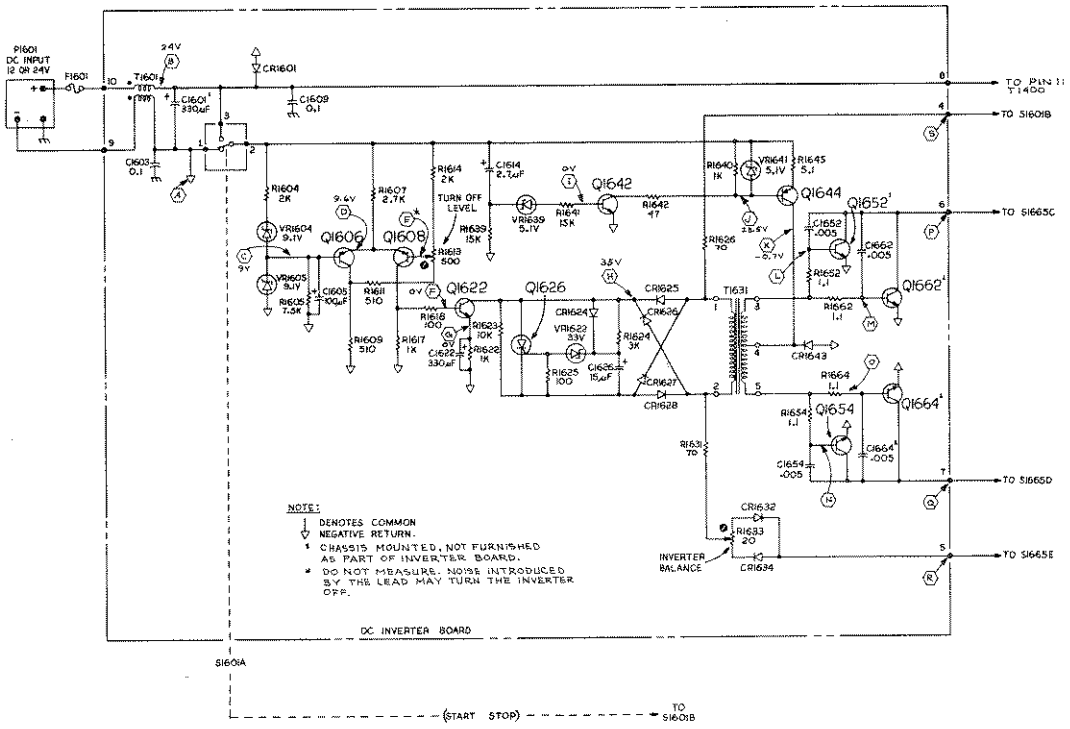


Fig. Option 7-2. 475A Option 7 DC Inverter.

R1664, distribute the drive evenly between the four transistors, C1652, C1662, C1654 and C1664 degenerate the high frequency response and reduce transients.

Feedback to maintain inverter operation is provided from T1400 primary to T1631 primary through R1626, R1631, R1633, CR1632 and CR1634. Resistors R1626 and R1631 provide frequency stability and current limiting. R1633, CR1632, and CR1634 compensate for differences in transistors and components. CR1632 and CR1634 conduct during different inverter half-cycles and permit R1633 to balance the drive to T1400.

C1681, C1682, C1683, C1684, C1685 and C1686 are added to the secondary of T1400 with Option 7 to provide optimum reduction of transients during inverter operation.

DC Input

External power is applied through P1601. CR1601 is normally reverse biased. If the wrong polarity external power is applied, CR1601 becomes forward biased and blows fuse F1601. Low-pass network T1601, C1601, C1603, and C1609 is a filter to reduce transients to the dc source.

Start-Stop Switch

S1601, Section A in the off (stop) position discharges the capacitors in the turn-off and start circuits. This ensures the correct time constants when S1601 is changed to the on (start) position. In the start position, the dc input is applied to the inverter circutiry by S1601, Section A. At the same time S1601, section B is closed, completing the feedback loop for the inverter transistors, S1601, section B stops the inverter in the off position by opening the feedback loop between T1400 and T1631.

Power-Mode Switch (S1665)

See Fig. Option 7-3. Sections A and F connect filter C1671 and R1671 to T1400 during 12 or 24 V operation to reduce converter transients. Sections C and D select either transformer terminals 10A and 12A or 10 and 12, to provide the same secondary output when operating on 12 or 24 V. Sections B and E connect transformer terminals 10 and 12 to S1665, C and D, and to the inverter feedback circuit during both 12 and 24 V operation.

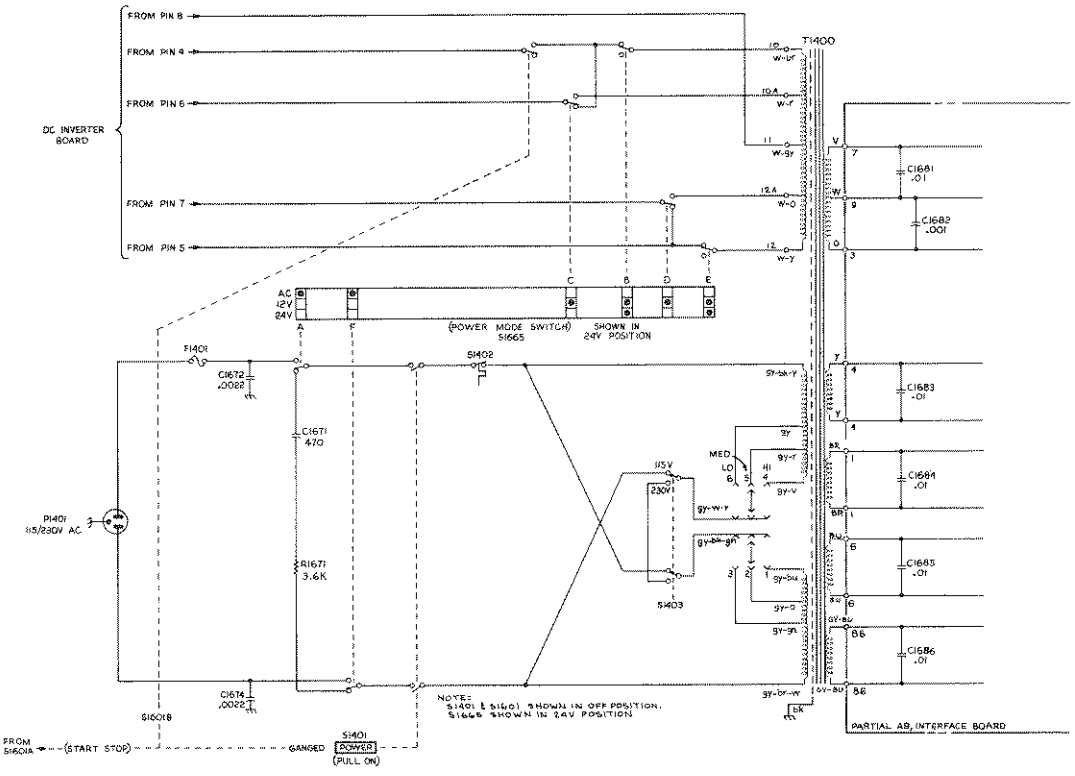


Fig. Option 7-3. 475A Option 7 primary winding.

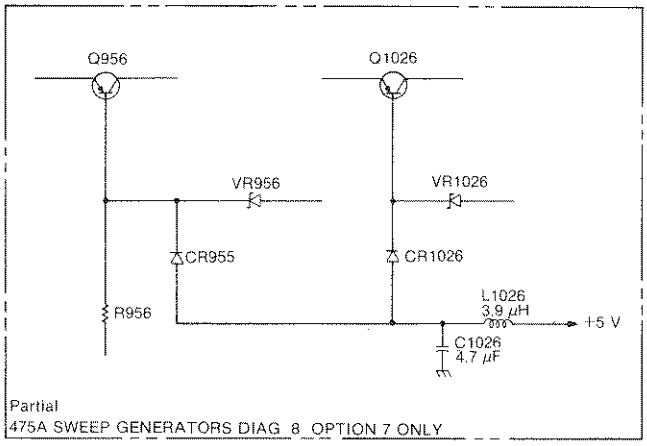


Fig. Option 7-4. Partial 475A Sweep Generators diagram 8, showing modification with Option 7.

MAINTENANCE

Obtaining Replacement Parts

STANDARD PARTS. All electrical and mechanical part replacements for Option 7 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts list for value, tolerance, rating and description.

SPECIAL PARTS. In addition to the standard electronic components, some special components are used in Option 7. These components are manufactured or selected by Tektronix, Inc., to meet specific performance requirements, or are manufactured for Tektronix, Inc., in accordance with our specifications. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

ORDERING PARTS. When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument type.
2. Instrument serial number.
3. A description of the part (if electrical, include the circuit number).
4. Tektronix part number.

Circuit Board Chassis Removal

The circuit board is mounted on a small chassis located between the power transformer and the crt shield. To remove the chassis, remove three screws. Two thread-forming screws are located at the top of the chassis. One screw is at the bottom of the chassis and is removed from the right-hand side by going just below the power transformer.

CALIBRATION

Option 7 may be calibrated without removing it from the oscilloscope.

The reference letters (A), (B), etc., refer to points indicated on the schematic and circuit board illustrations.

Equipment Required

DC VOLTMETER. 22 V to 28 V.

TEST OSCILLSOCOPE. Used to verify the inverter balance adjustment. If the instrument under test and Option 7 are operational and the power source has a negative ground, they may be used as the test oscilloscope for this check.

DC POWER SOURCE. Voltage from 22 V to 28 V and from 11.5 V to 14 V. A source voltage of less than 22 volts will turn off Option 7 when it is operating in the 24 V mode. Starting current in 24 V mode is approximately 4 to 10 A. The dc source must be capable of handling this surge without dropping to 22 V or less. The 12 V starting surge is approximately 15 A.

NOTE

Option 7 is calibrated at the factory using a power supply (having the specifications listed first under the equipment required list). This permits the most accurate setting of the turn-off volts and inverter balance adjustments. Because this type of power supply may not be available, several alternate possibilities are given. The alternate power supplies have drawbacks, including voltage stability vs. time with high discharge rates, see Fig. Option 7-5.

1. Variable power supply with the aformentioned capabilities.

2. Variable power supply with an adequate current rating, in series with items 4 or 5.

3. 1106 Power Supply battery pack.[2]

4. Two 12-volt wet-cell storage batteries, in series, tapped at 20, 22, or 24 V.[3]

5. 18 to 23 Ni Cd cells, 4.0 amp hr (D cells) or greater, furnishing 20 to 28 V.[3]

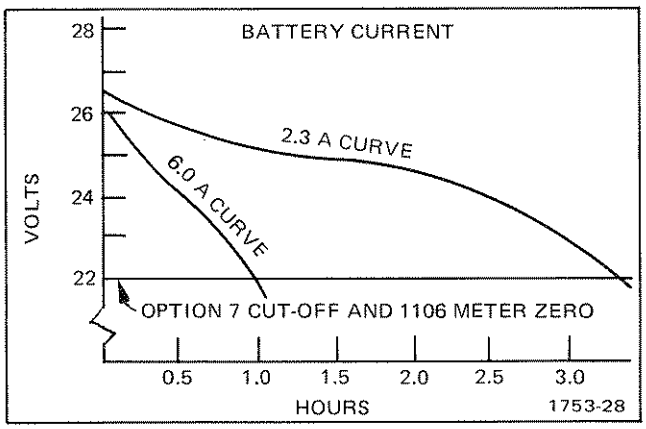


Fig. Option 7-5. Typical battery pack discharge curves.

CAUTION

This procedure is for an external dc source with the negative lead at ground potential (negative ground system).

Operating Range

a. Connect the dc source to the oscilloscope equipped with Option 7. Operate the oscilloscope in the 24 V mode. Connect the voltmeter between fuse, F1601 (B) and the common negative return (A). Vary the dc source from 28 V to 22 V.

CHECK—Oscilloscope should operate over the voltage range.

[2]To set the turn-off level, the battery is charged above the cut-off point (22 V). An oscilloscope is connected and the battery allowed to discharge while its voltage is being monitored. As it reaches 22 V the turn-off point is set to cut off Option 7. The turn-off point on Option 7 approximately coincides with the meter zero on the 1106.

[3]This does not permit accurate adjustment of the turn-off level. Ni Cd batteries can be used, following the technique used for item 3.

b. Change the dc source to 12 V. Operate the oscilloscope in the 12 V mode. Vary the dc source from 14 V to 11.5 V.

CHECK—Oscilloscope should operate over the voltage range.

Inverter Balance

NOTE

If the major oscilloscope use is with a 12-volt source, do this step while operating the oscilloscope and dc source on 12 volts.

Operate the oscilloscope in the 24 V mode. Set the dc source to 24 V. Connect the test oscilloscope between C1601 (C) and the common negative return (A).

CHECK—Signal should be flat. See Fig. Option 7-6.

ADJUST—Inverter Balance (R1633) for the flattest signal.

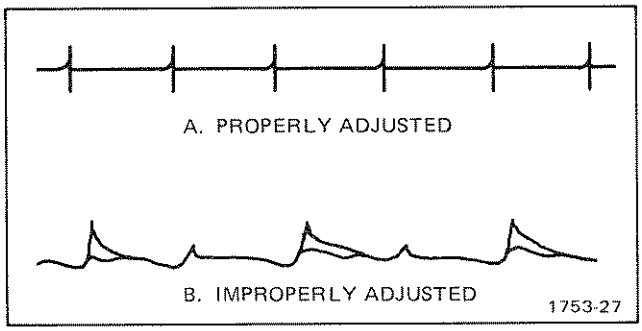


Fig. Option 7-6. Inverter Balance.

NOTE

There is a slow drift (about a second) after the inverter balance adjustment has been moved. This is due to transistor characteristics and will require a slight Inverter Balance readjustment.

A very close approximation of the preceding method can be obtained by setting the inverter balance control for the minimum sound coming from the inverter.

Turn-Off Level

Set the dc source for 21.8 V.

ADJUST—Turn-Off Level (R1613) slowly until Option 7 turns off.

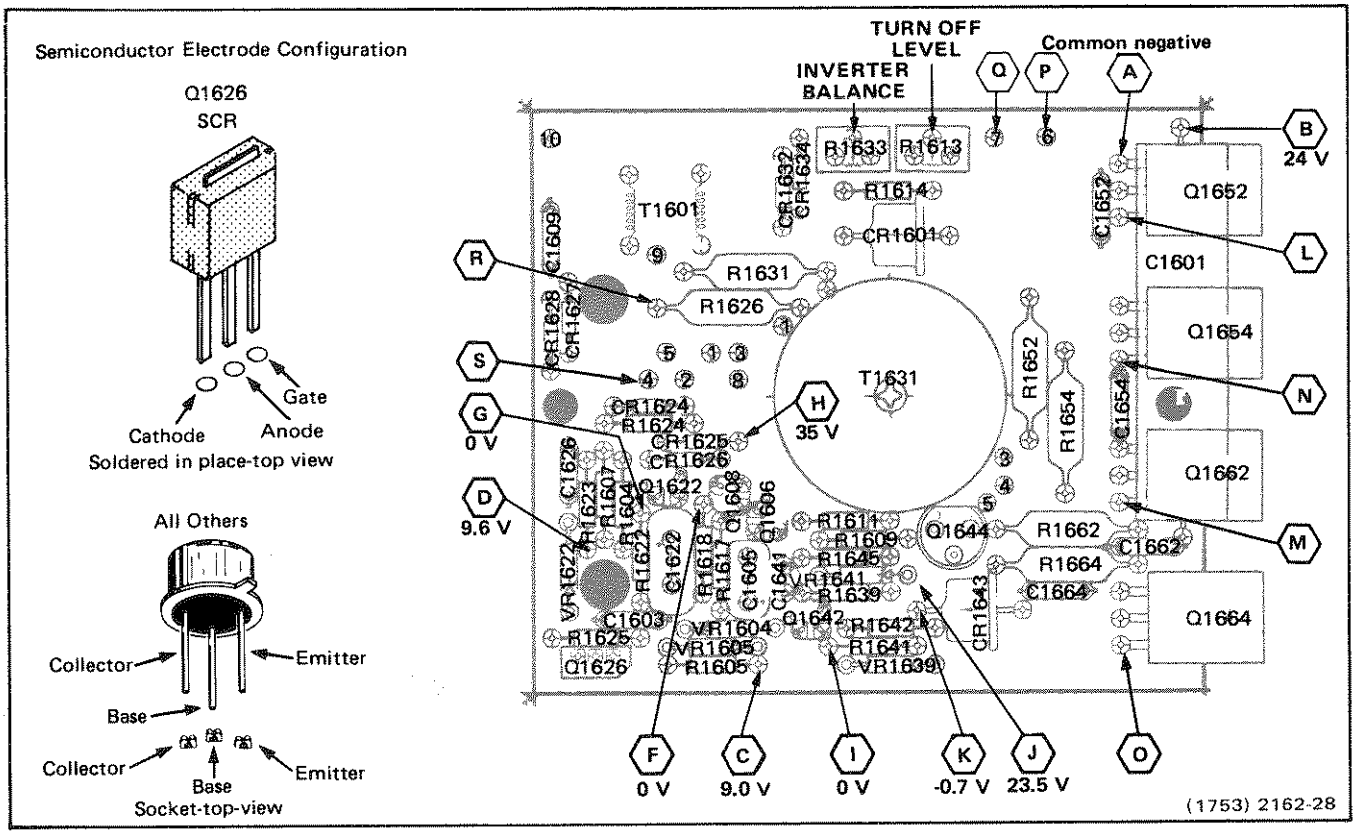


Fig. Option 7-7. Circuit board layout with test voltages.

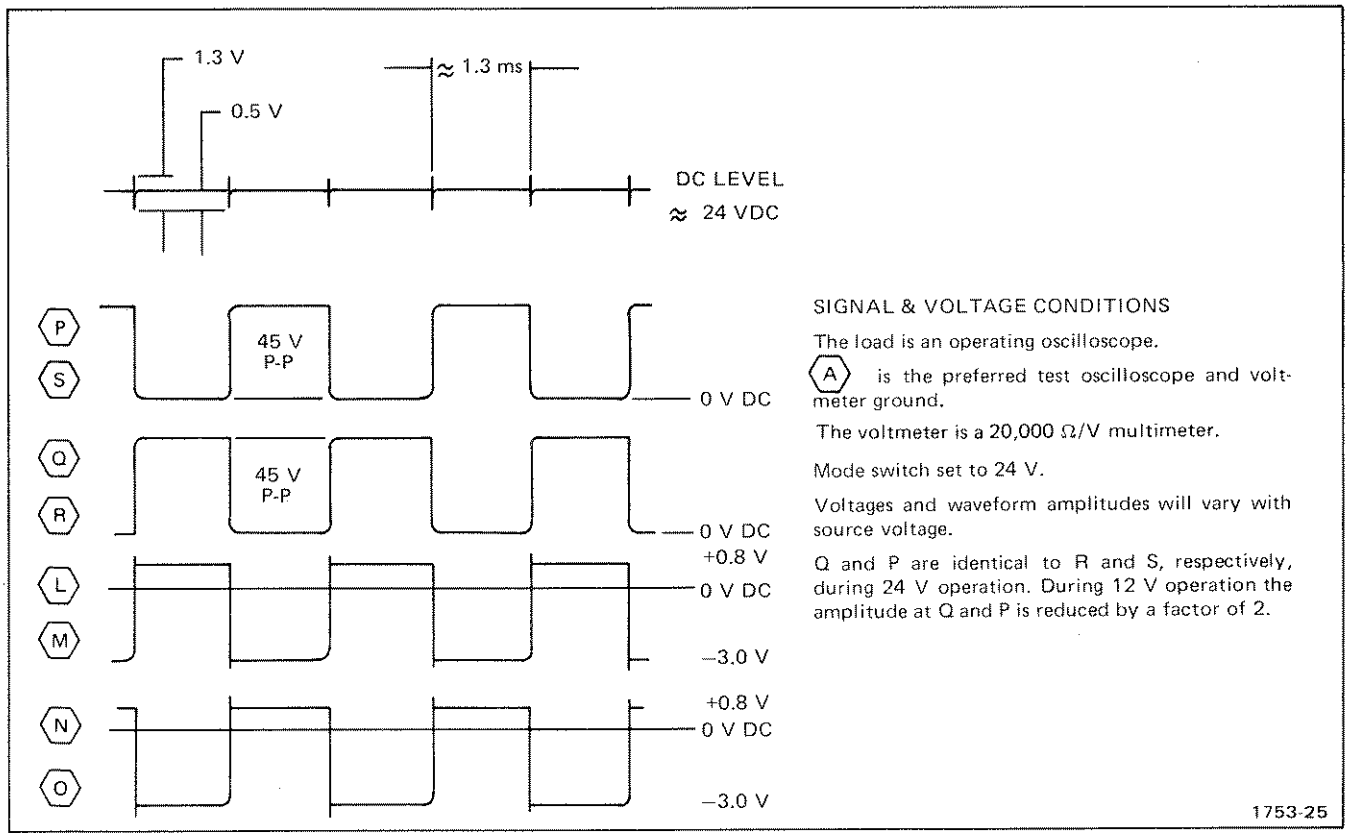
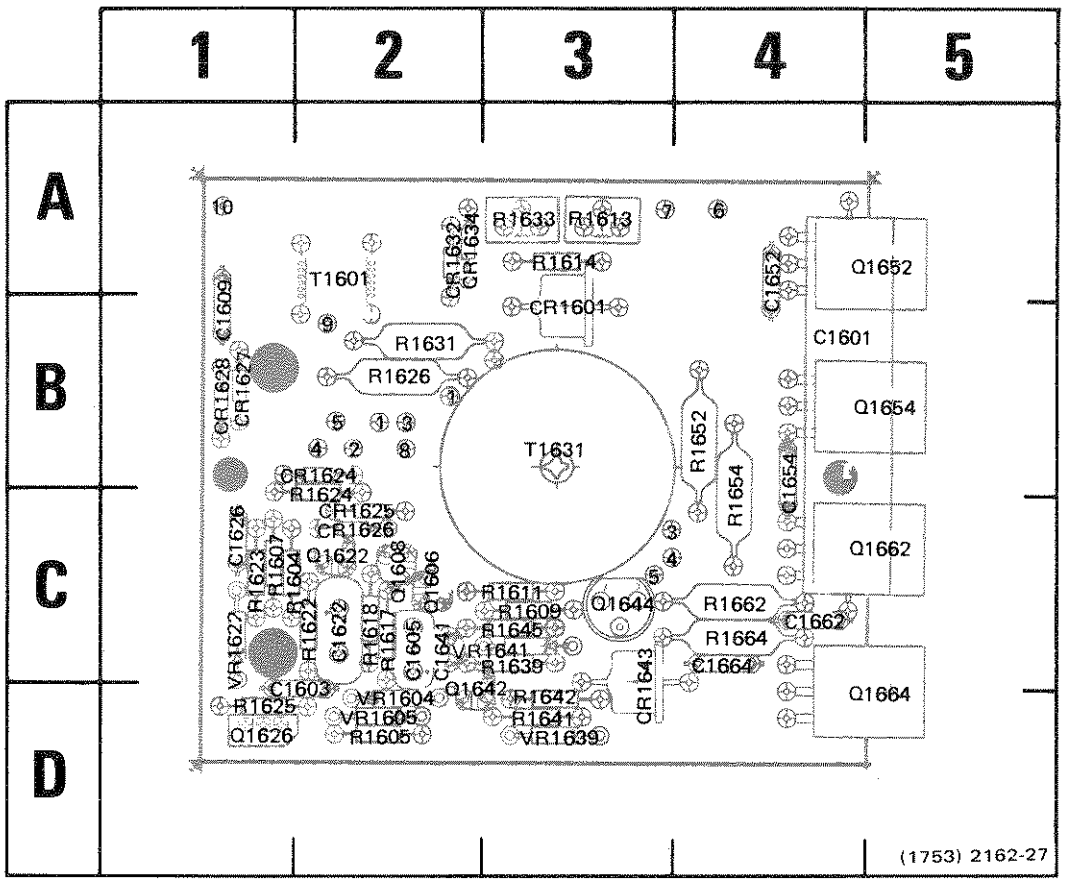


Fig. Option 7-8. Typical idealized waveforms.



CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC
C1601	4B	CR1628	1B	R1605	2D	R1642	3D
C1603	2D	CR1632	2A	R1607	1C	R1645	3C
C1605	2C	CR1634	2A	R1609	3C	R1652	4B
C1609	1B	CR1643	3D	R1611	3C	R1654	4B
C1622	2C			R1613	3A	R1662	4C
C1626	1C	Q1606	2C	R1614	3A	R1664	4C
C1641	2C	Q1608	2C	R1617	2C		
C1652	4A	Q1622	2C	R1618	2C	T1601	2A
C1654	4B	Q1626	1D	R1622	2C	T1631	3B
C1662	4C	Q1642	2D	R1623	1C		
C1664	4C	Q1644	3C	R1624	2C	VR1604	2D
		Q1652	5A	R1625	1D	VR1605	2D
CR1601	3B	Q1654	5B	R1626	2B	VR1622	1C
CR1624	2B	Q1662	5C	R1631	2B	VR1639	3D
CR1625	2C	Q1664	5D	R1633	3A	VR1641	3C
CR1626	2C			R1639	3C		
CR1627	1B	R1604	1C	R1641	3D		

Fig. Option 7-9. Circuit board layout with component locator grid.

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OPTION 7

REPLACEABLE ELECTRICAL PARTS

ABBREVIATIONS

ACTR	ACTUATOR	PLSTC	PLASTIC
ASSY	ASSEMBLY	QTZ	QUARTZ
CAP	CAPACITOR	RECP	RECEPTACLE
CER	CERAMIC	RES	RESISTOR
CKT	CIRCUIT	RF	RADIO FREQUENCY
COMP	COMPOSITION	SEL	SELECTED
CONN	CONNECTOR	SEMICOND	SEMICONDUCTOR
ELCTLT	ELECTROLYTIC	SENS	SENSITIVE
ELEC	ELECTRICAL	VAR	VARIABLE
INCAND	INCANDESCENT	WW	WIREWOUND
LED	LIGHT EMITTING DIODE	XFMR	TRANSFORMER
NONWIR	NON WIREWOUND	XTAL	CRYSTAL

ADDITIONAL PARTS ADDED TO THE STANDARD 475A

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
C1601	290-0667-00			CAP.,FXD,ELCTLT:330UF,+75-10%,50V	56289	500D158
C1671	283-0032-00			CAP.,FXD,CER DI:470PF,5%,500V	72982	831-500Z5D471J
C1672	283-0263-00[1]			CAP.,FXD,CER DI:0.0022UF,20%,3000V	56289	33C319
C1674	283-0263-00[1]			CAP.,FXD,CER DI:0.0022UF,20%,3000V	56289	33C319
C1681	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	19C241
C1682	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C1683	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	19C241
C1684	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	19C241
C1685	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	19C241
C1686	283-0068-00			CAP.,FXD,CER DI:0.01UF,+100-0%,500V	56289	19C241
F1601	159-0038-00			FUSE,CARTRIDGE:3AG,15A,32V,FAST-BLOW	71400	MDL 15A
P1601	131-1333-00			CONNECTOR,RCPT,:POWER	80009	131-1333-00
Q1652	151-0436-00			TRANSISTOR:SILICON,NPN	80009	151-0436-00
Q1654	151-0436-00			TRANSISTOR:SILICON,NPN	80009	151-0436-00
Q1662	151-0436-00			TRANSISTOR:SILICON,NPN	80009	151-0436-00
Q1664	151-0436-00			TRANSISTOR:SILICON,NPN	80009	151-0436-00
R1671	308-0349-00			RES.,FXD,WW:3.6K OHM,1%,3W	91637	RS2B-B36000F
S1601A,B	260-0834-00			SWITCH,TOGGLE:DPDT,5A,125VAC,0.25-40 THD	09353	7201SN260-834-1B
S1665	105-0479-00			ACTUATOR,SWITCH:	80009	105-0479-00
S1665A	260-0760-00			SWITCH,SENS:10A,250V,SPDT,SNAP ACTION	01963	E62-10A
S1665B	260-0760-00			SWITCH,SENS:10A,250V,SPDT,SNAP ACTION	01963	E62-10A
S1665C	260-0760-00			SWITCH,SENS:10A,250V,SPDT,SNAP ACTION	01963	E62-10A
S1665D	260-0760-00			SWITCH,SENS:10A,250V,SPDT,SNAP ACTION	01963	E62-10A
S1665E	260-0760-00			SWITCH,SENS:10A,250V,SPDT,SNAP ACTION	01963	E62-10A
S1665F	260-0760-00			SWITCH,SENS:10A,250V,SPDT,SNAP ACTION	01963	E62-10A

[1]Mounted on 475A Rear Panel.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
	670-2240-04			CKT BOARD ASSY:VERTICAL PREAMP	80009	670-2240-04
	670-2744-01			CKT BOARD ASSY:DC INVERTER	80009	670-2744-01
C338[1]	281-0504-00			CAP.,FXD,CER DI:10PF,+/-1PF,500V	72982	301-055C0G0100F
C1026[2]	290-0524-00			CAP.,FXD,ELCTLT:4.7UF,20%,10V	90201	TDC475M010EL
C1603	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145 E 104Z
C1605	290-0531-00			CAP.,FXD,ELCTLT:100UF,20%,10V	90201	TDC107M010WLC
C1609	283-0178-00			CAP.,FXD,CER DI:0.1UF,+80-20%,100V	72982	8131N145 E 104Z
C1614	290-0573-00			CAP.,FXD,ELCTLT:2.7UF,20%,50V	56289	196D275X0050JA1
C1622	290-0533-00			CAP.,FXD,ELCTLT:330UF,20%,,6V	56289	196D337X006MA3
C1626	290-0528-00			CAP.,FXD,ELCTLT:15UF,20%,50V	90201	TDC156M050WLC
C1652	283-0110-00			CAP.,FXD,CER DI:0.005UF,+80-20%,150V	56289	19C242B
C1654	283-0110-00			CAP.,FXD,CER DI:0.005UF,+80-20%,150V	56289	19C242B
C1662	283-0110-00			CAP.,FXD,CER DI:0.005UF,+80-20%,150V	56289	19C242B
C1664	283-0110-00			CAP.,FXD,CER DI:0.005UF,+80-20%,150V	56289	19C242B
CR1601	152-0198-00			SEMICOND DEVICE:SILICON,200V,3A	04713	1N4721
CR1624	152-0333-00			SEMICOND DEVICE:SILICON,55V,200MA	80009	152-0333-00
CR1625	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
CR1626	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
CR1627	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
CR1628	152-0107-00			SEMICOND DEVICE:SILICON,375V,400MA	80009	152-0107-00
CR1632	152-0333-00			SEMICOND DEVICE:SILICON,55V,200MA	80009	152-0333-00
CR1634	152-0333-00			SEMICOND DEVICE:SILICON,55V,200MA	80009	152-0333-00
CR1643	152-0198-00			SEMICOND DEVICE:SILICON,200V,3A	04713	1N4721
L1026[3]	108-0245-00			COIL,RF:3.9UH	80009	108-0245-00
Q1606	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q1608	151-0301-00			TRANSISTOR:SILICON,PNP	04713	2N2907A
Q1622	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1626	151-0506-00			TRANSISTOR:SILICON,CONTROLLED RECTIFIER	03508	C106B2
Q1642	151-0302-00			TRANSISTOR:SILICON,NPN	04713	2N2222A
Q1644	151-0335-00			TRANSISTOR:SILICON,PNP	80009	151-0335-00
R1604	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R1605	315-0752-00			RES.,FXD,CMPSN:7.5K OHM,5%,0.25W	01121	CB7525
R1607	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	01121	CB2725
R1609	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R1611	315-0511-00			RES.,FXD,CMPSN:510 OHM,5%,0.25W	01121	CB5115
R1613	311-1248-00			RES.,VAR,NONWIR:500 OHM,10%,0.50W	73138	72X-23-0-501K
R1614	315-0202-00			RES.,FXD,CMPSN:2K OHM,5%,0.25W	01121	CB2025
R1617	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1618	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	01121	CB1015
R1622	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1623	316-0103-00			RES.,FXD,CMPSN:10K OHM,10%,0.25W	01121	CB1031
R1624	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R1625	316-0101-00			RES.,FXD,CMPSN:100 OHM,10%,0.25W	01121	CB1011
R1626	308-0450-00			RES.,FXD,WW:70 OHM,1%,3W	91637	RS2B-B70R00F
R1631	308-0450-00			RES.,FXD,WW:70 OHM,1%,3W	91637	RS2B-B70R00F
R1633	311-1501-00			RES.,VAR,NONWIR:20 OHM,10%,0.50W	73138	72X-37-0-200
R1639	315-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
R1640	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R1641	315-0153-00			RES.,FXD,CMPSN:15K OHM,5%,0.25W	01121	CB1535
R1642	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705

[1]See Diagram 3, C338 is added from base to collector of Q338.
[2]See partial schematic in this section or blue line on Diagram 8.
[3]See partial schematic in this section or Diagram 8.

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R1645	307-0113-00			RES.,FXD,CMPSN:5.1 OHM,5%,0.25W	01121	CB51G5
R1652	308-0459-00			RES.,FXD,WW:1.1 OHM,5%,3W	91637	RS2B-D1R100J
R1654	308-0459-00			RES.,FXD,WW:1.1 OHM,5%,3W	91637	RS2B-D1R100J
R1662	308-0459-00			RES.,FXD,WW:1.1 OHM,5%,3W	91637	RS2B-D1R100J
R1664	308-0459-00			RES.,FXD,WW:1.1 OHM,5%,3W	91637	RS2B-D1R100J
T1601	120-0637-00			XFMR,TOROID:5 TURNS BIFILAR	80009	120-0637-00
T1631	120-0852-00			XFMR,TOROID:2 WINDINGS	80009	120-0852-00
VR1604	152-0306-00			SEMICOND DEVICE:ZENER,0.4W,9.1V,5%	81483	1N960B
VR1605	152-0306-00			SEMICOND DEVICE:ZENER,0.4W,9.1V,5%	81483	1N960B
VR1622	152-0241-00			SEMICOND DEVICE:ZENER,0.4W,33V,5%	04713	1N973B
VR1639	152-0279-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	07910	CD332305
VR1641	152-0279-00			SEMICOND DEVICE:ZENER,0.4W,5.1V,5%	07910	CD332305

OPTION 7

REPLACEABLE MECHANICAL PARTS

ABBREVIATIONS

BHB	binding head brass	h	height or high	OHB	oval head brass
BHS	binding head steel	hex.	hexagonal	OHS	oval head steel
CRT	cathode-ray tube	HHB	hex head brass	PHB	pan head brass
csk	countersunk	HHS	hex head steel	PHS	pan head steel
DE	double end	HSB	hex socket brass	RHS	round head steel
FHB	flat head brass	HSS	hex socket steel	SE	single end
FHS	flat head steel	ID	inside diameter	THB	truss head brass
Fil HB	fillister head brass	lg	length or long	THS	truss head steel
Fil HS	fillister head steel	OD	outside diameter	w	wide or width

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	441-1171-00			1	CHAS,ELEK EQUIP:DC INVERTER	80009	441-1171-00
					(ATTACHING PARTS)		
	211-0008-00			2	SCREW,MACHINE:4-40 X 0.25 INCH,PNH STL	83385	OBD
	210-0938-00			2	WASHER,FLAT:0.109 ID X 0.25 INCH OD,STL	75497	AN960-3
					- - - * - - -		
-2	----- -----			1	CIRCUIT BOARD ASSY:INVERTER		
-3	136-0252-04			15	. CONTACT,ELEC:0.188 INCH LONG	22526	75060
-4	----- -----			1	. XFMR,TOROID:(SEE T1601 EPL)		
					(ATTACHING PARTS)		
-5	343-0443-00			1	. RETAINER,XFMR:	80009	343-0443-00
-6	212-0011-00			1	. SCREW,MACHINE:8-32 X 0.750 INCH,FLH STL	83385	OBD
-7	210-0409-00			1	. NUT,PLAIN,HEX.:8-32 X 0.312 INCH,BRS	73743	3046-402
					- - - * - - -		
					(ATTACHING PARTS)		
-8	211-0116-00			2	SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
					- - - * - - -		
-9	----- -----			4	TRANSISTOR:(SEE Q1652,Q1654,Q1662,Q1664 EPL)		
					(ATTACHING PARTS)		
-10	210-0586-00			3	NUT,PLAIN,EXT W:4-40 X 0.25 INCH,STL	78189	OBD
-11	343-0451-00			1	RETAINER,XSTR:	80009	343-0451-00
-12	342-0195-00			1	INSULATOR,PLATE:0.70 X 3 INCH LONG	08530	OBD
					- - - * - - -		
-13	348-0141-00			1	GROMMET,PLASTIC:U-SHP,0.625 X0.658 INCH	80009	348-0141-00
-14	348-0055-00			1	GROMMET,PLASTIC:0.25 INCH DIA	80009	348-0055-00
-15	352-0031-00			1	FUSEHOLDER:3AG FUSE	75915	357001
					(ATTACHING PARTS)		
-16	211-0507-00			1	SCREW,MACHINE:6-32 X 0.312 INCH,PNH STL	83385	OBD
-17	210-0006-00			1	WASHER,LOCK:INTL,0.146 ID X 0.283"OD,STL	78189	1206-00-00-0541C
-18	210-0407-00			1	NUT,PLAIN,HEX.:6-32 X 0.25 INCH,BRS	73743	3038-0228-402
					- - - * - - -		
	342-0229-00			1	INSULATOR,FILM:1 X 2.55 INCH	80009	342-0229-00
-19	407-1341-00			1	BRACKET,SWITCH:INVERTER	80009	407-1341-00
					(ATTACHING PARTS)		
-20	211-0101-00			2	SCREW,MACHINE:4-40 X 0.25" 100 DEG,FLH STL	83385	OBD
					- - - * - - -		
-21	105-0479-00			1	ACTUATOR,SWITCH:INVERTER	80009	105-0479-00
-22	260-0760-00			6	SWITCH,SENS:SPDT,10A,250V	01963	E62-10A
					(ATTACHING PARTS)		
-23	211-0212-00			2	SCREW,MACHINE:2-56 X 1.75 INCH,PNH STL	83385	OBD
-24	210-0405-00			1	NUT,PLAIN,HEX.:2-56 X 0.188 INCH,BRS	73743	2X12157-402
					- - - * - - -		
-25	386-2649-00			1	PLATE,ACT GUIDE:INVERTER	80009	386-2649-00
	214-1925-00			1	SPRING,SW ACT:POWER SOURCE	80009	214-1925-00
-26	260-0834-00			1	SWITCH,TOGGLE:DPDT,5A,125VAC,0.25-40 THD	09353	7201-SN
					(ATTACHING PARTS)		
-27	210-0562-00			1	NUT,PLAIN,HEX.:0.25-40 X 0.312 INCH,BRS	73743	2X20224-402
-28	210-0046-00			1	WASHER,LOCK:INTL,0.26 ID X 0.40" OD,STL	78189	1214-05-00-0541C
					- - - * - - -		
	179-1963-00			1	WIRING HARNESS:	80009	179-1963-00
	348-0005-00			1	GROMMET,RUBBER:0.50 INCH DIA	70485	230
	200-1414-03			1	COVER,OSCP:REAR	80009	200-1414-03
	210-0204-00			1	TERMINAL,LUG:		
	334-2268-00			1	MARKER,IDENT:		
	131-1333-00			1	CONNECTOR,RCPT,:POWER	80009	131-1333-00
					(ATTACHING PARTS)		
	211-0101-00			2	SCREW,MACHINE:4-40 X 0.25" 100 DEG,FLH STL	83385	OBD
	348-0365-00			4	FOOT,CABINET:PLASTIC,W/LATCH GROOVE	80009	348-0365-00
					ACCESSORIES		
	161-0094-00			1	CABLE,ASSY,PWR:3 WIRE,36 INCHES LONG	16428	KH7667

OPTION 7 EXPLODED

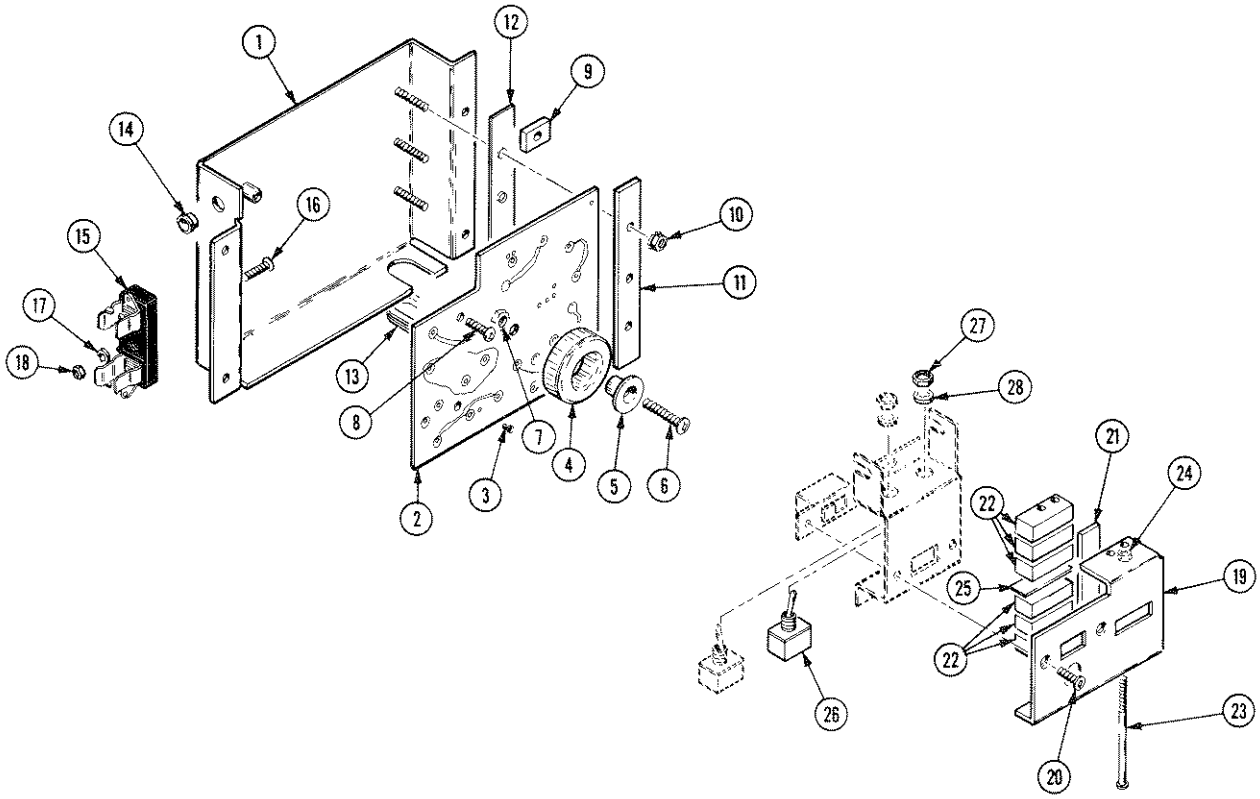

Fig. Option 7-10

OPTION 78

This option adds a Type P11 phosphor CRT to the instrument.

Parts List Changes

DELETE:

V1380	154-0677-10	CRT, P31 Phosphor

ADD:

V1380	154-0677-14	CRT, P11 Phosphor

If this option is being added to an instrument which is already equipped with a different phosphor, or if the cathode-ray tube requires replacement, use the following procedure:

1). Follow the crt removal and installation procedure in the maintenance section of this manual.

2). After completing crt installation, check Table 4-5 (Recalibration After Repair) for calibration adjustments which may require re-adjustment.