TSG2

TEKTRONIX®

TSG2

NTSC CONVERGENCE PATTERN TEST SIGNAL GENERATOR MODULE

INSTRUCTION MANUAL

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

Serial Number _____

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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.

Specifications and price change privileges reserved.

U.S.A. and foreign Tektronix products covered by U.S. and foreign patents and/or patents pending.

TABLE OF CONTENTS

This manual is divided into two parts for safety purposes. Part I should be used by both operating and service personnel; the Safety Summary should be reviewed before operating or servicing the instrument. Part II contains service instructions that can lead to exposure of personnel to hazardous voltages; these instructions are for qualified service personnel only.

PART I—OPERATORS INFORMATION

PART II—SERVICE INFORMATION

WARNING

The remaining portion of this Table of Contents lists servicing instructions that expose personnel to hazardous voltages. These instructions are for qualified service personnel only.

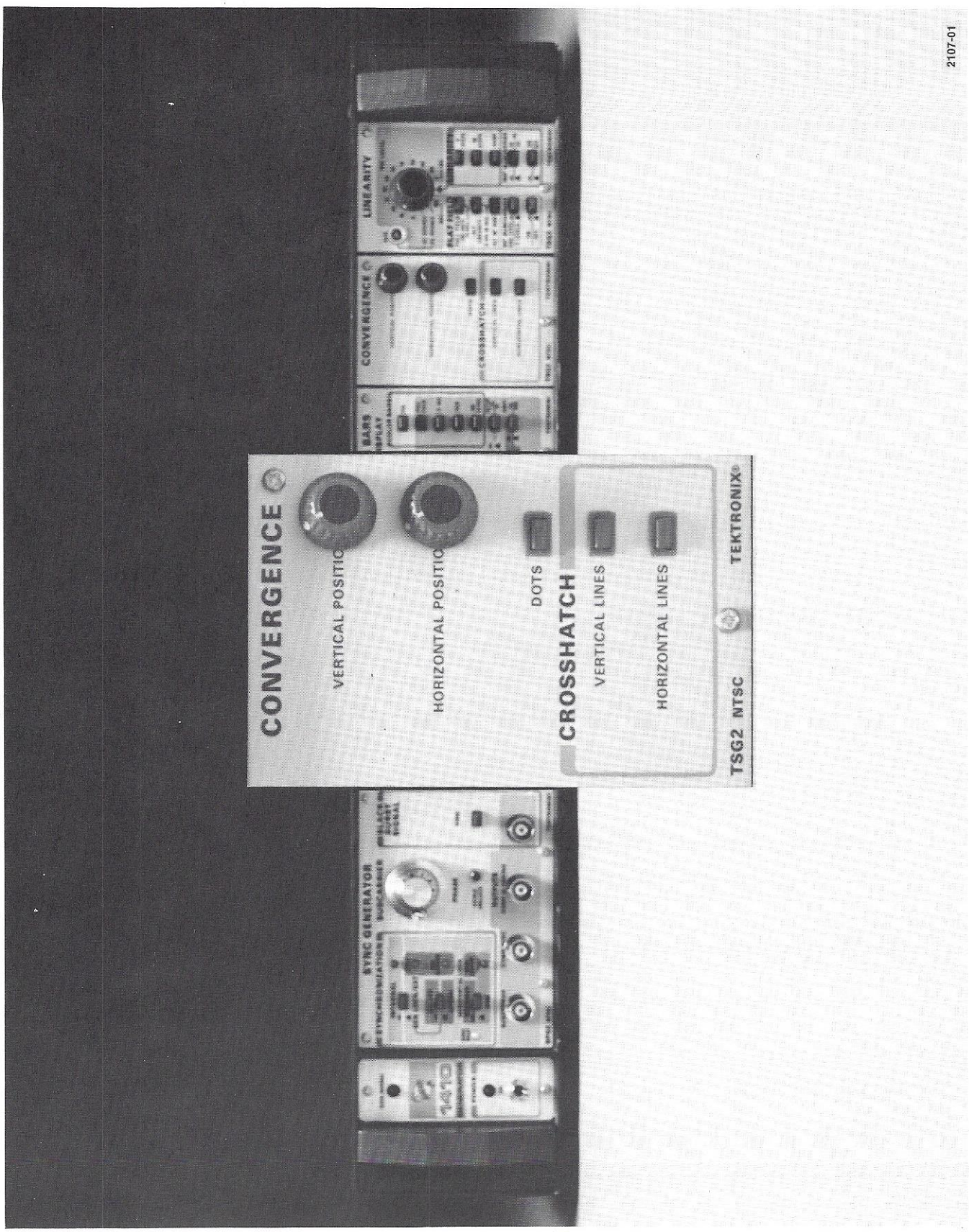


Fig. 1-1. The TSG2 NTSC Convergence Pattern Test Signal Generator module.

PART I
OPERATORS INFORMATION

OPERATING INSTRUCTIONS

SAFETY SUMMARY

This manual contains safety information which the operator and service technician must follow to avoid personal injury and to ensure safe operation of the instrument.

WARNING information is intended to protect the operator from personal injury.

CAUTION information is intended to protect the instrument from damage.

The following are general safety precautions that must be observed during all phases of operation and maintenance.

WARNING

To reduce electrical shock hazard, the instrument must be properly grounded. Refer to the 1410 Mainframe instruction manual for more information.

Electrical shock hazards are present inside the instrument. Only qualified service personnel should remove the instrument covers.

DESCRIPTION

The TSG2 NTSC Convergence Pattern Test Signal Generator Module circuitry is contained on one etched-circuit board which plugs into the 1410 Mainframe Interface board. Pin connectors on the bottom edge of the circuit board mate with vertical pins on the Interface board.

The TSG2 provides signal pulses which, when applied to a TV picture monitor, produce a crosshatch and dot pattern on the crt display. The crosshatch pattern consists of horizontal and vertical line pulses which are independently controlled by front-panel switches. The crosshatch pattern is generated when the vertical and horizontal pushbuttons are pushed in. Dot pulses, generated separately, may be viewed with or without the crosshatch pattern. Convenient pattern alignment with the picture monitor screen is provided by the horizontal and vertical position controls.

Composite video convergence pattern signals are useful for measuring picture monitor or camera scanning linearity, aspect ratio, and geometric distortion.

FRONT PANEL CONTROLS

1	VERTICAL POSITION	Potentiometer control positions display patterns vertically.
2	HORIZONTAL POSITION	Potentiometer control positions display patterns horizontally.
3	DOTS	Pushbutton switch selects dot pattern when pushed in.
4	VERTICAL LINES	Pushbutton switch selects vertical lines when pushed in. (Combines with horizontal lines to produce CROSSHATCH pattern.)
5	HORIZONTAL LINES	Pushbutton switch selects horizontal lines when pushed in. (Combines with vertical lines to produce CROSSHATCH pattern.)

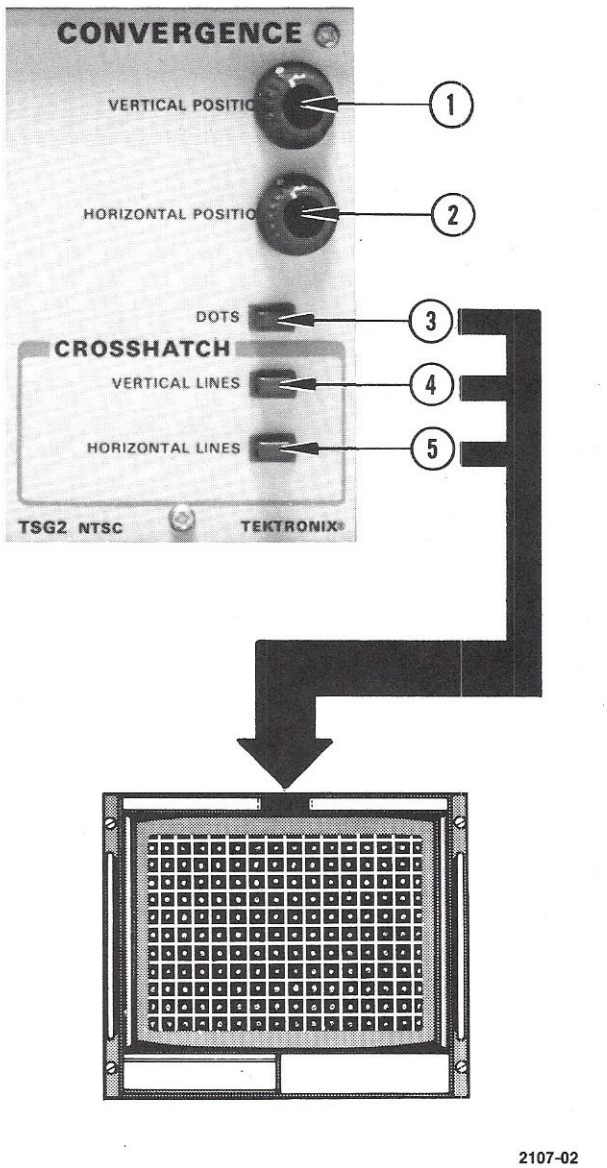


Fig. 1-2. Crosshatch and dot pattern display when pushbuttons are engaged.

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

The electrical performance requirements for this instrument module are valid over the environmental limits listed at the end of this section. Calibration at 20° C to 30° C ambient with a 20-minute warm-up period is required to maintain stated accuracies.

Characteristic	Performance Requirement
Blanking DC Level	0 V ±50 mV
Setup Level	7.5 IRE ±1.0 IRE (53.6 mV ±7.14 mV).
Sync Amplitude	40 IRE ±2.0 IRE (286 mV ±14 mV).
Peak Level	77 IRE ±3.0 IRE (550 mV ±21 mV).
Return Loss	At least 30 dB to 5 MHz.
Isolation	
Passive	Either open or short of one output shall cause an output level change at the other connector of 1% or less (40 dB) for all components of the signal.
Active (Non-Coherent Crosstalk)	A signal introduced to one output connector shall be attenuated by at least 40 dB at the other connector for signals between 0.5 and 4.0 volts in amplitude at or below color subcarrier frequency.
Rise and Fall Time	130 ns, +20 ns, −10 ns.
Crosshatch Vertical Lines	
Interval Repetition Rate	315 kHz.
Pulse Position Range	≥3.2 μs (overlap of one vertical line time).
Pulse Polarity	Positive.
Number of Unblanked Pulses	16 or 17.
Pulse Duration	225 ns ±33.75 ns.
Dot Duration	350 ns ±52.5 ns.
Crosshatch Horizontal lines	
Interval Repetition Rate	900 Hz.
Pulse Position Range	≥1.1 ms (overlap of one horizontal line time).
Pulse Polarity	Positive.
Number of Unblanked Pulses	13 or 14.
Crosshatch Pulse Duration	1 line at field rate.
Dot Pulse Duration	3 lines per frame.
Displays Available	Crosshatch only. Vertical Lines only. Horizontal Lines only. Dots only. Crosshatch plus Dots. Horizontal lines plus Dots. Vertical lines plus Dots.

ENVIRONMENTAL CHARACTERISTICS

Characteristics	Performance Requirements
Temperature	
Storage	−40° C to +65° C.
Operating	0° C to +50° C.
Altitude	
Storage	To 50,000 feet.
Operating	To 15,000 feet.

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.

PART II
SERVICE INFORMATION

INSTALLATION

INSTALLING IN THE MAINFRAME

Use the following steps to install the TSG2 module in the 1410 Mainframe. Turn the Mainframe POWER switch off before attempting installation.

1. Select one of the available 1410 Mainframe module locations for installation of the TSG2 module: Locations 2 through 6 with the SPG1 or SPG2 installed or locations 1 through 6 with the SPG3 installed (see Fig. 3-1).

2. Position the TSG2 board over the Mainframe Interface pins using the plastic guides for proper pin alignment. Seat the board firmly on the Interface board.

3. Install the plastic front-panel control extenders on the board control shafts.

4. Position the TSG2 front panel over the control extenders and secure to the 1410 Mainframe front casting with the screws provided.

5. Connect the coax cable from the front-panel OUTPUT connector to the board output connector. Connect the coax cable from the appropriate rear-panel MODULE OUTPUT connector to the other pair of board output connectors.

Reverse the installation steps to remove the module.

PACKAGING

At installation time, save the shipping carton and packing materials for packaging in case shipment becomes necessary.

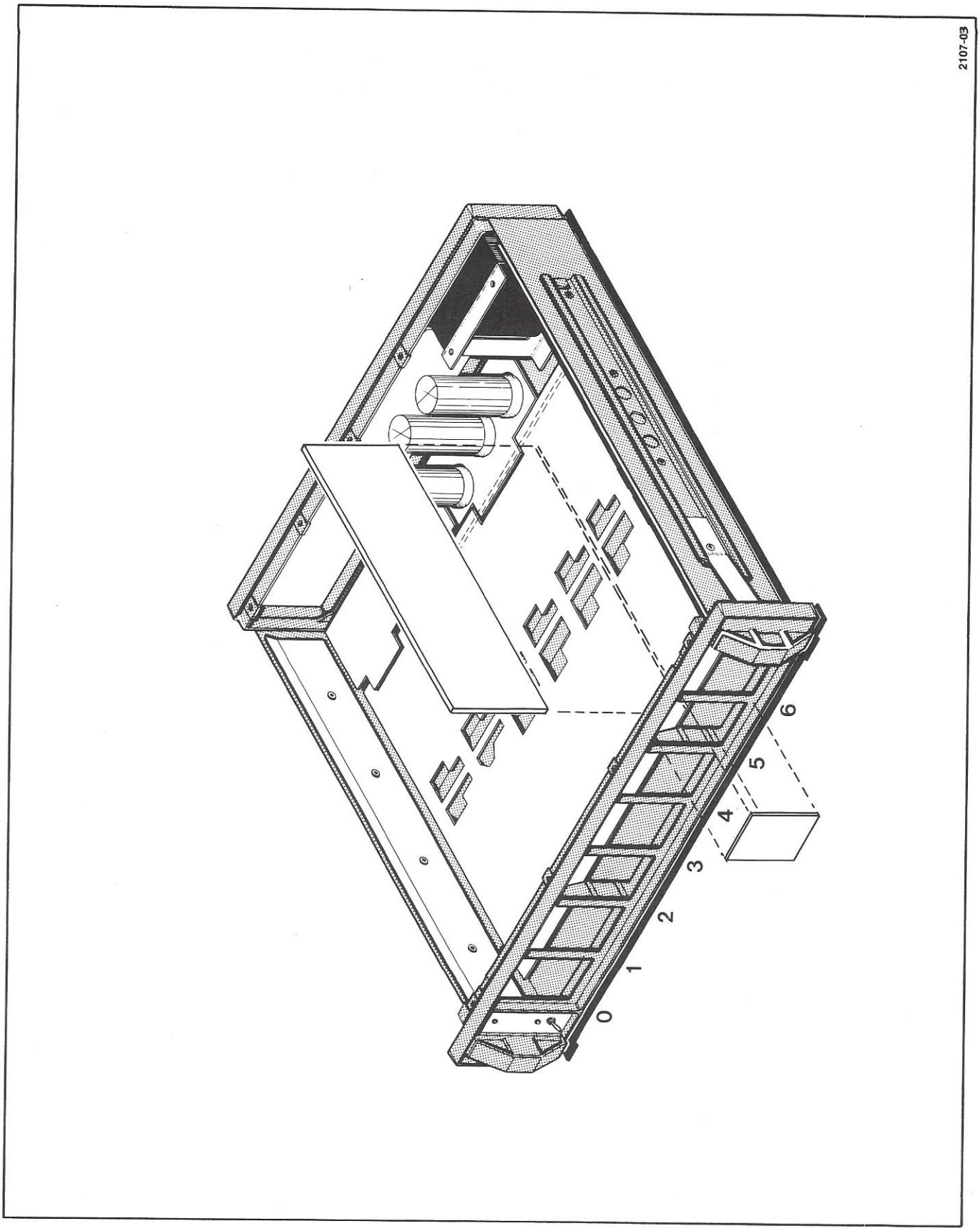


Fig. 3-1. Installing a module circuit board in the Mainframe.

PERFORMANCE CHECK/CALIBRATION PROCEDURE

INTRODUCTION

Procedures in this section serve as guides to perform calibration steps and performance checks. Limits, tolerances, and waveforms appearing in these procedures are not instrument specifications except as listed in the Specifications section.

Performance checks are identified by the word "Check" in the step heading. These steps may be performed to verify instrument performance. Steps that include the word "Adjust" must be performed during calibration.

The TSG2 front-panel control names in the text are capitalized; for example, DOTS. Control and connector names on test equipment and internal controls in the TSG2 module under test have only the first letter capitalized; for example, Test Oscilloscope Time/Div., or 1480 Mag control.

TEST EQUIPMENT

Test equipment capabilities described herein are the minimum required to calibrate the instrument. Examples represent test equipment used in developing these procedures.

1. Waveform Monitor. Capable of viewing line rate and field rate signals, with a magnifier to measure risetime and pulse duration. For example, a Tektronix 1480 WFM.

2. Test Oscilloscope. Bandwidth, dc to 30 MHz; minimum deflection, 1 mV/div; two input channels with provisions for independent or differential operation. For example, a Tektronix 7603 Oscilloscope with 7A13, 7A18, and 7B53A plug-in units.

3. Sine-wave Signal Generator. Minimum output, 500 mV; frequency range, 50 kHz and variable from 1 MHz to 5 MHz. For example, a Tektronix SG503 in a Tektronix TM500 Series Mainframe.

4. Return Loss Bridge. Tektronix Part No. 015-1049-00.

5. Minimum Loss Attenuator. Tektronix Part No. 011-0057-00.

6. Calibration Fixture (see Fig. 4-1).

7. Cable. Tektronix Part No. 012-0074-00.

8. 75 Ω End-Line Termination. Tektronix Part No. 011-0102-00.

9. 75 Ω Thru-Line Termination. Tektronix Part No. 011-0103-02.

10. Extender Circuit Board. Tektronix Part No. 670-4441-00.

Calibration Fixture

This fixture and the 1480 Waveform Monitor provide a variable calibrator voltage level which can be read directly from a 10-turn dial. The schematic diagram and parts list for the fixture appear in Fig. 4-1. When S1 is in the Fixed position, the 1480 calibrator voltage is determined by the internal calibrator circuit. When S1 is in the Variable position, the calibrator voltage is determined by the circuit in the fixture.

With P9034 connected to J9034 on the 1480, and S1 in the Fixed position, calibrate the 1480's graticule for 140 IRE (1 V). Set the Amplitude dial for 1000, and S1 to Variable. Adjust R3 (Cal), to exactly match the internal 1 V calibrator level. The dial is now calibrated so that each turn of the dial represents 100 mV.

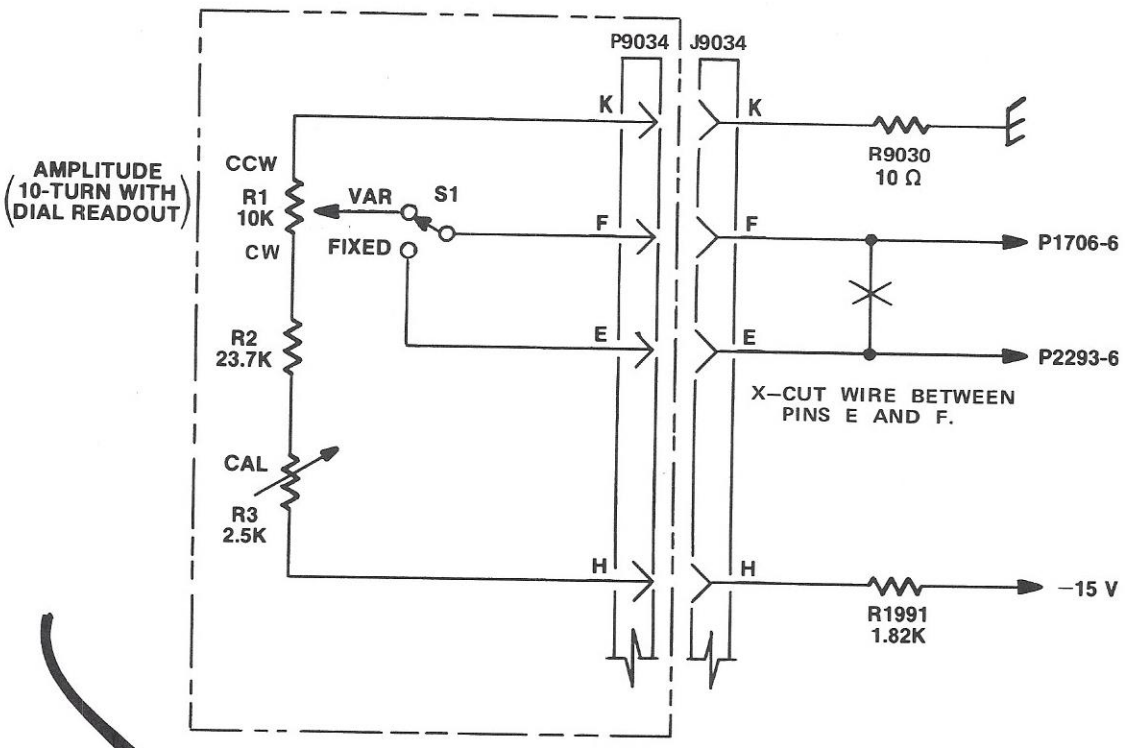
Measurements

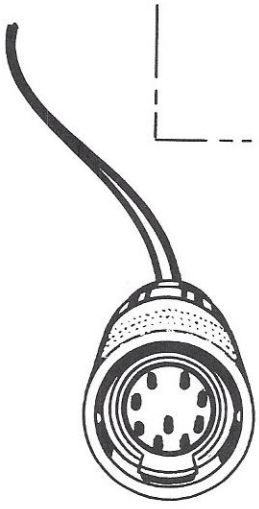
The signal to be measured must be fed to the 1480 CH A Input, and both the Oper and Cal buttons pushed. To check amplitude within a given tolerance, adjust the Calibration Fixture Amplitude dial while watching the waveform monitor display. When the level being measured overlays the blanking level, read the amplitude directly from the dial.

To adjust a signal level, use the calibration fixture as a reference. First, set the Amplitude dial to the desired level. Then adjust the proper TSG2 module control so that the signal level overlays the blanking level. The signal level now matches the Amplitude level.

CALIBRATION FIXTURE

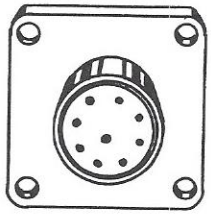
1480 REAR PANEL





P9034
REAR VIEW

J9034
REAR VIEW



PARTS LIST

Ckt No.	Description	TEKTRONIX p/n
P9034	9-pin Amphenol #165-13	134-0049-00
R1	10kΩ ± 5%, Ind. Lin. ±0.1%, 10-turn, prec. var.	311-1729-00
R2	23.7kΩ ± 1%, 1/8 W, metal film	321-0325-00
R3	2.5kΩ ± 20%	311-0086-00
S1	SPDT	260-0613-00
	10-turn dial for R1, Kilo-dial Mod. 461-S-41	331-0139-00
Misc.	Approx. 3 ft. of 4-conductor cable and a small metal or plastic enclosure or case.	

Set R1 fully counterclockwise (ccw) and the dial at 0 when installing.

2107-04

Fig. 4-1. Calibration Fixture illustration.

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PROCEDURE

1. Check/Adjust Convergence Amplitude

a. Connect the Convergence Pattern MODULE OUTPUT connector to the 1480 CH A input and terminate the 75 Ω.

b. Push in the TSG2 CROSSHATCH pushbuttons.

c. Set the 1480 Display to 10 μs/div, Volts Full Scale to 0.5, and push in the Cal and Oper switches.

d. Check—Using the Amplitude dial of the Calibration Fixture to match peak amplitude with blanking, read 550 mV ±21 mV.

e. Adjust—R238 (Gain), see Fig. 8-1, Section 8, for 550 mV amplitude of pulse peaks.

2. Check/Adjust DC Level

a. Set the 1480 Volts Full Scale to 1.0, Display to 10 μs/div., push in Oper switch, set DC Restorer Off and Response switch to Aux Video In. Position the trace to the 0 IRE graticule line and change the TSG2 output cable to the Aux Video In connector.

b. Check—The waveform blanking level should be 0 V ±50 mV (±7 IRE).

c. Adjust—R219 (DC Level) for 0 volt blanking level. Recheck step 1 Convergence Amplitude after making this adjustment. Return the TSG2 output cable to the 1480 CH A input connector.

3. Check Setup Amplitude

a. Repeat Step 1c.

b. Check—Setup level should be 53.6 mV, ±7.14 mV.

4. Check Sync Amplitude

a. Set the Calibration Fixture to match the top and bottom sync levels.

b. Check—Sync amplitude should be 286 mV, ±14 mV.

5. Check Convergence Pulse Rise and Fall Times

a. With the TSG2 CROSSHATCH signal on, set the 1480 to 1.0 VFS and X50 MAG. Adjust the HORIZONTAL POSITION control to display the beginning horizontal and vertical line pulses.

b. Check—Rise and fall times should be 130 ns, +20 ns, −10 ns. Graticule A of the 1480 Waveform Monitor has built-in rise and fall time measurement capability. Point R at 80 IRE Units aligns with T on the 0 IRE Unit reference line.

To measure rise or fall time, set the transition amplitude to 100 IRE Units (use the VARiable Volts Full Scale). Vertically position the display so that the transition is from the −10 IRE Unit line to the +90 IRE Unit line. Use the 100 ns/div time base and horizontally position the rise (or fall) of the transition through point R on the short 2 IRE Unit/div scale. Measure the distance from point T on the 0 IRE Unit reference line to where the transition crosses the reference line.

6. Adjust Convergence Transient Response

a. Set the 1480 to 1.0 VFS and X10 Mag. Adjust the Horizontal Position control to view the beginning horizontal and vertical pulses. Remove the module circuit board to the extender board to access the adjustments in Step 6b. Carefully align the board pin connectors to ensure good contact.

b. Adjust L200 and L210 for best square corner on the leading edge of the horizontal line pulse and at the blanking level of the trailing edge of the vertical line pulses. Check that sync shape is comparable; adjust for best compromise.

c. Check—Repeat Step 5.

7. Check Vertical Line and Dot Pulse Duration

a. Check—Pulse duration at HAD points (from setup to peak) should be 225 ns, ±34 ns.

b. Disable the TSG2 CROSSHATCH pattern and push in the DOTS switch.

c. Check—Dot duration at HAD points should be 350 ns, ±52.5 ns.

8. Check/Adjust Vertical Line and Dot Pulses

a. Disable the TSG2 DOTS, push in VERTICAL LINES, and rotate the HORIZONTAL POSITION control fully clockwise. Set the 1480 Mag to 1 μs/div.

b. Check—3 pulses for 9.5 major horizontal divisions ±0.5 minor divisions.

c. Adjust—R134 (CH Width) for 3 pulses in 9.5 major horizontal divisions ±0.5 minor division.

d. Check—17 pulses depending on VERTICAL POSITION control setting.

9. Check VERTICAL POSITION Range

a. Push in the TSG2 HORIZONTAL LINES switch only and rotate the VERTICAL POSITION control fully counterclockwise. Set the 1480 Display to 2 Field and Mag to X5.

b. Use the 1480 Horizontal and Vertical Position controls to place the first line pulse at a major tick marking on the 0 IRE graticule line.

c. Rotate the TSG2 VERTICAL POSITION control fully clockwise.

d. Check—Pulse should move at least 2 major horizontal divisions (1.1 ms) from the reference point.

10. Check HORIZONTAL POSITION Range

a. Push in the TSG2 VERTICAL LINES switch and rotate the HORIZONTAL POSITION control fully counterclockwise. Set the 1480 Display to 10 μs/div and Mag to 1 μs/Div.

b. Repeat Step 9b.

c. Rotate the TSG2 HORIZONTAL POSITION control fully clockwise.

d. Check—Pulse should move at least 3.2 μs from the reference point.

11. Check Isolation

a. Check—Sync amplitude should be 40 IRE ±2 IRE. Peak level should be 77 IRE ±3 IRE.

b. Short opposite output pins together.

c. Check—Change in output should not exceed 1%.

d. Move the module output coaxial cable to opposite pair of output pins.

e. Connect the Test Oscilloscope to one pair of output connectors through a 75 Ω in-line terminator.

f. Connect the Sine-wave Generator to the unused pair of output pins through a 75 Ω in-line terminator. Set the Sine-wave Generator frequency to 3.58 MHz.

g. Check—Subcarrier added to the output signal should be −40 dB or more as the generator amplitude is varied from 5 mV to 40 mV. Reverse output connections and repeat check.

12. Check Return Loss

a. Connect the Return Loss Bridge to the Test Oscilloscope Differential Comparator. Set the Differential Comparator for differential measurements.

b. Connect the Sine-wave Generator output through a "T" connector to the Return Loss Bridge input (see the Return Loss Bridge instruction manual) and to the Test Oscilloscope Vertical Amplifier plug-in. Balance the bridge.

c. Set the Test Oscilloscope for alternate channel viewing.

d. Set the Sine-wave Generator frequency controls for 50 kHz output.

e. Remove the 75 Ω terminator from the Return Loss Bridge Unknown arm.

f. Set the Sine-wave Generator Amplitude control for 500 mV output as monitored on the Test Oscilloscope.

g. Connect the Return Loss Bridge Unknown arm to the TSG2 Module output connector at the rear of the Mainframe.

h. Check—Amplitude should not exceed 16 mV (30 dB return loss) as frequency is varied from 50 kHz to 5 MHz. Maintain constant sine-wave amplitude as monitored on the Test Oscilloscope Vertical Amplifier channel.

THEORY OF OPERATION

This section begins with a Block Diagram Description of the TSG2. Illustrated signal paths and circuit relationships provide an overview of instrument operation.

The Circuit Description portion of this section provides a detailed discussion of the circuit diagram. The diagram is segmented with gray-tint blocks according to circuit function. Circuit block titles correspond to those listed in this section and the Block Diagram.

The Block Diagram and circuit diagram are located on fold-out pages at the rear of the manual. Pull out the appropriate diagram when reading this discussion.

BLOCK DIAGRAM DESCRIPTION

Horizontal Position and Timing

Multivibrators in this block use horizontal blanking to derive the dot and vertical line signals of the convergence pattern. Front-panel horizontal position control is provided by this circuitry. The output is fed to the Vertical Position and Timing block and combined with the horizontal lines.

Vertical Position and Timing

Horizontal lines are generated by the 35:1 counter which counts down from horizontal blanking. The Vertical Position control, which determines when the counter starts, provides variable positioning of the horizontal lines. The counter output is decoded and combined with the vertical line and dot signals.

Output

Vertical and horizontal dot and line signals are combined with composite sync and composite blanking and then shaped. The Output Amplifier provides variable dc leveling and gain of the convergence pattern signal.

CIRCUIT DESCRIPTION

NTSC Convergence Pattern Generator

Crosshatch and dot signals are formed by the vertical and horizontal timing circuits and combined, shaped and amplified before appearing at the output connector. Signal levels and elements are set and added by the Current Switch circuitry.

Horizontal Position and Timing

At the start of horizontal blanking, pin 5 of U130B (a one-shot multivibrator) goes high for a period of time determined by C140, R124 and R105, the HORIZONTAL POSITION control. The monostable action of U130B then switches pin 5 low which enables oscillator U150A and B. See Fig. 5-1 for an illustration of the signal relationships described.

The duration of the positive gate pulse from pin 5 of U130B is always less than the period of horizontal blanking, so that the oscillation commences before the end of horizontal blanking. When oscillation starts, vertical crosshatch lines or dots are generated. Since the HORIZONTAL POSITION control setting determines when the oscillation starts with relation to horizontal blanking, this will also determine the horizontal position of the crosshatch lines or dots during the active part of each television line.

R134 (Crosshatch Width Adj.) controls the frequency at which U150A and B toggles U169A and hence the vertical line rate at U170A and dot rate at U170B. This provides a convenient means for varying the pattern spacing.

Vertical line pulses at pin 13 of U170A are controlled by the front-panel pushbutton labeled VERT LINES. When the switch is pushed in, a low is removed from pin 3 which allows output pulses at pin 13. Dot generation is controlled in the same manner with the front-panel pushbutton labeled DOTS removing the inhibiting low at pin 11 of U170B.

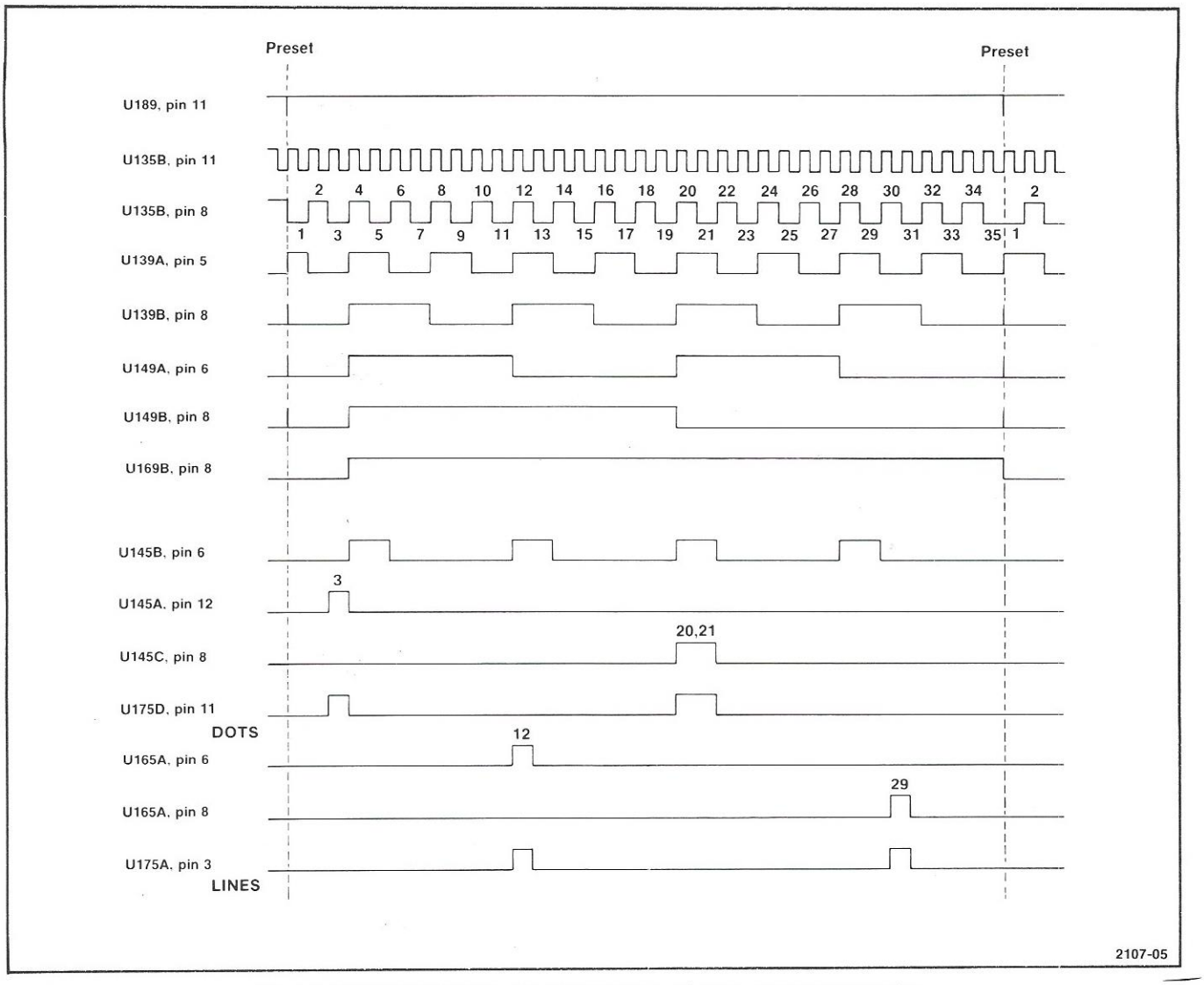


Fig. 5-1. Horizontal Position and Timing chart showing signal relationships.

Vertical Position and Timing

U135B, U139A and B, U149A and B, U169B, and U189D form a 35-line counter which advances at the end of each line. U130A, U135A, U175B, and U175C produce a negative pulse at the end of field two which presets and holds the counter. The duration of this pulse, which determines when the counter starts, is set by C124, R165 and R109, the VERTICAL POSITION control. Upon completion of the 35th count, pin 8 of U169B goes low presetting the counter to start a new counting sequence. See Fig. 5-2.

U165A and B and U175A decode that portion of the counter output that causes TP188 to be high during counts 12 and 29 when horizontal lines are to appear in the convergence pattern. U145A, B, and C and U175D decode counter information causing TP189 to go high during counts 3, 20, and 21 when dots are to appear. Selection of these times ensures accurate field-one and field-two pattern interlacing.

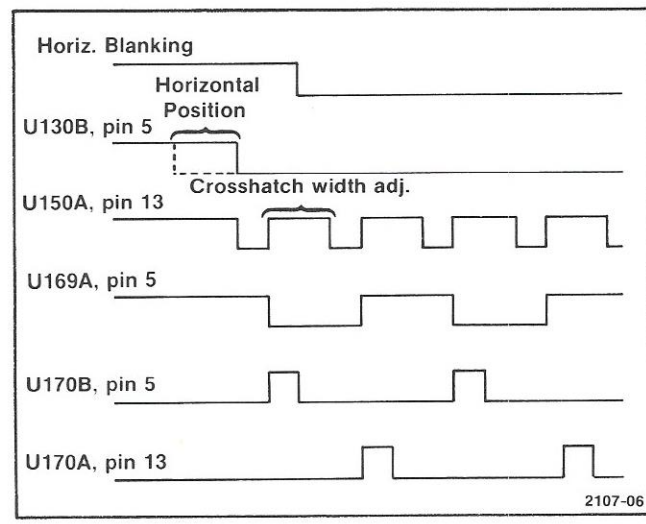


Fig. 5-2. Vertical Position and Timing chart showing signal relationships.

Signals at TP188 and TP189 are combined with the vertical lines and dots by U185B and U189C. The HORIZONTAL LINES front-panel switch controls gate U189A. When the switch is pushed in, pin 2 of U189A goes high gating the signal from pin 1 to pin 3. U180C gates these signals so that the complete convergence pattern appears at TP192. Composite blanking from the current switch is then combined with the convergence signal at U185B.

Current Switch and Filter

Convergence pattern signal current from Q215 is combined with setup and sync currents developed in Q205 and Q206. U189B, U185A and D, and U180D provide composite sync and blanking and video disable signals necessary to develop and control the convergence pattern signal. The convergence pattern current drives the 5-pole filter where pulse shaping takes place.

Output Amplifier

Q225, Q226, Q237, and Q247 form an operational amplifier whose gain is adjustable by potentiometer, R238. R219 sets the signal dc level at the summing input. The amplified convergence signal is coupled through R244 and R245 for use at the rear-panel module connectors.

MAINTENANCE

INTRODUCTION

This section is divided into three parts: Maintenance, Troubleshooting, and Repair.

Maintenance includes inspection, cleaning, and recalibration. Troubleshooting contains information for isolating a trouble to a component. Repair includes procedures for removing and replacing components.

MAINTENANCE

A regular schedule of maintenance can improve instrument reliability. How often the maintenance is performed should be determined by the severity of the operating environment. Turn off the instrument power and remove the power cord before cleaning the module.

Cleaning

Dust accumulating on the circuit board acts as an insulating blanket, preventing efficient heat dissipation, and possibly causing overheating and component breakdown. A layer of dust can also provide an electrical conduction path, especially under high humidity conditions.

CAUTION

Avoid the use of chemical cleaning agents that might damage the plastics used in this instrument. Avoid chemicals that contain benzene, toluene, xylene, or similar solvents.

The best way to remove heavy accumulation of dust is to blow it off with a dry, low-velocity air jet. Remaining dust can be removed with a small brush followed by a soft cloth dampened in a mild detergent and water solution. A cotton-tipped applicator is useful in tight places.

Visual Inspection

Visually inspect the circuit board or boards during the maintenance routine for such defects as broken connectors, loose or disconnected pin connectors, improperly seated transistors and integrated circuits, and damaged components. Make sure that the board is properly seated on the 1410 Mainframe Interface jacks. Boards with shields should be parallel to each other and held firmly by the plastic clips provided for this purpose.

The corrective procedure for most visible defects is obvious; however, care must be taken to determine and correct the cause of heat-damaged components. Heat damage is sometimes an indication of trouble elsewhere in the instrument.

Multi-Pin Connectors

Board output signals are fed to the rear-panel connectors through coaxial cable and multi-pin connectors. The connector holder has identification numbers that identify terminal connectors No. 2 and up. A triangular key symbol is also located on the circuit board to identify pin No. 1 (see Fig. 6-1) so that the connector can be properly oriented.

Transistor and Integrated Circuit Checks

Periodic transistor and integrated circuit checks are not recommended. The best performance check for these devices is actual operation of the instrument. Performance of the circuit is thoroughly checked during the performance check or calibration procedure. Any sub-standard transistors or integrated circuits will usually be detected at that time.

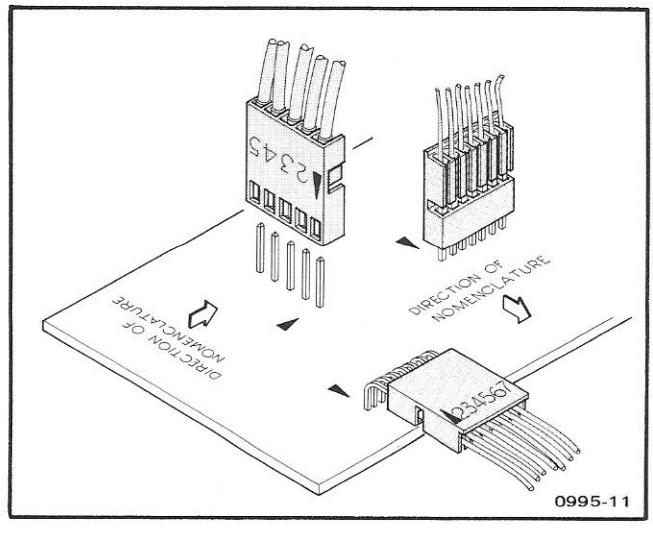


Fig. 6-1. Multiple pin connector holders.

Recalibration

The length of time between recalibration depends on the amount of use the circuitry receives, the nature of the environment, and the change in performance when some components are replaced.

In general, a partial recalibration is necessary if the components replaced affect the board calibration. Complete recalibration is recommended if the board or boards are not operating to their full capability. To ensure correct and accurate operation, performance should be checked at regular intervals; for example, after 1,000 hours of operation if used continuously, or every six months if used infrequently.

A Performance Check/Calibration Procedure is given in Section 4.

TROUBLESHOOTING

Information contained here may be used as a guide in locating circuit failures. The schematic diagrams, circuit description, and calibration sections should be referred to for fast, efficient location and repair of defects.

Diagram

The circuit diagram is shown on the foldout pages in Section 9. The circuit number and electrical value of each component is shown on the diagram. Important waveforms are also shown.

Circuit Board

The circuit board is outlined in blue on the schematic diagrams. The circuit board illustration is provided on the back of the foldout page that precedes the relevant diagram. The assembly number assigned to the circuit board is an abbreviated method for identifying the board.

When troubleshooting the circuit board in the instrument, the use of an extender board facilitates access to the board connections and components. Removing the circuit board to the extender board will save time in looking for faults. Carefully align the board pin connectors to ensure good contact.

Circuit numbers are assigned on a grid system to facilitate component location. Low numbers start at the lower front corner of the board increasing to the rear and top.

Wire Color Code

Insulated wires are color-coded to facilitate circuit tracing.

Resistor Color Code

Color stripes on resistors signify electrical values, tolerances, etc., according to the EIA standard color code (see Fig. 6-2). Resistors not color-coded usually have the value imprinted on the body.

Capacitor Markings

The capacitance value of a common disc capacitor or small electrolytic is marked in microfarads on the side of the component body. White ceramic capacitors are color coded in picofarads using a modified EIA code (see Fig. 6-2). The "tear drop" capacitors are color-coded in microfarads using a modified EIA code, with the dot indicating both temperature and positive (+) side. See Fig. 6-3.

Transistor and Integrated Circuit Lead Configurations. Fig. 6-4 illustrates the lead configurations for the socket-mounted transistors and integrated circuits (IC) used on the circuit board.

IC Diagrams

Positive logic functions of the IC's are shown in Section 9 of this manual.

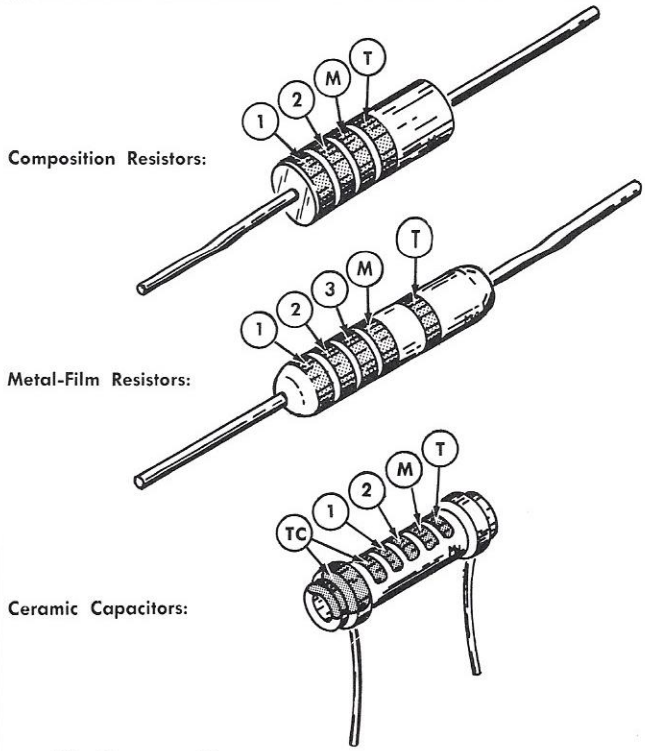
Troubleshooting Equipment

The following test equipment is useful for troubleshooting the generator circuit board.

1. Test Oscilloscope. For viewing waveforms at various test points in the circuit. Frequency response: dc to at least 10 MHz. It should be equipped with a 10X probe.

2. DVM and Ohmmeter. For measuring dc voltages and resistance accurately. The ohmmeter is also required for checking continuity.

3. Semiconductor Tester. Some means of testing the transistors and diodes is helpful. A transistor-curve tracer such as the Tektronix Type 576 will give the most complete information.



Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier: Resistors	Multiplier: Capacitors	Tolerance: Resistors	Tolerance: Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^{2}	10^{2}	±2%	±2%
Orange	3	10^{3}	10^{3}	±3%	±3%
Yellow	4	10^{4}	10^{4}	±4%	+100% −0%
Green	5	10^{5}	10^{5}	±0.5%	±5% or 0.5 pF*
Blue	6	10^{6}	10^{6}	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

*For capacitance of 10 pF or less.

(1) (2) and (3) —1st, 2nd and 3rd significant figures;
(M) —multiplier; (T) —tolerance;
(TC) —temperature coefficient.

NOTE: (T) and/or (TC) color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 6-2. Standard EIA color coding for resistors and capacitors.

Troubleshooting Procedure

This procedure starts with simple, but sometimes taken-for-granted problem areas and proceeds to detailed troubleshooting.

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, refer to the Operating Instructions or Installation sections.

2. Check Associated Boards. Before troubleshooting a board, check that the Sync Timing board is operating properly and supplying the correct signals to the Mainframe Interface board. Make sure that other boards on the Interface board are not defective. Check that the test oscilloscope probe, if used, is not defective.

3. Isolate Trouble to a Circuit. Symptoms will often identify the circuit in which the trouble is located. Incorrect operation of all circuits often means trouble in the power supply section of the Mainframe. Consider this possibility if voltages are incorrect. Make sure that all board pin connectors are making good contact before proceeding with trouble isolation.

4. Visual Check. Visually check the portion of the board in which the trouble is suspected. Some troubles can be located by checking for unsoldered connections, broken wires, loosely-seated transistors, loose-fitting connectors, damaged components, or damaged circuit boards.

5. Check Voltages and Waveforms. Often the defective component or stage can be located by checking for the correct voltage or waveform in the circuit. Typical waveforms are given near the diagram. To obtain operating conditions similar to those used to take these waveforms, refer to the instructions at the start of the Diagram section.

CAUTION

Due to component density on the circuit board, special care should be exercised when using meter leads and tips. Accidental shorts can cause abnormal voltages or transients that may destroy many components.

Rated Voltage VDC 25°C	Color	CODE FOR CAPACITANCE IN PICOFARADS		
		1st Figure	2nd Figure	Multiplier—pF
4	Black	0	0	None
6	Brown	1	1	X 10
10	Red	2	2	X 10^2
15	Orange	3	3	X 10^3
20	Yellow	4	4	X 10^4
25	Green	5	5	X 10^5
35	Blue	6	6	X 10^6
50	Violet	7	7	X 10^7
	Gray	8	8	
3	White	9	9	

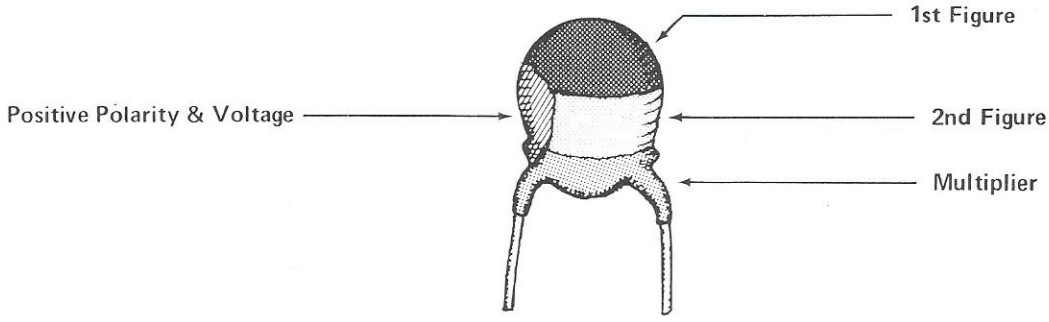


Fig. 6-3. Color coding for dipped tantalum capacitors.

WARNING

"Ground lugs" are not always at ground potential. Check the diagram before using such connections as ground for meter prods or oscilloscope probes. Some transistor cases may be elevated from ground potential.

6. Check Individual Components. After the trouble has been isolated to one circuit or stage, the next step is to isolate the trouble to one component or part. Components that are soldered in place are best checked by disconnecting one end to isolate the measurement from the effects of surrounding circuitry. The following methods are provided for checking individual electrical components in the module.

a. Transistors. The best check of transistor operation is actual performance under operating conditions. If a transistor is suspected of being defective, it can be checked by substituting a new component or one which has been checked previously. However, be sure that the circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester (such as the Tektronix Type 576) to check the transistor.

b. Integrated Circuits. Integrated circuits should not be replaced unless they are actually defective. The best method for checking these devices is by direct substitution with a new component or one which is known to be good. Be sure that circuit conditions are not such that a replacement component might be damaged.

c. Diodes. A diode can be checked for an open or shorted condition by measuring the resistance between terminals. Use an ohmmeter, set to the 1k scale to keep from damaging the diode, for measuring the diode resistance. The resistance should be very high in one direction and very low when the ohmmeter leads are reversed.

d. Resistors. Resistors can be checked with an ohmmeter: Check the Electrical Parts List for the

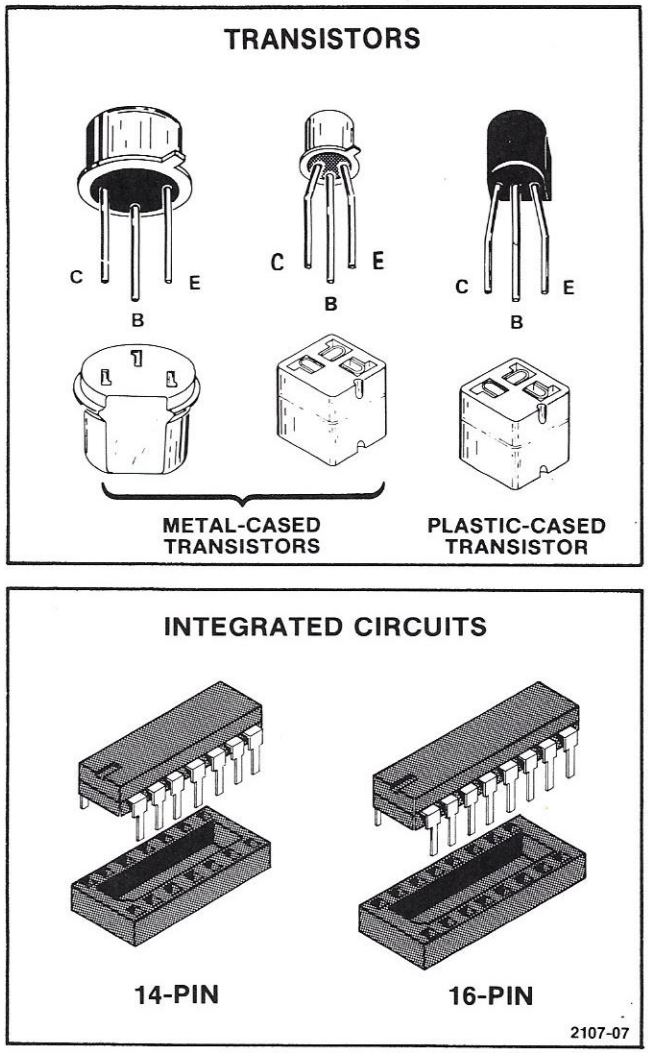


Fig. 6-4. Transistor and Integrated Circuit basing illustration.

tolerance of the resistors used in the instrument. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

e. Inductors and Switch Contacts. Check for an open circuit (that should normally be closed) by checking continuity with an ohmmeter.

f. Capacitors. A leaky or shorted capacitor can best be detected by checking the resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. An open capacitor can best be detected with a capacitance meter or by checking whether the capacitor passes ac signals.

REPAIR

Repair consists of component replacement and circuit board repair. Special techniques required to replace components in this instrument are given here.

Soldering Techniques

WARNING

Disconnect the instrument power cord before soldering.

Reliability and optimum performance of circuit boards can be maintained only if proper soldering techniques are used when repairing or replacing parts. Soldering techniques that apply to repair of precision electronic equipment should be used when working on the boards. Use only 60/40 rosin-core, electronic grade solder. The choice of soldering iron is determined by the repair to be made. When soldering on circuit boards, use a 15- to 25-watt pencil-type soldering iron with a 1/8-inch wide, wedge-shaped tip. Keep the tip properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the etched wiring from the base material. Avoid excessive heat; apply only enough heat to remove the component or to make a good solder joint. Also, apply only enough solder to make a firm solder joint; do not apply too much solder. Use a desoldering tool or other device when it is necessary to remove excess solder.

The pencil-type soldering iron used on the circuit boards can be used for soldering to switch terminals, potentiometers, or metal terminals mounted in plastic holders. For ground lugs that are connected to the chassis, or other metal terminals that are connected to a large heat-radiating surface, use a higher-wattage-rating soldering iron with a larger tip.

After soldering is completed, clean the area around the solder connection with a flux-remover solvent. Be careful not to remove any information printed in the area.

Location Guide for Replacing Parts

The exploded-view drawings associated with the Replaceable Mechanical Parts list (located at the rear of the manual) are helpful in the removal or disassembly of individual components or subassemblies. Circuit board illustrations are provided on the backs of foldout pages in the Diagram section of this manual.

Pushbutton Switch Replacement

Before removing a pushbutton switch, disengage the pushbutton actuating arm so that it does not project beyond the rear of the switch. Next, carefully pry back the plastic retainer clip at the rear of the switch with the tip of a small screwdriver (see Fig. 6-5). Remove by lifting the switch body up and back from the front retainer clip.

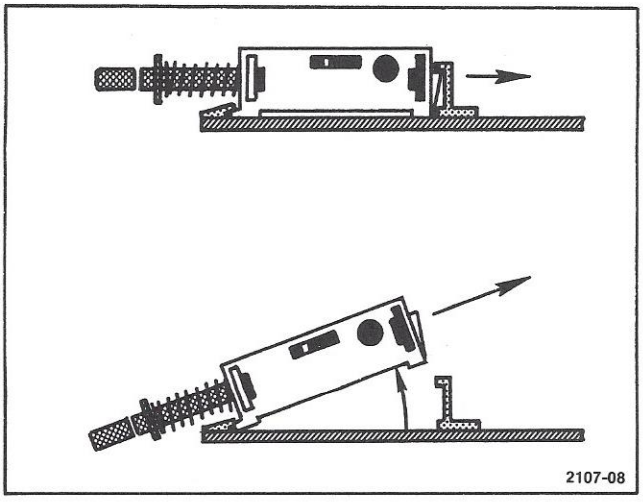


Fig. 6-5. Pushbutton switch replacement.

Reverse the removal procedure to install the replacement switch.

Circuit Board Replacement

If a circuit board is damaged beyond repair, the entire assembly, including all soldered-on components, can be replaced. Tektronix part numbers are given in the Replaceable Electrical Parts list.

Circuit Board Removal

1. Disconnect the multi-pin connectors from the board. Note the order of these connectors so they can be correctly replaced. Disconnect any other connectors that are used for interconnection with other circuits.

2. Disengage the front-panel knobs by pulling them straight out from the front panel until the board controls are free. Remove the plastic retaining clips from the top of the boards.

3. Grasp the board at both ends and pull straight up from the Interface board.

4. To replace the board, reverse the order of removal. Use the mating plastic guides to align the board pin connectors. Match the triangle key symbol on the multi-pin connectors to the same symbol on the board.

Interconnecting Pins. 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 board with a pair of pliers. Be careful not to damage the wiring on the board with too much heat. Ream out the hole in the circuit board with a 0.031-inch drill. 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. If the old pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins.

NOTE

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

Transistors and IC's

Transistors and IC's 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 transposing of semiconductors may affect the calibration of the board.

CAUTION

Disconnect the instrument power before removing or replacing semiconductors.

Any replacement component should be of the original type or a direct replacement. Cut and shape the leads to conform with the component being replaced. After a component is replaced, check the operation and calibration of associated circuits.

An extracting tool should be used to remove the 14- and 16-pin intergated circuits to prevent damage to the pins. This tool is available from Tektronix, Inc. Order Tektronix Part No. 003-0619-00. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the IC. Try to avoid having one end of the IC disengage from the socket before the other end.

@

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
0000L	Matsuhita Electric	200 Park Avenue, 54th Floor	New York, NY 10017
00213	Sage Electronics Corp., Subsidiary of Nytronics, Inc.,	Orange St.	Darlington, SC 29532
00853	Sangamo Electric Co., S. Carolina Div.	P. O. Box 128	Pickens, SC 29671
01121	Allen-Bradley Co.	1201 2nd St. South	Milwaukee, WI 53204
01295	Texas Instruments, Inc., Components Group	P. O. Box 5012	Dallas, TX 75222
04713	Motorola, Inc., Semiconductor Products Div.	5005 E. McDowell Rd.	Phoenix, AZ 85008
07263	Fairchild Semiconductor, A Div. of Fairchild Camera and Instrument Corp.	464 Ellis St.	Mountain View, CA 94040
07910	Teledyne Semiconductor	12515 Chadron Ave.	Hawthorne, CA 90250
27014	National Semi-Conductor Corp.	2900 San Ysidro Way	Santa Clara, CA 95051
27940	Central Quality Industries., Inc.	900 S. Division	Polo, IL 61064
56289	Sprague Electric Co.		North Adams, MA 01247
72982	Erie Technological Products, Inc.	644 W. 12th St.	Erie, PA 16512
73138	Beckman Instruments, Inc., Helipot Div.	2500 Harbor Blvd.	Fullerton, CA 92634
80009	Tektronix, Inc.	P. O. Box 500	Beaverton, OR 97005
91637	Dale Electronics, Inc.	P. O. Box 609	Columbus, NB 68601

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A35	670-4457-00			CKT CARD ASSY:CONVERGENCE	80009	670-4457-00
C122	290-0534-00			CAP.,FXD,ELCTLT:1UF,20%,35V	56289	196D105X0035HA1
C124	285-0703-00			CAP.,FXD,PLSTC:0.1UF,5%,100V	56289	410P112
C132	283-0032-00			CAP.,FXD,CER DI:470PF,5%,500V	72982	831-500Z5D471J
C140	283-0730-00			CAP.,FXD,MICA D:274PF,1%,500V	27940	D155E2740F0
C141	283-0672-00			CAP.,FXD,MICA D:200PF,1%,500V	00853	D155F201F0
C142	283-0000-00			CAP.,FXD,CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C148	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	72982	8005H2AADW5R103K
C156	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	72982	8005H2AADW5R103K
C160	283-0032-00			CAP.,FXD,CER DI:470PF,5%,500V	72982	831-500Z5D471J
C162	283-0638-00			CAP.,FXD,MICA D:130PF,1%,100V	00853	D151E131F0
C169	283-0032-00			CAP.,FXD,CER DI:470PF,5%,500V	72982	831-500Z5D471J
C170	283-0638-00			CAP.,FXD,MICA D:130PF,1%,100V	00853	D151E131F0
C174	283-0633-00			CAP.,FXD,MICA D:77PF,1%,100V	00853	D151E770F0
C186	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	72982	8005H2AADW5R103K
C200	283-0660-00			CAP.,FXD,MICA D:510PF,2%,500V	00853	D155F511G0
C202	283-0602-00			CAP.,FXD,MICA D:53PF,5%,300V	00853	D153E530J0
C210	283-0625-00			CAP.,FXD,MICA D:220PF,1%,500V	00853	D105F221F0
C211	283-0632-00			CAP.,FXD,MICA D:87PF,1%,100V	00853	D151E870F0
C215	281-0773-00			CAP.,FXD,CER DI:0.01UF,10%,100V	72982	8005H2AADW5R103K
C220	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	0000L	ECE-A25V22L
C222	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	0000L	ECE-A25V22L
C227	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C230	290-0745-00			CAP.,FXD,ELCTLT:22UF,+50-10%,25V	0000L	ECE-A25V22L
C235	281-0593-00			CAP.,FXD,CER DI:3.9PF,10%,500V	72982	301-000C0J0399C
C238	283-0081-00			CAP.,FXD,CER DI:0.1UF,+80-20%,25V	56289	36C600
C243	283-0177-00			CAP.,FXD,CER DI:1UF,+80-20%,25V	72982	8131N039651105Z
C244	281-0576-00			CAP.,FXD,CER DI:11PF,5%,500V	72982	301-000C0G0110J
C245	281-0576-00			CAP.,FXD,CER DI:11PF,5%,500V	72982	301-000C0G0110J
CR195	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR196	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR197	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
CR208	152-0141-02			SEMICOND DEVICE:SILICON,30V,150MA	07910	1N4152
L200	114-0257-00			COIL,RF:6-11UF	80009	114-0257-00
L210	114-0308-00			COIL,RF:2.9-6.5UH	80009	114-0308-00
Q205	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q206	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q207	151-0190-00			TRANSISTOR:SILICON,NPN	80009	151-0190-00
Q215	151-0192-00			TRANSISTOR:SILICON,NPN,SEL FROM MPS6521	80009	151-0192-00
Q216	151-0220-00			TRANSISTOR:SILICON,PNP	80009	151-0220-00
Q225	151-0459-00			TRANSISTOR:SILICON,PNP	04713	2N3251
Q226	151-0460-00			TRANSISTOR:SILICON,NPN	07263	2N3947
Q237	151-0220-00			TRANSISTOR:SILICON,PNP	80009	151-0220-00
Q247	151-0103-00			TRANSISTOR:SILICON,NPN	04713	2N2219A
R105	311-1888-00			RES.,VAR,NONWW:20K OHM,10%,1W	01121	14M871
R109	311-1888-00			RES.,VAR,NONWW:20K OHM,10%,1W	01121	14M871
R124	321-0318-00			RES.,FXD,FILM:20K OHM,1%,0.125W	91637	MFF1816G20001F
R125	321-0210-00			RES.,FXD,FILM:1.5K OHM,1%,0.125W	91637	MFF1816G15000F
R134	311-1562-00			RES.,VAR,NONWIR:2K OHM,20%,0.50W	73138	91A-20000M
R139	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R142	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R144	321-0274-00			RES.,FXD,FILM:6.98K OHM,1%,0.125W	91637	MFF1816G69800F
R154	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R155	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R160	315-0471-00			RES.,FXD,CMPSN:470 OHM,5%,0.25W	01121	CB4715
R162	321-0260-00			RES.,FXD,FILM:4.99K OHM,1%,0.125W	91637	MFF1816G49900F
R163	321-0253-00			RES.,FXD,FILM:4.22K OHM,1%,0.125W	91637	MFF1816G42200F
R172	321-0249-00			RES.,FXD,FILM:3.83K OHM,1%,0.125W	91637	MFF1816G38300F
R178	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R179	315-0472-00			RES.,FXD,CMPSN:4.7K OHM,5%,0.25W	01121	CB4725
R182	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R185	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R188	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	01121	CB1035
R194	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R198	321-0399-00			RES.,FXD,FILM:140K OHM,1%,0.125W	91637	MFF1816G14002F
R205	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R206	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R207	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R208	321-0329-00			RES.,FXD,FILM:26.1K OHM,1%,0.125W	91637	MFF1816G26101F
R212	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R215	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R216	321-0117-00			RES.,FXD,FILM:162 OHM,1%,0.125W	91637	MFF1816G162R0F
R218	321-0306-00			RES.,FXD,FILM:15K OHM,1%,0.125W	91637	MFF1816G15001F
R219	311-1564-00			RES.,VAR,NONWIR:500 OHM,20%,0.50W	73138	91A-500R0M
R220	315-0220-00			RES.,FXD,CMPSN:22 OHM,5%,0.25W	01121	CB2205
R222	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R225	315-0622-00			RES.,FXD,CMPSN:6.2K OHM,5%,0.25W	01121	CB6225
R228	321-0237-00			RES.,FXD,FILM:2.87K OHM,1%,0.125W	91637	MFF1816G28700F
R229	321-0188-00			RES.,FXD,FILM:887 OHM,1%,0.125W	91637	MFF1816G887R0F
R234	321-0251-00			RES.,FXD,FILM:4.02K OHM,1%,0.125W	91637	MFF1816G40200F
R235	315-0470-00			RES.,FXD,CMPSN:47 OHM,5%,0.25W	01121	CB4705
R236	315-0302-00			RES.,FXD,CMPSN:3K OHM,5%,0.25W	01121	CB3025
R237	321-0256-00			RES.,FXD,FILM:4.53K OHM,1%,0.125W	91637	MFF1816G45300F
R238	311-1565-00			RES.,VAR,NONWIR:250 OHM,20%,0.50W	73138	91A-250R0M
R244	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
R245	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
R246	308-0426-00			RES.,FXD,WW:470 OHM,5%,3W	00213	1240S-470R0J
S110 S112 S114	260-1448-00			SWITCH,PUSH:3 STA,NON-SHORT	80009	260-1448-00
TP154	214-0579-00			TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
TP179	214-0579-00			TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
TP188	214-0579-00			TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
TP189	214-0579-00			TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
TP192	214-0579-00			TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
TP214	214-0579-00			TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
TP248	214-0579-00			TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
U130	156-0733-00			MICROCKT,DGTL:DUAL MONOSTABLE MV W/ST	27014	DM74LS221N
U135	156-0388-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	01295	SN74LS74N
U139	156-0388-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	01295	SN74LS74N
U145	156-0481-00			MICROCIRCUIT,DI:TRIPLE 3-INPUT AND GATE	01295	SN74LS11N
U149	156-0388-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	01295	SN74LS74N

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
U150	156-0733-00			MICROCKT,DGTL:DUAL MONOSTABLE MV W/ST	27014	DM74LS221N
U165	156-0478-00			MICROCIRCUIT,DI:DUAL 4-INPUT AND GATE	01295	SN74LS21N
U169	156-0388-00			MICROCIRCUIT,DI:DUAL D-TYPE FLIP-FLOP	01295	SN74LS74N
U170	156-0733-00			MICROCKT,DGTL:DUAL MONOSTABLE MV W/ST	27014	DM74LS221N
U175	156-0479-00			MICROCIRCUIT,DI:QUAD 2-INPUT OR GATE	01295	SN74LS32N
U180	156-0383-00			MICROCIRCUIT,DI:QUAD 2-INPUT NOR GATE	01295	SN74LS02N
U185	156-0479-00			MICROCIRCUIT,DI:QUAD 2-INPUT OR GATE	01295	SN74LS32N
U189	156-0480-00			MICROCIRCUIT,DI:QUAD 2-INPUT AND GATE	01295	SN74LS08N
VR238	152-0280-00			SEMICOND DEVICE:ZENER,0.4W,6.2V,5%	04713	1N753A

SERVICING ILLUSTRATION

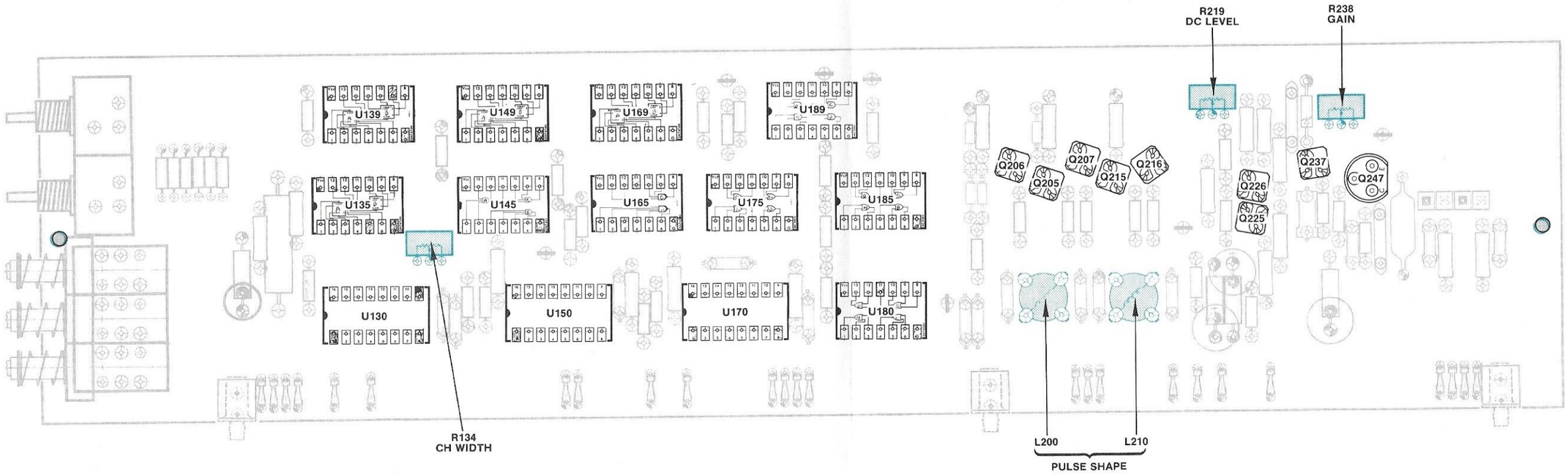
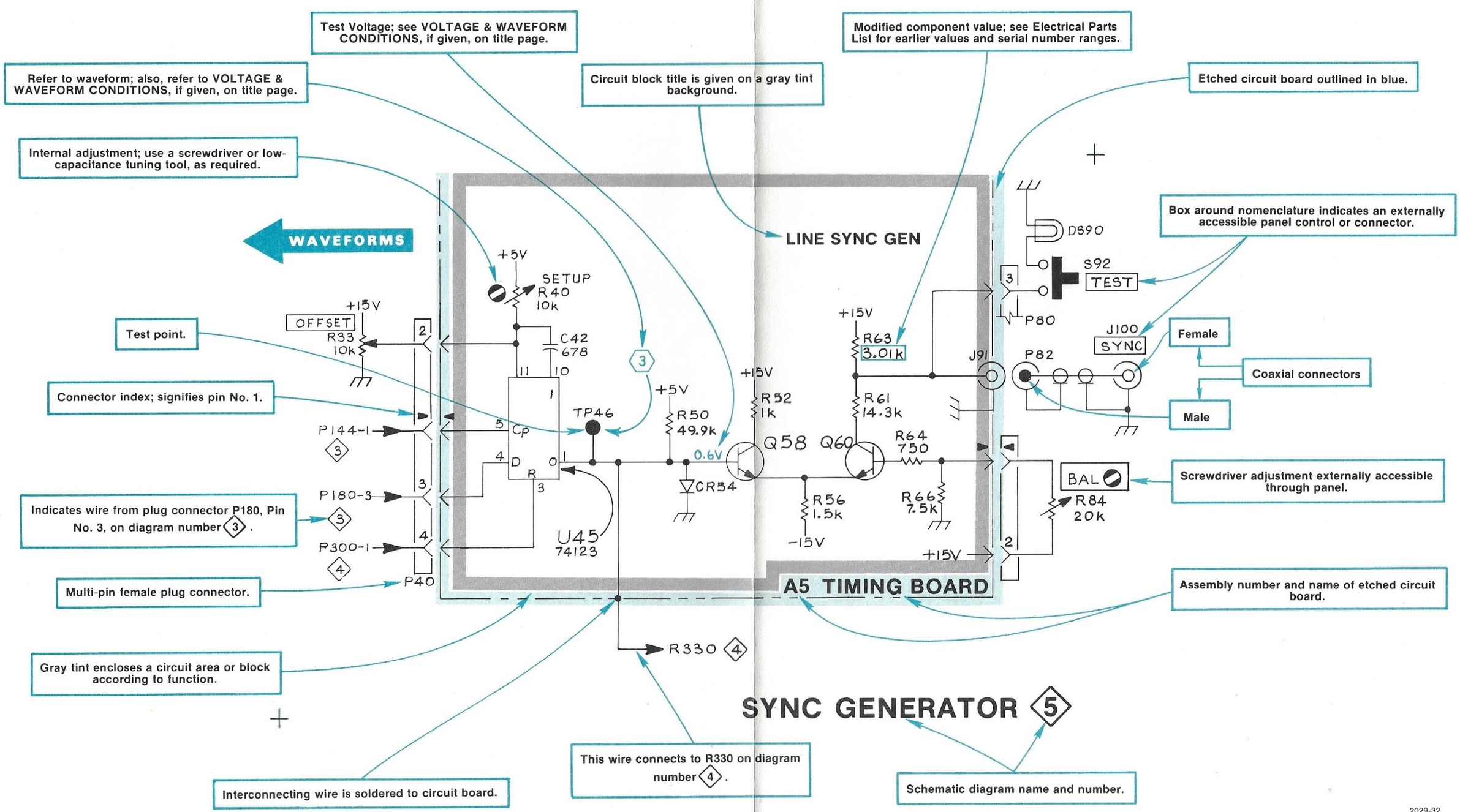


FIG. 8-1. A35 CONVERGENCE PATTERN ADJUSTMENT LOCATIONS



SCHEMATIC EXAMPLE

DIAGRAM AND CIRCUIT BOARD ILLUSTRATION

This section of the manual contains the block and schematic diagram with waveforms and etched circuit board illustration.

Symbols

Symbols used on the diagrams are based on ANSI Y32.2-1970 and IEEE No. 315 March 1971. Logic symbology is based on ANSI Y32.14-1973 (IEEE Std. 91-1973). Logic symbols depict the logic function performed and may differ from the manufacturer's data.

Component Values

Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors = Values one or greater are in picofarads (pF).
Values less than one are in micofarads (μF).

Resistors = Ohms (Ω).

Semiconductor Types

Refer to the Electrical Parts List.

Reference Designators

The following letters are used as reference designators to identify components or assemblies on Tektronix, Inc. schematic diagrams.

A	Assembly, separable or repairable (circuit board, etc.)
AT	Attenuator, fixed or variable
B	Motor
BT	Battery
C	Capacitor, fixed or variable
CR	Diode, signal or rectifier
DH	Decoupling Hybrid
DL	Delay Line
DS	Indicating device (lamp)
E, SG	Spark Gap
F	Fuse
FL	Filter
H	Heat dissipating device (heat sink, heat radiator, etc.)
HR	Heater
J	Connector, stationary portion
K	Relay
L	Inductor, fixed or variable
LR	Inductor/resistor combination
M	Meter
P	Connector, movable portion
Q	Transistor, silicon-controlled rectifier, or programmable unijunction transistor
R	Resistor, fixed or variable
RT	Thermistors
S	Switch
T	Transformer
TC	Thermocouple
TP	Test Point
U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
V	Electron tube
VR	Voltage regulator (zener diode, etc.)
Y	Crystal

Partial Schematic Diagram With Explanations

The partial diagram at the left is an example of the various symbols and other information provided on Tektronix, Inc. diagrams.

Transformer Wiring

A two-letter abbreviation color code is used to identify wires without terminal connection labels.

Bk	Black
Br	Brown
Rd	Red
Or	Orange
Yl	Yellow
G	Green
Bl	Blue
Vi	Violet
Gy	Gray
W	White

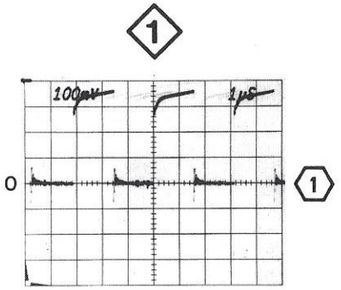
@

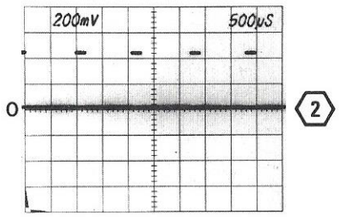
WAVEFORM CONDITIONS

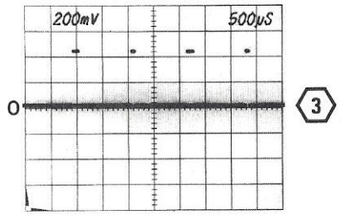
Waveform photographs in this section were taken with a TEKTRONIX C-59 Oscilloscope Camera mounted on a TEKTRONIX 7603 Oscilloscope with 7B53A Time Base and 7A13 Differential Comparator plug-ins.

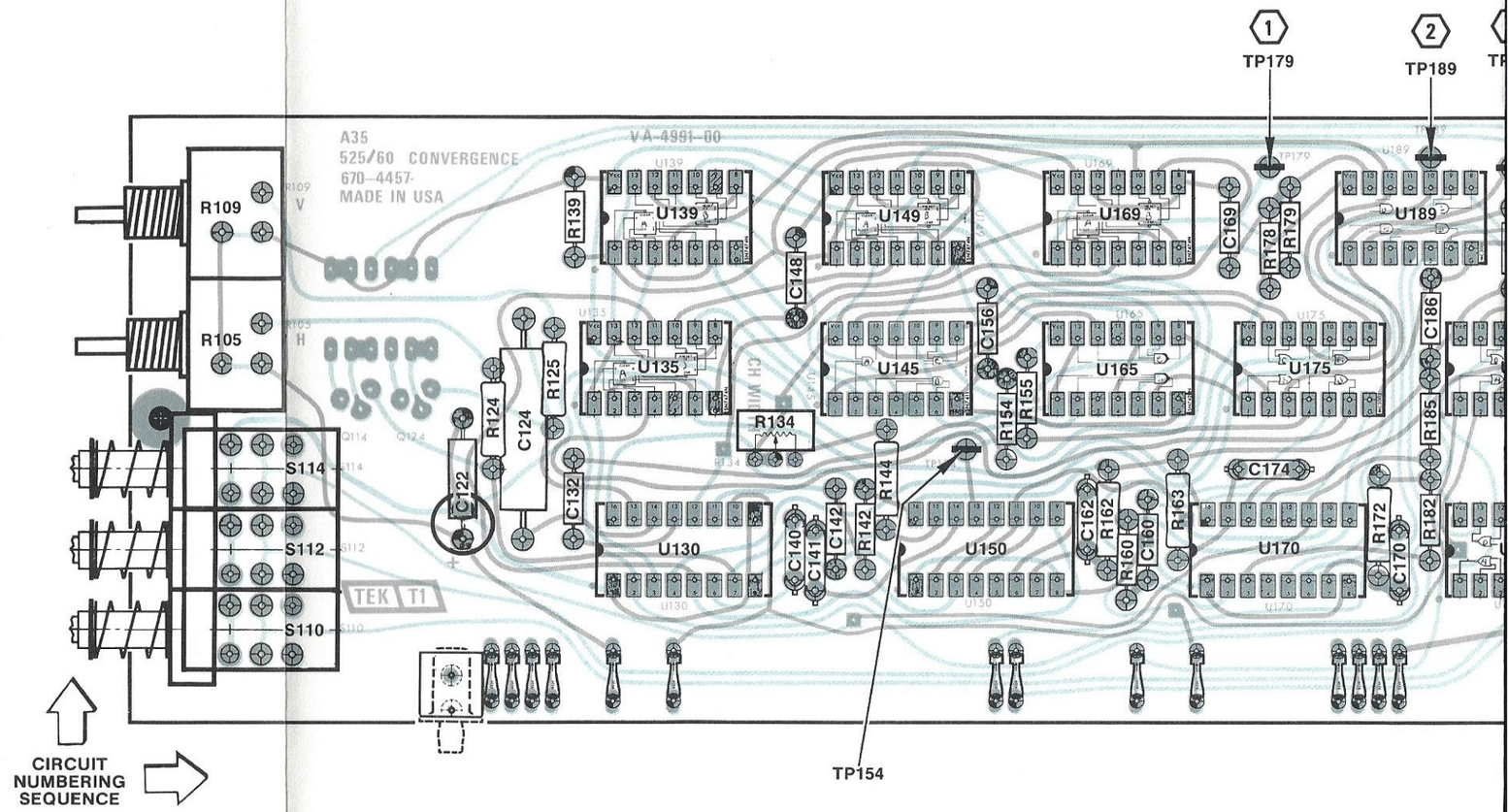
The vertical input was dc coupled except for those waveforms identified as ac coupled.

@

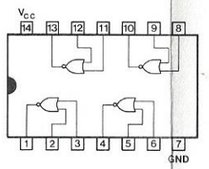




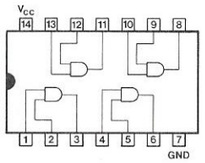




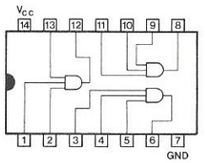
A35 CONVERGENCE PATTERN CIRCUIT BOARD



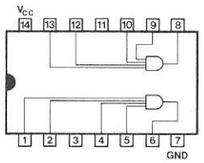
7402



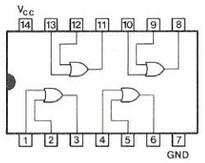
7408



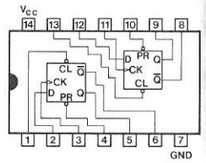
7411



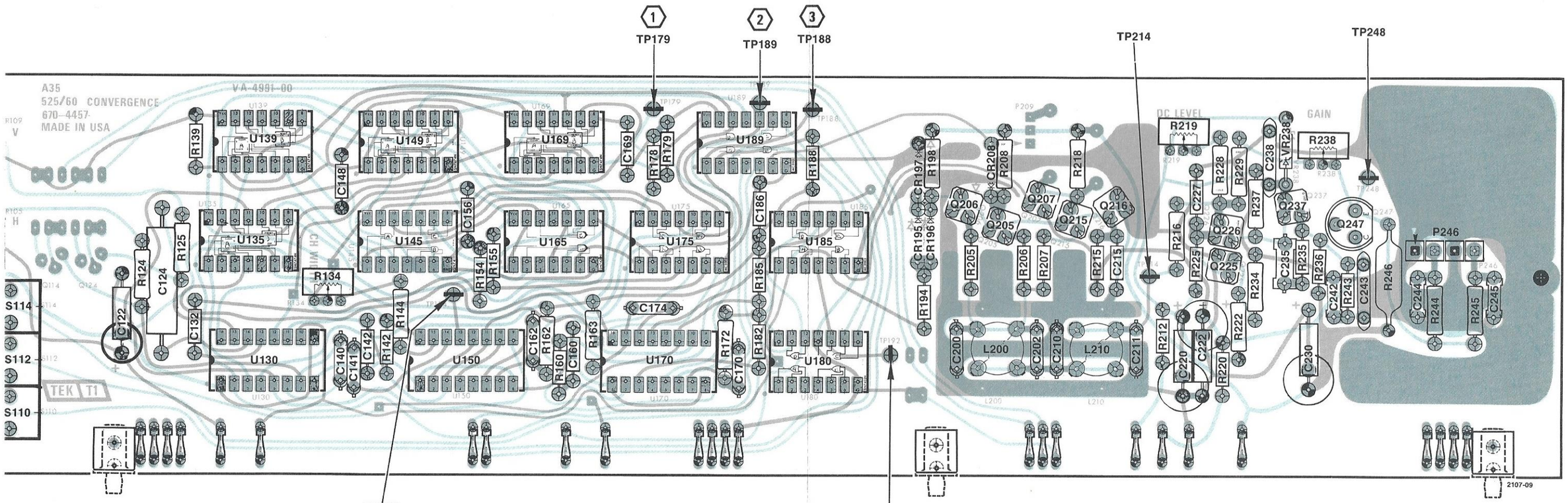
7421



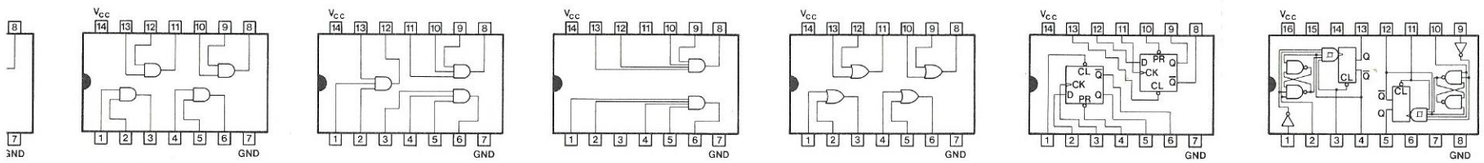
7432



74LS74



ERGENCE PATTERN CIRCUIT BOARD



1

CONVERGENCE PATTERN GENERATOR PARTS LOCATING CHART

C122	D5	R105	D1	S110	B1
C124	A1	R109	A1	S112	D1
C132	A1	R124	D1	S114	D1
C140	D1	R125	A1		
C141	C2	R134	C2	TP154	D2
C142	D5	R139	C5	TP179	D2
C148	B2	R142	C4	TP188	B3
C156	C2	R144	C2	TP189	C3
C160	D2	R154	A2	TP192	C4
C162	D2	R155	A2	TP214	B4
C169	B3	R160	D2	TP248	A5
C170	D3	R162	D1		
C174	C3	R163	C2	U130A	A1
C186	D4	R172	D3	U130B	D1
C200	B4	R178	BC	U135A	A2
C202	B4	R179	BC	U135B	B1
C210	B4	R182	D1	U139A	B2
C211	B4	R185	D1	U139B	B2
C215	C5	R188	C1	U145A	C2
C220	D5	R194	D4	U145B	C2
C222	D5	R198	D4	U145C	C3
C227	A4	R205	D4	U149A	B2
C230	D5	R206	D4	U149B	B3
C235	A5	R207	B5	U150A	D2
C238	A5	R208	D4	U150B	D1
C243	A5	R212	D5	U165A	B3
C244	B5	R215	C5	U165B	C3
C245	B5	R216	B4	U169A	D2
		R218	C5	U169B	B3
CR195	D4	R219	A4	U170A	D3
CR196	D4	R220	D5	U170B	D3
CR197	D4	R222	A4	U175A	C3
CR208	D4	R225	A4	U175B	A2
		R228	B4	U175C	A2
L200	B4	R229	B5	U175D	C3
L210	B4	R234	A4	U180C	C4
		R235	A5	U180D	D4
P246	A5	R236	A5	U185A	D4
		R237	A4	U185B	C4
Q205	D4	R238	B5	U185C	C3
Q206	D4	R244	A5	U185D	D4
Q207	C4	R245	B5	U189A	C3
Q215	C5	R246	B5	U189B	D4
Q216	C5			U189C	C4
Q225	A4			U189D	A2
Q226	A4				
Q237	A5			VR238	A5
Q247	A5				

WAVEFORMS

A20 ① a SPG1 E2 35

(H)

R109 20K +5V VERTICAL POSITION

R125 1.50K C124 0.1 C132 410 R154 4.7K +5V R155 4.7K U175B 1/4 74LS32

U130A 1/4 74LS221

U135A 1/4 74LS74

VERTICAL POSITIONING & TIMING

U175C 1/4 74LS32

U189D 1/4 74LS04

U135B 1/2 74LS74 U139A 1/2 74LS74 U139B 1/2 74LS74

U149A 1/2 74LS74 U149B 1/2 74LS74 U169B 1/4 74LS74

+5V R178 4.7K R179 4.7K C169 470

+5V C148 .01

S110 CROSSHATCH HORIZ LINES +5V R188 10K

U165A 1/2 74LS21 U165B 1/2 74LS21

TP188 ③ U175A 1/4 74LS32 U189A 1/4 74LS08 U185C 1/4 74LS32 U180C 1/4 74LS02

TP192 U185B 1/4 74LS32

TP189 ② U175D 1/4 74LS32 U189C 1/4 74LS08

+5V C156 .01

U145B 1/3 74LS11 U145C 1/3 74LS11 U145A 1/3 74LS11

R163 4.22K C174 77

CH WIDTH R134 2K +5V R144 6.98K C141 200 C162 130

R105 20K R124 20.0K C140 274 +5V HORIZONTAL POSITION

R162 4.99K +5V

U130B 1/4 74LS221 U150B 1/2 74LS221 U150A 1/4 74LS221

TP154 TP179 ① R160 470 C160 470

U170A 1/2 74LS221

R172 3.83K C170 130 +5V U170B 1/4 74LS221

U169A 1/4 74LS74

HORIZONTAL POSITIONING & TIMING

S114 DOTS +5V R185 10K +5V R182 10K

S112 CROSSHATCH VERT LINES

A35 CONVERGENCE BOARD

A28 ① b SPG1 E2 A20 ① a SPG1 E2 A22 ③ SPG1 E2

V (BLANKING) H (BLANKING) U185A 1/4 74LS32 U185D 1/4 74LS32

(COMP SYNC) U189B 1/4 74LS08 U180D 1/4 74LS02 (VIDEO DISABLE)

CURRENT SWITCH

R194 1K CR196 CR195 CR197 CR208 Q206 Q205 +0.6V

R205 47 R206 47 R198 140K R208 26.1K +5V -15V C186 .01

OUTPUT AMPLIFIER

+15V R237 4.53K C238 0.1 VR238 6.2V +5V C243 1.0μF Q237 Q247 TP 248

R225 6.2K Q226 Q225 C227 0.1 +15 R222 10.0K R234 4.02K

C235 3.9 R235 47 R236 3K -15V

+15V D.C. LEVEL R219 500 R228 2.87K R229 887 R238 250 GAIN

P246 R244 75.0 C244 11 C245 11 R245 75.0 R246 470 -15V

MODULE OUTPUT REAR PANEL THRU REAR INTERCONNECT BOARD

TP 214 R216 162 C211 77 C210 200 C202 36 C200 470

L 210 2.9 to 6.5 μH SHAPING L 200 2 to 11 μH

FILTER

R207 47 +5V Q207 Q215 +0.6V R218 15.0K -15V

+5V R139 1K +0.6V Q216 C215 .01 R142 1K C142 .001 +5V +5V R215 1K

POWER SUPPLY

R212 22 C220 22μF C230 22μF R220 22 C222 22μF C122 1μF

+15V 62 +15V GND 66 GND -15V 70 -15V +5V 64 +5V +5V DIGITAL GND 6 +5V DIGITAL GND 45 GND

A3 ② 1410 & 1410-1

NTSC CONVERGENCE PATTERN GENERATOR ⑦

TSG2 @ GEM 6/76 CONVERGENCE PATTERN GENERATOR ①

REPLACEABLE MECHANICAL PARTS

PARTS ORDERING INFORMATION

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

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

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

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

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

1 2 3 4 5 Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
- - - * - - -
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
- - - * - - -
Parts of Detail Part
Attaching parts for Parts of Detail Part
- - - * - - -

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ITEM NAME

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

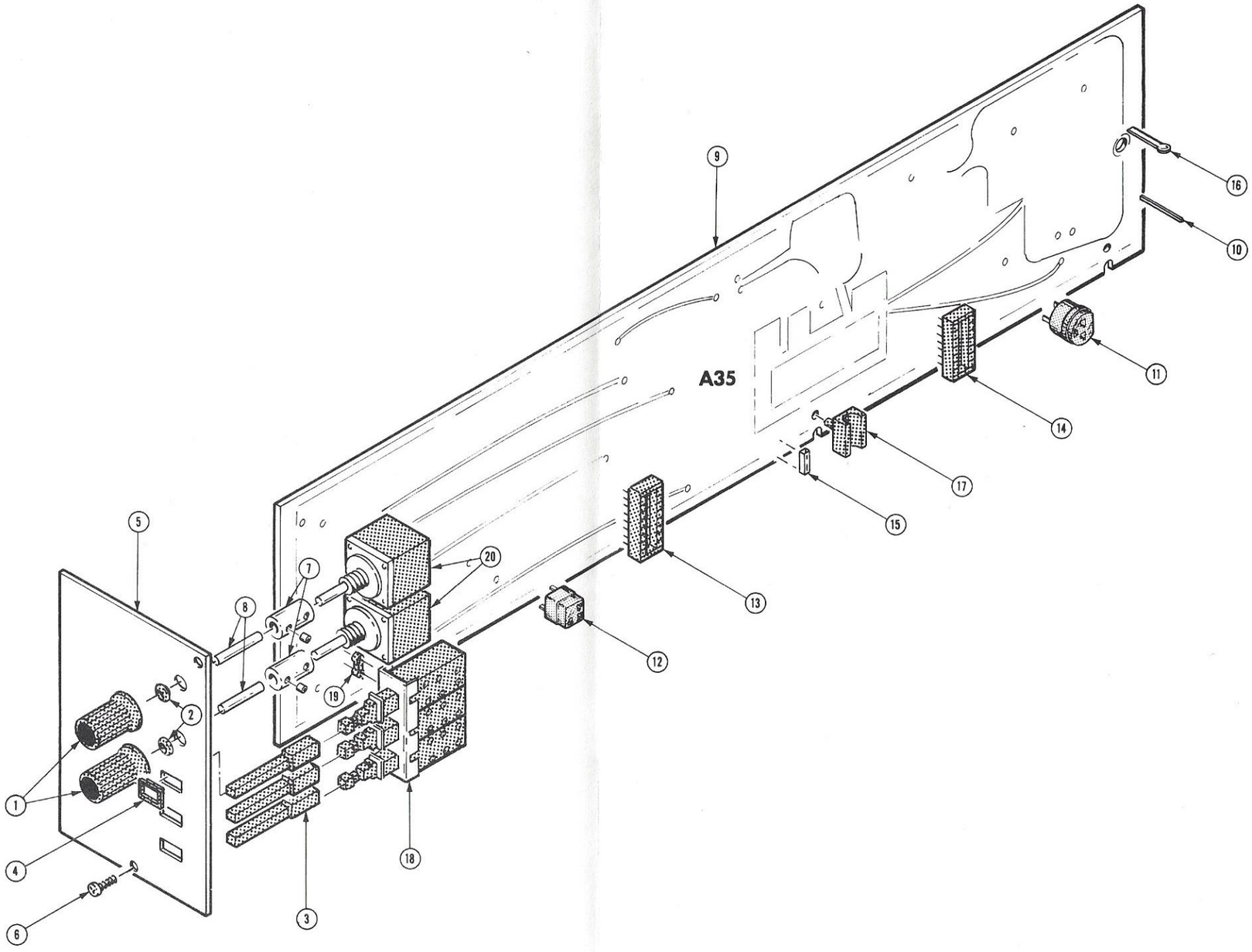
ABBREVIATIONS

"	INCH
#	NUMBER SIZE
ACTR	ACTUATOR
ADPTR	ADAPTER
ALIGN	ALIGNMENT
AL	ALUMINUM
ASSEM	ASSEMBLED
ASSY	ASSEMBLY
ATTEN	ATTENUATOR
AWG	AMERICAN WIRE GAGE
BD	BOARD
BRKT	BRACKET
BRS	BRASS
BRZ	BRONZE
BSHG	BUSHING
CAB	CABINET
CAP	CAPACITOR
CER	CERAMIC
CHAS	CHASSIS
CKT	CIRCUIT
COMP	COMPOSITION
CONN	CONNECTOR
COV	COVER
CPLG	COUPLING
CRT	CATHODE RAY TUBE
DEG	DEGREE
DWR	DRAWER
ELCTRN	ELECTRON
ELEC	ELECTRICAL
ELCTLT	ELECTROLYTIC
ELEM	ELEMENT
EPL	ELECTRICAL PARTS LIST
EQPT	EQUIPMENT
EXT	EXTERNAL
FIL	FILLISTER HEAD
FLEX	FLEXIBLE
FLH	FLAT HEAD
FLTR	FILTER
FR	FRAME or FRONT
FSTNR	FASTENER
FT	FOOT
FXD	FIXED
GSKT	GASKET
HDL	HANDLE
HEX	HEXAGON
HEX HD	HEXAGONAL HEAD
HEX SOC	HEXAGONAL SOCKET
HLCPS	HELICAL COMPRESSION
HLEXT	HELICAL EXTENSION
HV	HIGH VOLTAGE
IC	INTEGRATED CIRCUIT
ID	INSIDE DIAMETER
IDENT	IDENTIFICATION
IMPLR	IMPELLER
IN	INCH
INCAND	INCANDESCENT
INSUL	INSULATOR
INTL	INTERNAL
LPHLDR	LAMPHOLDER
MACH	MACHINE
MECH	MECHANICAL
MTG	MOUNTING
NIP	NIPPLE
NON WIRE	NOT WIRE WOUND
OBD	ORDER BY DESCRIPTION
OD	OUTSIDE DIAMETER
OVH	OVAL HEAD
PH BRZ	PHOSPHOR BRONZE
PL	PLAIN or PLATE
PLSTC	PLASTIC
PN	PART NUMBER
PNH	PAN HEAD
PWR	POWER
RCPT	RECEPTACLE
RES	RESISTOR
RGD	RIGID
RLF	RELIEF
RTNR	RETAINER
SCH	SOCKET HEAD
SCOPE	OSCILLOSCOPE
SCR	SCREW
SE	SINGLE END
SECT	SECTION
SEMICOND	SEMICONDUCTOR
SHLD	SHIELD
SHLDR	SHOULDERED
SKT	SOCKET
SL	SLIDE
SLFLKG	SELF-LOCKING
SLVG	SLEEVING
SPR	SPRING
SQ	SQUARE
SST	STAINLESS STEEL
STL	STEEL
SW	SWITCH
T	TUBE
TERM	TERMINAL
THD	THREAD
THK	THICK
TNSN	TENSION
TPG	TAPPING
TRH	TRUSS HEAD
V	VOLTAGE
VAR	VARIABLE
W/	WITH
WSHR	WASHER
XFMR	TRANSFORMER
XSTR	TRANSISTOR

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
01295	Texas Instruments, Inc., Components Group	P. O. Box 5012	Dallas, TX 75222
22526	Berg Electronics, Inc.	Youk Expressway	New Cumberland, PA 17070
70276	Allen Mfg. Co.	P. O. Drawer 570	Hartford, CT 06101
71590	Centralab Electronics, Div. of Globe-Union, Inc.	5757 N. Green Bay Ave.	Milwaukee, WI 53201
71785	TRW Electronic Components, Cinch Connector Operations	1501 Morse Ave.	Elk Grove Village, IL 60007
74445	Holo-Krome Co.	31 Brook St. West	Hartford, CT 06110
80009	Tektronix, Inc.	P. O. Box 500	Beaverton, OR 97005
83385	Central Screw Co.	2530 Crescent Dr.	Broadview, IL 60153

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	366-1189-00			2		KNOB:GRAY	80009	366-1189-00
	213-0153-00			2		. SETSCREW:5-40 X 0.125 INCH,HEX SOC STL	74445	OBD
-2	358-0378-01			2		BUSHING,SLEEVE:0.25-32 X 0.535 INCH LONG	80009	358-0378-01
-3	366-1691-00			3		PUSH BUTTON:GRAY,1.20 INCHES LONG	80009	366-1691-00
-4	426-1206-00			3		FRAME,PUSH BTN:GRAY,PLASTIC	80009	426-1206-00
-5	333-2161-00			1		PANEL,FRONT:TSG2	80009	333-2161-00
						(ATTACHING PARTS)		
-6	213-0120-00			2		SCR,TPG,THD FOR:2-32 X 0.250 INCH,PNH STL	83385	OBD
						- - - * - - -		
-7	376-0029-00			2		CPLG,SHAFT,RGD:0.128 ID X 0.312 OD X 0.5"L	80009	376-0029-00
	213-0075-00			4		. SETSCREW:4-40 X 0.094 INCH,HEX SOC STL	70276	OBD
-8	384-1171-00			2		EXTENSION SHAFT:0.125 OD X 1.05 INCH L	80009	384-1171-00
-9	----- -----			1		CKT CARD ASSY:CONVERGENCE(SEE A35 EPL)		
-10	131-0589-00			4		. CONTACT,ELEC:0.46 INCH LONG	22526	47350
-11	136-0183-00			1		. SOCKET,PLUG-IN:3 PIN,ROUND	80009	136-0183-00
-12	136-0220-00			8		. SOCKET,PLUG-IN:3 PIN,SQUARE	71785	133-23-11-034
-13	136-0260-02			3		. SOCKET,PLUG-IN:16 CONTACT,LOW CLEARANCE	01295	C931602
-14	136-0269-02			9		. SOCKET,PLUG-IN:14 CONTACT,LOW CLEARANCE	01295	C931402
-15	136-0328-03			23		. SOCKET,PIN TERM:HORIZONTAL	22526	47710
-16	214-0579-00			7		. TERM.,TEST PT:0.40 INCH LONG	80009	214-0579-00
-17	214-2440-00			3		. RECEPTACLE,PIN:CIRCUIT CARD	80009	214-2440-00
-18	260-1448-00			1		. SWITCH,PUSH:3 STA,NON-SHORT	80009	260-1448-00
-19	361-0542-00			6		. SPACER,SWITCH:PLASTIC	71590	J-64281
-20	----- -----			2		. RES.,VAR:VERT,HORIZ POS(SEE R105,R109 EPL)		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MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

SERVICE NOTE

Because of the universal parts procurement problem, some electrical parts in your instrument may be different from those described in the Replaceable Electrical Parts List. The parts used will in no way alter or compromise the performance or reliability of this instrument. They are installed when necessary to ensure prompt delivery to the customer. Order replacement parts from the Replaceable Electrical Parts List.

CALIBRATION TEST EQUIPMENT REPLACEMENT

Calibration Test Equipment Chart

This chart compares TM 500 product performance to that of older Tektronix equipment. Only those characteristics where significant specification differences occur, are listed. In some cases the new instrument may not be a total functional replacement. Additional support instrumentation may be needed or a change in calibration procedure may be necessary.

Comparison of Main Characteristics

DM 501 replaces 7D13		
PG 501 replaces 107	PG 501 - Risetime less than 3.5 ns into 50 Ω.	107 - Risetime less than 3.0 ns into 50 Ω.
108	PG 501 - 5 V output pulse; 3.5 ns Risetime.	108 - 10 V output pulse; 1 ns Risetime.
111	PG 501 - Risetime less than 3.5 ns; 8 ns Pretrigger pulse delay.	111 - Risetime 0.5 ns; 30 to 250 ns Pretrigger Pulse delay.
114	PG 501 - ±5 V output.	114 - ±10 V output. Short proof output.
115	PG 501 - Does not have Paired, Burst, Gated, or Delayed pulse mode; ±5 V dc Offset. Has ±5 V output.	115 - Paired, Burst, Gated, and Delayed pulse mode; ±10 V output. Short-proof output.
PG 502 replaces 107		
108	PG 502 - 5 V output	108 - 10 V output.
111	PG 502 - Risetime less than 1 ns; 10 ns Pretrigger pulse delay.	111 - Risetime 0.5 ns; 30 to 250 ns Pretrigger pulse delay.
114	PG 502 - ±5 V output	114 - ±10 V output. Short proof output.
115	PG 502 - Does not have Paired, Burst, Gated, Delayed & Undelayed pulse mode; Has ±5 V output.	115 - Paired, Burst, Gated, Delayed & Undelayed pulse mode; ±10 V output. Short-proof output.
2101	PG 502 - Does not have Paired or Delayed pulse. Has ±5 V output.	2101 - Paired and Delayed pulse; 10 V output.
PG 506 replaces 106	PG 506 - Positive-going trigger output signal at least 1 V; High Amplitude output, 60 V.	106 - Positive and Negative-going trigger output signal, 50 ns and 1 V; High Amplitude output, 100 V.
067-0502-01	PG 506 - Does not have chopped feature.	0502-01 - Comparator output can be alternately chopped to a reference voltage.
SG 503 replaces 190, 190A, 190B	SG 503 - Amplitude range 5 mV to 5.5 V p-p.	190B - Amplitude range 40 mV to 10 V p-p.
191	SG 503 - Frequency range 250 kHz to 250 MHz.	191 - Frequency range 350 kHz to 100 MHz.
067-0532-01	SG 503 - Frequency range 250 kHz to 250 MHz.	0532-01 - Frequency range 65 MHz to 500 MHz.
TG 501 replaces 180, 180A	TG 501 - Marker outputs, 5 sec to 1 ns. Sinewave available at 5, 2, and 1 ns. Trigger output - slaved to marker output from 5 sec through 100 ns. One time-mark can be generated at a time.	180A - Marker outputs, 5 sec to 1 μs. Sinewave available at 20, 10, and 2 ns. Trigger pulses 1, 10, 100 Hz; 1, 10, and 100 kHz. Multiple time-marks can be generated simultaneously.
181	TG 501 - Marker outputs, 5 sec to 1 ns. Sinewave available at 5, 2, and 1 ns.	181 - Marker outputs, 1, 10, 100, 1000, and 10,000 μs, plus 10 ns sinewave.
184	TG 501 - Marker outputs, 5 sec to 1 ns. Sinewave available at 5, 2, and 1 ns. Trigger output - slaved to marker output from 5 sec through 100 ns. One time-mark can be generated at a time.	184 - Marker outputs, 5 sec to 2 ns. Sinewave available at 50, 20, 10, 5, and 2 ns. Separate trigger pulses of 1 and .1 sec; 10, 1, and .1 ms; 10 and 1 μs. Marker amplifier provides positive or negative time marks of 25 V min. Marker intervals of 1 and .1 sec; 10, 1, and .1 ms; 10 and 1 μs.
2901	TG 501 - Marker outputs, 5 sec to 1 ns. Sinewave available at 5, 2, and 1 ns. Trigger output - slaved to marker output from 5 sec through 100 ns. One time-mark can be generated at a time.	2901 - Marker outputs, 5 sec to 0.1 μs. Sinewave available to 50, 10, and 5 ns. Separate trigger pulses, from 5 sec to 0.1 μs. Multiple time-marks can be generated simultaneously.

NOTE: All TM 500 generator outputs are short-proof. All TM 500 plug-in instruments require TM 500-Series Power Module.

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