MAINTENANCE

This section contains information for conducting preventive maintenance, troubleshooting, and corrective maintenance on the instrument. Circuit board removal procedures are included in the corrective maintenance part of this section.

STATIC–SENSITIVE COMPONENTS

The following precautions are applicable when performing any maintenance involving internal access to the instrument.

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. Table 6–1 lists the relative susceptibility of various classes of semiconductors. Static voltages of 1 KV to 30 KV are common in unprotected environments.

When performing maintenance, observe the following precautions to avoid component damage:

1. Minimize handling of static-sensitive components.

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

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

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

Table 6–1
Relative Susceptibility to Static–Discharge Damage

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

[a]Voltage equivalent for levels (voltage discharged from a 100-pF capacitor through a resistance of 100 Ω):

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

5. Keep the component leads shorted together whenever possible.

6. Pick up components by their bodies, never by their leads.

EXTERNAL Z-AXIS AND PROBE ADJUST

Equipment Required (See Table 4-1):

Leveled Sine-Wave Generator (Item 2)	Dual-Input Coupler (Item 9)
Screwdriver (Item 5)	50-Ω BNC Termination (Item 10)
50-Ω BNC Coaxial Cable (Item 8)	10X Probe (Provided with instrument)

INITIAL CONTROL SETTINGS

Vertical

Channel 1 POSITION	Midrange
MODE	CH 1
CH 1 VOLTS/DIV	1 V
CH 1 VOLTS/DIV Variable	CAL detent
Magnification	X1 (CAL knob in)
Channel 1 AC-GND-DC	DC

Horizontal

POSITION	Midrange
HORIZONTAL MODE	X1
SEC/DIV	20 ms
SEC/DIV Variable	CAL detent

Trigger

SLOPE	Positive (_/‾)
LEVEL	Midrange
MODE	P-P AUTO
HOLDOFF	MIN
SOURCE	VERT MODE
COUPLING	DC

PROCEDURE STEPS

1. Check External Z-Axis Operation

a. Connect the leveled sine-wave generator output via a 50-Ω BNC coaxial cable, a 50-Ω BNC termination, and a dual-input coupler to the CH 1 OR X and the EXT INPUT OR Z input connectors.

b. Set the generator to produce a five-division, 50-kHz signal.

c. CHECK—For noticeable intensity modulation. The positive part of the sine wave should be of lower intensity than the negative part.

d. Disconnect the test equipment from the instrument.

2. Check Probe Adjust Operation

a. SET:

CH 1 VOLTS/DIV	10 mV
SEC/DIV	0.5 ms
Trigger SOURCE	CH 1

b. Connect the 10X Probe to the CH 1 OR X input connector and clip the probe tip to the PROBE ADJUST terminal on the instrument front panel. If necessary, adjust the probe compensation for a flat-topped square-wave display (see Probe instruction manual).

c. CHECK—Display amplitude is 4.75 to 5.25 divisions.

d. Disconnect the probe from the instrument.

7. Do not slide the components over any surface.

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

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

10. Use only approved antistatic, vacuum-type desoldering tools for component removal.

PREVENTIVE MAINTENANCE

INTRODUCTION

Preventive maintenance consists of cleaning, visual inspection, and checking instrument performance. When performed regularly, it may prevent instrument malfunction and enhance instrument reliability. The severity of the environment in which the instrument is used determines the required frequency of maintenance. An appropriate time to accomplish preventive maintenance is just before instrument adjustment.

GENERAL CARE

The cabinet minimizes accumulation of dust inside the instrument and should normally be in place when operating the oscilloscope.The optional front cover for the instrument provides both dust and damage protection for the front panel and crt. Whenever the instrument is stored or is being transported, the front cover should be used.

CAUTION

Do not use chemical cleaning agents that might damage the plastics used in this instrument. Use a nonresidue-type cleaner, preferably isopropyl alcohol or a solution of 1% mild detergent with 99% water. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

INSPECTION AND CLEANING

The instrument should be visually inspected and cleaned as often as operating conditions require. Accumulation of dust in the instrument can cause overheating and component breakdown. Dust on components acts as an insulating blanket, preventing efficient heat dissipation. It also provides an electrical conduction path that could result in instrument failure, especially under high-humidity conditions.

Exterior

INSPECTION. Inspect the external portions of the instrument for damage, wear, and missing parts; use Table 6-2 as a guide. Instruments that appear to have been dropped or otherwise abused should be checked thoroughly to verify correct operation and performance. Any problems found that could cause personal injury or could lead to further damage to the instrument should be repaired immediately.

CAUTION

Do not allow moisture to get inside the instrument during external cleaning. Use only enough liquid to dampen the cloth or applicator.

CLEANING. Loose dust on the outside of the instrument can be removed with a soft cloth or small soft-bristle brush. The brush is particularly useful for dislodging dirt on and around the controls and connectors. Dirt that remains can be removed with a soft cloth dampened in a mild detergent-and-water solution. Do not use abrasive cleaners.

A plastic light filter is provided with the oscilloscope. Clean the light filter and the crt face with a soft lint-free cloth dampened with either isopropyl alcohol or a mild detergent-and-water solution.

Interior

To gain access to internal portions of the instrument for inspection and cleaning, refer to the Removal and Replacement Instructions in the Corrective Maintenance part of this section.

Table 6-2
External Inspection Checklist

Item	Inspect For	Repair Action
Cabinet and Front Panel	Cracks, scratches, deformations, and damaged hardware or gaskets.	Touch up paint scratches and replace defective parts.
Front-panel controls	Missing, damaged, or loose knobs, buttons, and controls.	Repair or replace missing or defective items.
Connectors	Broken shells, cracked insulation, and deformed contacts. Dirt in connectors.	Replace defective parts. Clean or wash out dirt.
Carrying Handle	Correct operation.	Replace defective parts.
Accessories	Missing items or parts of items, bent pins, broken or frayed cables, and damaged connectors.	Replace damaged or missing items, frayed cables, and defective parts.

Table 6-3
Internal Inspection Checklist

Item	Inspect For	Repair Action
Circuit Boards	Loose, broken, or corroded solder connections. Burned circuit boards. Burned, broken, or cracked circuit-run plating.	Clean solder corrosion with an eraser and flush with isopropyl alcohol. Resolder defective connections. Determine cause of burned items and repair. Repair defective circuit runs.
Resistors	Burned, cracked, broken, or blistered.	Replace defective resistors. Check for cause of burned component and repair as necessary.
Solder Connections	Cold solder or rosin joints.	Resolder joint and clean with isopropyl alcohol.
Capacitors	Damaged or leaking cases. Corroded solder on leads or terminals.	Replace defective capacitors. Clean solder connections and flush with isopropyl alcohol.
Wiring and Cables	Loose plugs or connectors. Burned, broken, or frayed wiring.	Firmly seat connectors. Repair or replace defective wires or cables.
Chassis	Dents, deformations, and damaged hardware.	Straighten, repair, or replace defective hardware.

INSPECTION. Inspect the internal portions of the instrument for damage and wear, using Table 6-3 as a guide. Deficiencies found should be repaired immediately. 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.

If any electrical component is replaced, conduct a Performance Check for the affected circuit and for other closely related circuits (see Section 4). If repair or replacement work is done on any of the power supplies, conduct a complete Performance Check and, if so indicated, an instrument readjustment (see Sections 4 and 5).

CAUTION

To prevent damage from electrical arcing, ensure that circuit boards and components are dry before applying power to the instrument.

CLEANING. To clean the interior, blow off dust with dry, low-pressure air (approximately 9 psi). Remove any remaining dust with a soft brush or a cloth dampened with a solution of mild detergent and water. A cotton-tipped applicator is useful for cleaning in narrow spaces and on circuit boards.

VOLT/DIV And SEC/DIV SWITCHES. These are maintenance free. DO NOT CLEAN.

CAUTION

Most spray-type circuit coolants contain Freon 12 as a propellant. Because many Freons adversely affect switch contacts, do not use spray-type coolants on the switches or attenuators. Carbon based solvents will damage the board material.

LUBRICATION

Most of the potentiometers used in this instrument are permanently sealed and generally do not require periodic lubrication. All switches, both rotary- and lever-type, are installed with proper lubrication applied where necessary and will rarely require any additional lubrication. A regular periodic lubrication program for the instrument is, therefore, not recommended.

SEMICONDUCTOR CHECKS

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

PERIODIC READJUSTMENT

To ensure accurate measurements, check the performance of this instrument every 2000 hours of operation, or if used infrequently, once each year. In addition, replacement of components may necessitate readjustment of the affected circuits.

Complete Performance Check and Adjustment instructions are given in Sections 4 and 5. The Performance Check Procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor problems may be revealed or corrected by readjustment. If only a partial adjustment is performed, see the interaction chart, Table 5-1, for possible adjustment interaction with other circuits.

TROUBLESHOOTING

INTRODUCTION

Preventive maintenance performed on a regular basis should reveal most potential problems before an instrument malfunctions. However, should troubleshooting be required, the following information is provided to facilitate location of a fault. In addition, the material presented in the Theory of Operation and Diagrams sections of this manual may be helpful while troubleshooting.

TROUBLESHOOTING AIDS

Schematic Diagrams

Complete schematic diagrams are located on tabbed foldout pages in the Diagrams section. Portions of circuitry mounted on each circuit board are enclosed by heavy black lines. The assembly number and name of the circuit are shown near either the top or the bottom edge of the enclosed area.

Functional blocks on schematic diagrams are outlined with a wide grey line. Components within the outlined area perform the function designated by the block label. The Theory of Operation uses these functional block names when describing circuit operation as an aid in cross-referencing between the theory and the schematic diagrams.

Component numbers and electrical values of components in this instrument are shown on the schematic diagrams. Refer to the first page of the Diagrams section for the reference designators and symbols used to identify components. Important voltages and waveform reference numbers (enclosed in hexagonal-shaped boxes) are also shown on each diagram. Waveform illustrations are located adjacent to their respective schematic diagram.

Circuit Board Illustrations

Circuit board illustrations showing the physical location of each component are provided for use in conjunction with each schematic diagram. Each board illustration is found in the Diagrams section on the back of a foldout page, preceding the first schematic diagram(s) to which it relates.

The locations of waveform test points are marked on the circuit board illustrations with hexagonal outlined numbers corresponding to the waveform numbers on both the schematic diagram and the waveform illustrations.

Also provided in the Diagrams section is an illustration of the bottom side of the Main circuit board. This illustration aids in troubleshooting by showing the connection pads for the components mounted on the top side of the circuit board. By using this illustration, circuit tracing and probing for voltages and signals that are inaccessible from the top side of the board may be achieved without dismantling portions of the instrument.

Circuit Board Locations

The placement of each circuit board in the instrument is shown in board locator illustrations. These illustrations are located on foldout pages along with the circuit board illustration.

Circuit Board Interconnections

A circuit board interconnection diagram is provided in the Diagrams section to aid in tracing a signal path or power source between boards. All wire, plug, and jack numbers are shown along with their associated wire or pin numbers.

Power Distribution

A Power Distribution diagram is provided to aid in troubleshooting power-supply problems. This diagram shows the service jumper connections used to apply power to the various circuit boards. Excessive loading on a power supply by a circuit board fault may be isolated by disconnecting the appropriate service jumpers.

Grid Coordinate System

Each schematic diagram and circuit board illustration has a grid border along its left and top edges. A table located adjacent to each diagram lists the grid coordinates of each component shown on that diagram. To aid in physically locating components on the circuit board, this table also lists the grid coordinates of each component on the circuit board illustration.

Near each circuit board illustration is an alphanumeric listing of all components mounted on that board. The second column in each listing identifies the schematic diagram in which each component can be found. These component-locator tables are especially useful when more than one schematic diagram is associated with a particular circuit board.

Component Color Coding

Information regarding color codes and markings of resistors and capacitors is located on the color-coding illustration (Figure 9-1) at the beginning of the Diagrams section.

RESISTOR COLOR CODE. Resistors used in this instrument are carbon-film, composition, or precision metal-film types. They are usually color coded with the EIA color code; however, some metal-film type resistors may have the value printed on the body. The color code is interpreted starting with the stripe nearest to one end of the resistor. Composition resistors have four stripes; these represent two significant digits, a multiplier, and a tolerance value. Metal-film resistors have five stripes representing three significant digits, a multiplier, and a tolerance value.

CAPACITOR MARKINGS. Capacitance values of common disc capacitors and small electrolytics are marked on the side of the capacitor body. White ceramic capacitors are color coded in picofarads, using a modified EIA code.

Dipped tantalum capacitors are color coded in microfarads. The color dot indicates both the positive lead and the voltage rating. Since these capacitors are easily destroyed by reversed or excessive voltage, be careful to observe the polarity and voltage rating when replacing them.

DIODE COLOR CODE. The cathode end of each glass-encased diode is indicated by either a stripe, a series of stripes or a dot. For most diodes marked with a series of stripes, the color combination of the stripes identifies three digits of the Tektronix Part Number, using the resistor color-code system. The cathode and anode ends of a metal-encased diode may be identified by the diode symbol marked on its body.

Semiconductor Lead Configurations

Figure 9-2 in the Diagrams section shows the lead configurations for semiconductor devices used in the instrument. These lead configurations and case styles are typical of those used at completion of the instrument design. Vendor changes and performance improvement changes may result in changes of case styles or lead configurations. If the device in question does not appear to match the configuration shown in Figure 9-2, examine the associated circuitry or consult the manufacturer's data sheet.

RIBBON-CABLE CONNECTORS

The multipin connectors of the 2225 are designed to make the interboard connections directly to the ribbon cables. Insert the trimmed ribbon-cable wires into the connector slots (see Figure 6-1 A). Pressing down on the release bar (the top of the connector) with your fingertip will make it easier to push the wires into the connector (see Figure 6-1 C). The cable locks firmly into the connector (Figure 6-1 B) when the pressure is removed from the release bar. To disconnect the ribbon cable from the connector, press down on the release bar and lift the cable out of the connector (see Figure 6-1 C and D). The ribbon cable wire should be evenly trimmed to expose 5 mm of wire (about 1/4 inch) for correct insertion into the connectors.

The ribbon cables are either color coded in the standard color codes or have a striped index wire. Align the index wire with the pin 1 indicator when reinserting a cable into its connector.

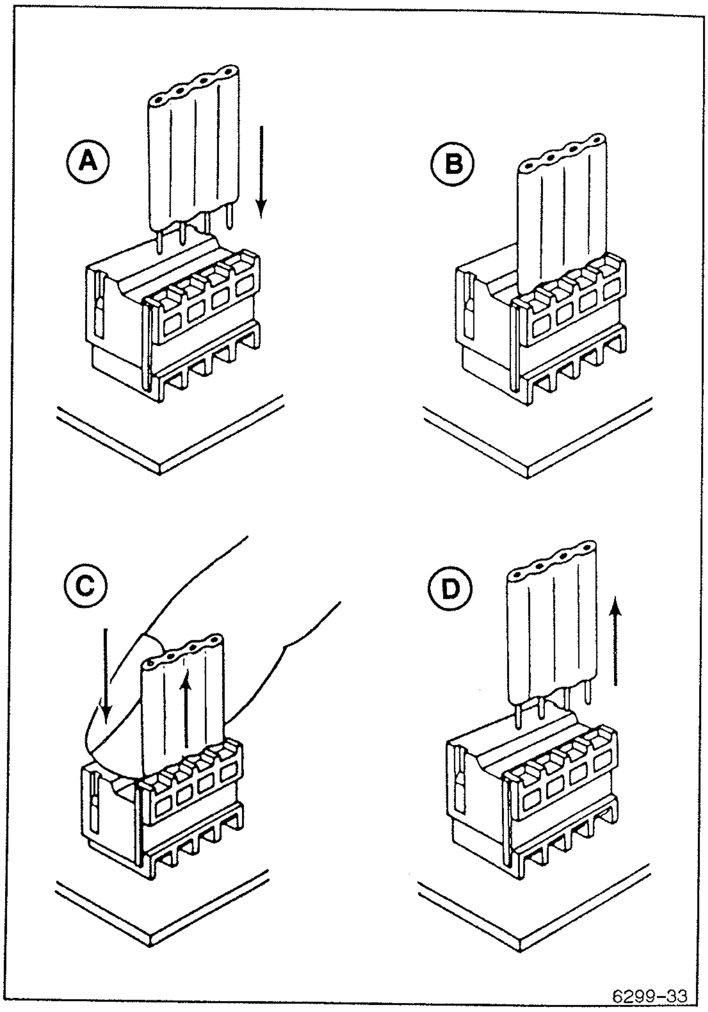

Figure 6-1. Multi-connector operation.

TROUBLESHOOTING EQUIPMENT

The equipment listed in Table 4-1 of this manual, or equivalent equipment, may be useful when troubleshooting this instrument.

TROUBLESHOOTING TECHNIQUES

The following procedure is arranged in an order that enables checking simple trouble possibilities before requiring more extensive troubleshooting. The first four steps ensure proper control settings, connections, operation, and adjustment. If the trouble is not located by these checks, the remaining steps will aid in locating the defective component. When the defective component is located, replace it using the appropriate replacement procedure given under Corrective Maintenance in this section.

CAUTION

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

1. Check Control Settings

Incorrect control settings can give a false indication of instrument malfunction. If there is any question about the correct function or operation of any control, refer to either the Operating Information in Section 2 of this manual or to the Operators Manual.

2. Check Associated Equipment

Before proceeding, ensure that any equipment used with the instrument is operating correctly. Verify that input signals are properly connected and that the interconnecting cables are not defective. Check that the ac-power-source voltage to all equipment is correct.

WARNING

To avoid electrical shock, disconnect the instrument from the ac power source before making a visual inspection of the internal circuitry.

3. Visual Check

Perform a visual inspection. This check may reveal broken connections or wires, damaged components, semiconductors not firmly mounted, damaged circuit boards, or other clues to the cause of an instrument malfunction.

WARNING

Dangerous potentials exist at several points throughout this instrument. If it is operated with the cabinet removed, do not touch exposed connections or components.

4. Check Instrument Performance and Adjustment

Check the performance of either those circuits where trouble appears to exist or the entire instrument. The apparent trouble may be the result of misadjustment. Complete performance check and adjustment instructions are given in Sections 4 and 5 of this manual.

5. Isolate Trouble to a Circuit.

To isolate problems to a particular area, use any symptoms noticed to help locate the trouble. Refer to the troubleshooting charts in the Diagrams section as an aid in locating a faulty circuit.

6. Check Power Supplies.

WARNING

For safety reasons, an isolation transformer must be connected whenever troubleshooting is done in the Preregulator and Inverter Power Supply sections of the instrument.

When trouble symptoms appear in more that one circuit, first check the power supplies; then check the affected circuits by taking voltage and waveform readings. Check first for the correct output voltage of each individual supply. These voltages are measured between the power supply test points and ground (see the associated circuit board illustration and Table 6-5).

Voltage levels may be measured either with a DMM or with an oscilloscope. Voltage ripple amplitudes must be measured using an oscilloscope. Before checking power-supply circuitry, set the INTENSITY control to normal brightness, the SEC/DIV switch to 0.1 ms, the Trigger MODE to P-P AUTO, and the Vertical MODE switch to CH 1.

When measuring ripple, use a 1X probe. The ripple values listed are based on a system limited in bandwidth to 30 kHz. Using a system with wider bandwidth will result in higher readings.

If the power-supply voltages and ripple are within the ranges listed in Table 6-4, the supply can be assumed to be working correctly. If they are outside the range, the supply may be either misadjusted or operating incorrectly. Use the Power Supply and CRT Display subsection in the Adjustment procedure to adjust the -8.6-V supply.

A defective component elsewhere in the instrument can create the appearance of a power-supply problem and may also affect the operation of other circuits.

7. Check Circuit Board Interconnections.

After the trouble has been isolated to a particular circuit, again check for loose or broken connections, improperly seated semiconductors, and heat-damaged components.

8. Check Voltages and Waveforms.

Often the defective component can be located by checking circuit voltages or waveforms. Typical voltages are listed on the schematic diagrams. Waveforms indicated on the schematic diagrams by hexagonal-outlined numbers are shown adjacent to the diagrams. Waveform test points are shown on the circuit board illustrations.

Table 6-4
Power Supply Voltage and Ripple Limits

Power Supply	Test Point	Reading (Volts)	P-P Ripple (mV)
-8.6 V	W989	-8.557 to -8.643	3 mV
+5.2 V	W991	+5.044 to 5.35	4 mV
+8.6 V	W987	+8.526 to 8.874	3 mV
+38 V	W972	+37.24 to 39.14	10 mV
+99 V	W984	+97.02 to 101.97	100 mV

NOTE

Voltages and waveforms indicated on the schematic diagrams are not absolute and may vary slightly between instruments. To establish operating conditions similar to those used to obtain these readings, see the Voltage and Waveform Setup Conditions preceding the waveform illustrations in the Diagrams section. Note the recommended test equipment, front-panel control settings, voltage and waveform conditions, and cable-connection instructions. Any special control settings required to obtain a given waveform are noted under the waveform illustration. Changes to the control settings from the initial setup, other than those noted, are not required.

9. Check Individual Components

WARNING

To avoid electric shock, always disconnect the instrument from the ac power source before removing or replacing components.

The following procedures describe methods of checking individual components. Two-lead components that are soldered in place are most accurately checked by first disconnecting one end from the circuit board. This isolates the measurement from the effects of the surrounding circuitry. See Figure 9-1 for component value identification and Figure 9-2 for semiconductor lead configurations.

CAUTION

When checking semiconductors, observe the static-sensitivity precautions located at the beginning of this section.

TRANSISTORS. A good check of a transistor is actual performance under operating conditions. A transistor can most effectively be checked by substituting a known-good component. 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-type transistor checker for testing. Static-type transistor checkers are not recommended, since they do not check operation under simulated operating conditions.

When troubleshooting transistors in the circuit with a voltmeter, measure both the emitter-to-base and emitter-to-collector voltages to determine whether they are consistent with normal circuit voltages. Voltages across a transistor may vary with the type of device and its circuit function.

Some of these voltages are predictable. The emitter-to-base voltage for a conducting silicon transistor will normally range from 0.6 V to 0.8 V. The emitter-to-collector voltage for a saturated transistor is about 0.2 V. Because these values are small, the best way to check them is by connecting a sensitive voltmeter across the junction rather than comparing two voltages taken with respect to ground. If the former method is used, both leads of the voltmeter must be isolated from ground.

If voltage values measured are less that those just given, either the device is shorted or no current is flowing in the external circuit. If values exceed the emitter-to-base values given, either the junction is reverse biased or the device is defective. Voltages exceeding those given for typical emitter-to-collector values could indicate either a nonsaturated device operating normally or a defective (open-circuited) transistor. If the device is conducting, voltage will be developed across the resistors in series with it; if open, no voltage will be developed across the resistors unless current is being supplied by a parallel path.

CAUTION

When checking emitter-to-base junctions, do not use an ohmmeter range that has a high internal current. High current may damage the transistor. Reverse biasing the emitter-to-base junction with a high current may degrade the current-transfer ratio (Beta) of the transistor.

A transistor emitter-to-base junction also can be checked for an open or shorted condition by measuring the resistance between terminals with an ohmmeter set to a range having a low internal source current, such as the R X 1-kΩ range. The junction resistance should be very high in one direction and much lower when the meter leads are reversed.

When troubleshooting a field-effect transistor (FET), the voltage across its elements can be checked in the same manner as previously described for other transistors. However, remember that in the normal depletion mode of operation, the gate-to-source junction is reverse biased; in the enhanced mode, the junction is forward biased.

INTEGRATED CIRCUITS. An integrated circuit (IC) can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of circuit operation is essential when troubleshooting a circuit having IC components. Use care when checking voltages and waveforms around the IC so that adjacent leads are not shorted together. An IC test clip provides a convenient means of clipping a test probe to an IC.

CAUTION

When checking a diode, do not use an ohmmeter scale that has a high internal current. High current may damage a diode. Checks on diodes can be performed in much the same manner as those on transistor emitter-to-base junctions. Do not check tunnel diodes or back diodes with an ohmmeter; use a dynamic tester, such as the TEKTRONIX 576 Curve Tracer.

DIODES. A diode can be checked for either an open or a shorted condition by measuring the resistance between terminals with an ohmmeter set to a range having a low internal source current, such as the R X

1-kΩ range. The diode resistance should be very high in one direction and much lower when the meter leads are reversed.

Silicon diodes should have 0.6 V to 0.8 V across their junctions when conducting; Schottky diodes about 0.2 V to 0.4 V. Higher readings indicate that they are either reverse biased or defective, depending on polarity.

RESISTORS. Check resistors with an ohmmeter. Refer to the Replaceable Electrical Parts list for the tolerances of resistors used in this instrument. A resistor normally does not require replacement unless its measured value varies widely from its specified value and tolerance.

INDUCTORS. Check for open inductors by checking continuity with an ohmmeter. Shorted or partially shorted inductors can usually be found by checking the waveform response when high-frequency signals are passed through the circuit.

CAPACITORS. A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter set to one of the highest ranges. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after the capacitor is charged to the output voltage of the ohmmeter. An open capacitor can be detected with a capacitance meter or by checking whether the capacitor passes ac signals.

10. Repair and Adjust the Circuit

If any defective parts are located, follow the replacement procedures given under Corrective Maintenance in this section. After any electrical component has been replaced, the performance of that circuit and any other closely related circuit should be checked. Since the power supplies affect all circuits, performance of the entire instrument should be checked if work has been done on the power supplies or if the power transformer has been replaced. Readjustment of the affected circuitry may be necessary. Refer to the Performance Check and Adjustment Procedure, Sections 4 and 5 of this manual and to Table 5-1, Adjustments affected by repairs.

CORRECTIVE MAINTENANCE

INTRODUCTION

Corrective maintenance consists of component replacement and instrument repair. This part of the manual describes special techniques and procedures required to replace components in this instrument. If it is necessary to ship your instrument to a Tektronix Service Center for repair or service, refer to the Repackaging information in Section 2 of this manual.

MAINTENANCE PRECAUTIONS

To reduce the possibility of personal injury or instrument damage, observe the following precautions.

1. Disconnect the instrument from the ac-power source before removing or installing components.
2. Verify that the line-rectifier filter capacitors are discharged prior to performing any servicing.
3. Use care not to interconnect instrument grounds which may be at different potentials (cross grounding).
4. When soldering on circuit boards or small insulated wires, use only a 15-watt, pencil-type soldering iron.

OBTAINING REPLACEMENT PARTS

Most electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can usually be obtained from a local commercial source. Before purchasing or ordering a part from a source other than Tektronix, Inc., please check the Replaceable Electrical Parts list for the proper value, rating, tolerance, 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 parts are used in the instrument. 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. The various manufacturers can be identified by referring to the Cross Index-Manufacturer's Code number to Manufacturer at the beginning of the Replaceable Electrical Parts list. Most of the mechanical parts used in this instrument were 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., be sure to include all of the following information:

1. Instrument type (include all modification and option numbers).
2. Instrument serial number.
3. A description of the part (if electrical, include its full circuit component number).
4. Tektronix part number.

Selectable Components

Several components in the instrument are selectable to obtain optimum circuit operation. Value selection of these components is done during the initial factory adjustment procedure. Usually, further selection is not necessary for subsequent adjustments unless a component has been changed that affects circuitry for which a selected component has been specifically chosen.

MAINTENANCE AIDS

The maintenance aids listed in Table 6-5 include items required for performing most of the maintenance procedures in this instrument. Equivalent products may be substituted for those given, provided their characteristics are similar.

INTERCONNECTIONS

Interconnections in this instrument are made with wire-trap connectors soldered onto the circuit boards. If any individual wire in the cable is faulty, the entire cable assembly should be replaced. To remove a cable from a wire-trap connector, press down on top of the connector and lift out cable. Reinstallation is the reverse of this procedure. To provide correct orientation of a cable, a number "1" is stamped on the circuit board. The cable is either color-coded, so the index is the brown wire, or the index wire is striped a different color than the rest of the cable. Be sure the index wire is aligned with the "1" when a cable is reinserted into the connector (see Figure 6-1, shown previously).

TRANSISTORS AND INTEGRATED CIRCUITS

Transistors and integrated circuits should not be replaced unless they are actually defective. If removed from their sockets or unsoldered from the circuit board during routine maintenance, return them to their original board locations. Unnecessary replacement or transposing of semiconductor devices may affect the adjustment of the instrument. When a semiconductor is replaced, check the performance of any circuit that may be affected.

Any replacement component should be of the original type or a direct replacement. Bend transistor leads to fit their circuit board holes, and cut the leads to the same length as the original component. See Figure 9-2 in the Diagrams section for lead-configuration illustrations.

Table 6-5
Maintenance Aids

Description	Specification	Usage	Example
1. Soldering Iron	15 to 25 W.	General soldering and unsoldering.	Antex Precision Model C.
2. Torx Screwdriver	Torx tips #T9 and #T15.	Assembly and disassembly.	Tektronix p/n #T9 003-0965-00 #T15 003-0966-00
3. Nutdrivers	1/4 inch, 7/16 inch, and 1/2 inch.	Assembly and disassembly.	Xcelite #8, #14 and #16.
4. Open-end Wrench	5/16 inch and 1/2 inch.	Channel Input, EXT BNC connectors and Transformer.	
5. Hex Wrenches	1/16 inch.	Assembly and disassembly.	Allen wrenches.
6. Long-nose Pliers		Component removal and replacement.	
7. Diagonal Cutters		Component removal and replacement.	
8. Vacuum Solder Extractor.	No Static Charge Retention.	Unsoldering components.	Pace Model PC-10.
9. 1X Probe		Power supply ripple check.	Tektronix P6101 Probe (X1), p/n 010-6101-03.
10. Lubricant	No-Noise.®	Switch lubrication.	Tektronix p/n 006-0442-02.

Power-supply transistor Q913 is insulated from the chassis by a heat-transferring pad and insulation bushing. Reinstall the pad and bushing when replacing this transistor.

NOTE

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

To remove socketed, dual-in-line-packaged (DIP) integrated circuits, pull slowly and evenly on both ends of the device. Avoid disengaging one end of the integrated circuit from the socket before the other, since this may damage the pins.

To remove a soldered DIP IC when it is going to be replaced, clip all the leads of the device and remove the leads from the circuit board one at a time. If the device must be removed intact for possible reinstallation, do not heat adjacent conductors consecutively. Apply heat to pins at alternate sides and ends of the IC as solder is removed. Allow a moment for the circuit board to cool before proceeding to the next pin.

SOLDERING TECHNIQUES

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used to remove or replace parts. General soldering techniques, which apply to maintenance of any precision electronic equipment, should be used when working on this instrument.

WARNING

To avoid an electric-shock hazard, observe the following precautions before attempting any soldering: turn the instrument off, disconnect it from the ac power source, and wait at least three minutes for the line-rectifier filter capacitors to discharge.

Use rosin-core wire solder containing 63% tin and 37% lead. Contact your local Tektronix Field Office or representative to obtain the names of approved solder types.

When soldering on circuit boards or small insulated wires, use only a 15-watt, pencil-type soldering iron. A higher wattage soldering iron may cause etched-circuit conductors to separate from the board base material and melt the insulation on small wires. Always keep the soldering-iron tip properly tinned to ensure best heat transfer from the iron tip to the solder joint. Apply only enough solder to make a firm joint. After soldering, clean the area around the solder connection with an approved flux-removing solvent (such as isopropyl alcohol) and allow it to air dry.

CAUTION

Attempts to unsolder, remove, and resolder leads from the component side of a circuit board may cause damage to the reverse side of the circuit board.

The following techniques should be used to replace a component on a circuit board:

1. Touch the vacuum desoldering tool to the lead at the solder connection. Never place the iron directly on the board; doing so may damage the board.

NOTE

Some components are difficult to remove from the circuit board due to a bend placed in the component leads during machine insertion. To make removal of machine-inserted components easier, straighten the component leads on the reverse side of the circuit board.

2. When removing a multipin component, especially an IC, do not heat adjacent pins consecutively. Apply heat to the pins at alternate sides and ends of the IC as solder is removed. Allow a moment for the circuit board to cool before proceeding to the next pin.

CAUTION

Excessive heat can cause the etched-circuit conductors to separate from the circuit board. Never allow the solder extractor tip to remain at one place on the board for more than three seconds. Damage caused by poor soldering techniques can void the instrument warranty.

3. Bend the leads of the replacement component to fit the holes in the circuit board. If the component is replaced while the board is installed in the instrument, cut the leads so they protrude only a small amount through the reverse side of the circuit board. Excess lead length may cause shorting to other conductive parts.

4. Insert the leads into the holes of the board so that the replacement component is positioned the same as the original component. Most components should be firmly seated against the circuit board.

5. Touch the soldering iron to the connection and apply enough solder to make a firm solder joint. Do not move the component while the solder hardens.

6. Cut off any excess lead protruding through the circuit board (if not clipped to the correct length in step 3).

7. Clean the area around the solder connection with an approved flux-removing solvent. Be careful not to remove any of the printed information from the circuit board.

REMOVAL AND REPLACEMENT INSTRUCTIONS

The exploded view drawings in the Replaceable Mechanical Parts list (Section 10) may be helpful during the removal and reinstallation of individual subassemblies or components. Circuit board and component locations are shown in the Diagrams section.

Cabinet

WARNING

To avoid electric shock, disconnect the instrument from the ac-power-input source before removing or replacing any component or assembly.

To remove the instrument cabinet, perform the following steps:

1. Disconnect the power cord from the instrument. For instruments with a power-cord securing clamp, remove the Phillips-head screw holding the power-cord securing clamp before disconnecting the power cord.

2. Remove two screws from the rear panel (located on each side) and remove it from the instrument.

3. Remove four screws, one from the left-rear side and three from the right-rear side of the cabinet.

4. Pull the front panel and attached chassis forward and out of the cabinet.

5. To reinstall the cabinet, perform the reverse of the preceding steps. Ensure that the cabinet is flush with the rear of the chassis and that the cabinet and rear-panel holes are aligned with the screw holes in the chassis frame.

6. Reconnect the power cord.

Cathode-Ray Tube

WARNING

Use care when handling a crt. Breakage of the crt may cause high-velocity scattering of glass fragments (implosion). Protective clothing and safety glasses should be worn. Avoid striking the crt on any object which may cause it to crack or implode. When storing a crt, either 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.

The crt can be removed and reinstalled as follows:

1. Unsolder the Trace Rotation wires (J987) from the Front-Panel circuit board (note the connection locations and wire colors for reinstallation reference).

WARNING

The crt anode lead and the High-Voltage Multiplier output lead retain a high-voltage charge after the instrument is turned off. To avoid electrical shock, disconnect the High-Voltage Multiplier lead from the crt anode lead and ground both leads to the main instrument chassis.

2. Unplug the crt anode lead connector from the High-Voltage Multiplier lead located on the inner chassis. Discharge both the anode lead connector and the High-Voltage Multiplier lead to chassis ground.

3. Remove two front-panel screws that retain the plastic crt frame and light filter to the front panel. Remove the crt frame and light filter from the instrument.

4. Remove the grounding spring from between the top of the crt funnel and front chassis.

5. Remove the crt socket cap from the rear of the crt socket. Save the cap for reinstallation.

6. With the rear of the instrument facing you, place the fingers of both hands over the front edge of the front subpanel. Then, using both thumbs, press forward gently on the crt funnel near the front of the crt. When the crt base pins disengage from the socket, remove the crt and the crt shield through the instrument front panel. Place the crt in a safe place until it is reinstalled. If the plastic crt corner pads fall out, save them for reinstallation.

NOTE

When installing the crt into the instrument, reinstall any loose plastic crt corner pads that are out of place. Ensure all crt pins are straight and that the indexing keys on the crt base, socket, and shield are aligned. Ensure that the ground clip makes contact only with the outside of the crt shield.

To reinstall the crt, perform the reverse of the preceding steps.

Power Transformer

The Power Transformer (T901) can be removed and reinstalled as follows:

1. Disconnect connector J902 from the Line Filter board. (The J902 connector is not polarized so can be fitted either way). Note the orientation of the connector for proper reinstallation.

2. Note the physical orientation of the Power Transformer. Undo the two locking nuts from the center of the Power Transformer.

3. Supporting the Transformer, withdraw the center bolt (complete with the rear stiffening plate).

To reinstall the Power Transformer, perform the reverse of the preceding steps.

Mains Input Circuit Board

The Mains Input circuit board can be removed and reinstalled as follows:

1. Disconnect connector J902 from the Mains Input board. (The J902 connector is not polarized so can be fitted either way. Note the orientation for correct reinstallation.)

2. Unsolder W903 from Mains Input board.

3. Disengage the Power switch extension shaft from the Mains Power switch (S901).

4. Remove the two screws and nuts that secure the AC Power inlet connector to the rear chassis.

5. Remove the grounding screw and nut that secures the Mains Input board to the inner chassis.

6. Pull the Mains Input board towards the inner chassis and up out of the instrument.

To reinstall the Mains Input board, perform the reverse of the preceding steps.

Attenuator/Timebase Circuit Board

The Attenuator/Timebase circuit board can be removed and reinstalled as follows:

1. Turn the instrument over (Main circuit board up) and unsolder the two resistors from the CH 1 and CH 2 attenuator switches. Also unsolder the grounding straps connected between the Front Panel and the Attenuator/Timebase boards, noting their respective positions. Turn the instrument over again and continue with the Attenuator/Timebase circuit board procedure.

2. Use a 1/16-inch hex wrench to loosen the set screws on both the CH 1 and CH 2 VOLTS/DIV Variable knobs, and SEC/DIV Variable knob. Remove the knobs. Withdraw the CH 1 and CH 2 VOLTS/DIV knobs and SEC/DIV knob.

3. Remove the two rear screws that secure the Attenuator/Timebase board to the support pillars.

4. Remove the screw that secures the Front Panel brace to the Attenuator/Timebase board. Turn the instrument over (Main circuit board up) and remove the screw that secures the Front Panel brace pillar to the Attenuator/Timebase board.

5. Remove the Focus knob shaft by disengaging it from the Focus pot and pulling the shaft out through the front panel.

6. Disconnect the following cables from the Attenuator/Timebase circuit board, noting their locations for reinstallation reference:

   a. J90, a six-wire cable located at the rear edge of the board.

   b. J755, a four-wire cable located at the rear right-hand corner of the board.

   c. J30, a four-wire cable located to the left of the CH 1 attenuator switch.

   d. J80, a four-wire cable located between the CH 1 and CH 2 attenuator switches.

   e. J7, a six-wire cable located between the CH 2 attenuator switch and the SEC/DIV switch.

   f. J701, a six-wire cable located at the front right-hand corner of the board.

7. Pull the Attenuator/Timebase circuit board straight back from the front of the instrument until the attenuator switches are clear of the Front-Panel circuit board. Then lift out the entire assembly through the top of the instrument.

To reinstall the Attenuator/Timebase circuit board, perform the reverse of the preceding steps.

The Bottom Shield of the Attenuator/Timebase circuit board assembly can be removed by removing the two screws and nuts located at the front edge of the board.

Front-Panel Circuit Board

The Front-Panel circuit board can be removed and reinstalled as follows:

1. Perform the Attenuator/Timebase Circuit Board Assembly removal procedure.

2. Remove the knobs from the following control shafts by pulling them straight out from the front panel:

   a. INTENSITY.

   b. Channel 1 and Channel 2 POSITION.

   c. TRACE SEP.

   d. COARSE and FINE Horizontal POSITION controls.

   e. LEVEL.

   f. HOLDOFF.

3. Unsolder both the resistor (R382) to the EXT INPUT center connector and the wire strap to the EXT INPUT OR Z ground lug.

4. Unsolder the resistors and wire straps to the CH 1 OR X and CH 2 OR Y input connectors.

5. Unsolder the Trace Rotation wires (J987) from the Front-Panel circuit board (note the connection locations and wire colors for reinstallation reference).

6. Remove the Power Switch extension shaft by disengaging from power switch and pulling it out through the Front Panel.

7. Disconnect the following cables from the Front Panel board to the front edge of the Main circuit board: J1, J2, J3, J4, J5, and J6.

8. Remove the five screws that secure the Front Panel board to the front chassis, noting their respective positions.

9. Withdraw the Front Panel circuit board from the front chassis taking care not to lose the slider switch covers.

To reinstall the Front-Panel circuit board, perform the reverse of the preceding steps.

Main Circuit Board

All components on the Main circuit board are accessible either directly or by removing either the crt, Power Transformer or the Attenuator/Timebase circuit board assembly. Removal of the Main circuit board is required only when it is necessary to replace the circuit board with a new one.

The Main circuit board can be removed and re-installed as follows:

WARNING

The crt anode lead and the output terminal to the High-Voltage Multiplier will retain a high-voltage charge after the instrument is turned off. To avoid electrical shock, ground the crt side of the anode lead to the main instrument chassis.

1. Remove the crt. Disengage the HV Multiplier connector from the clip located on the inner chassis.

2. Unsolder W893 from the Main board. The cable is connected to the Focus pot located on the rear of the inner chassis.

3. Unsolder W903 from the rear of the Mains Input board.

4. Disengage the following cables from their respective wire-trap connectors located on the Attenuator/Timebase board:

   a. J755, four-wire cable located at rear right corner of board.

   b. J90, six-wire cable located at center rear edge of board.

c. J30, four-wire cable located at the left hand side of the CH 1 attenuator switch.

d. J80, four-wire cable located between the CH 1 and CH 2 attenuator switches.

e. J701, six-wire cable located at front right corner of board.

5. Turn instrument upside down (bottom of Main board facing up) with the rear of the instrument facing you.

6. Remove the two screws that secure the heat-sink for the vertical output transistors (Q256 and Q257) to the rear chassis.

7. Remove the screw that secures the heatsink for the power supply transistors (Q950, Q980, Q923 and Q913) to the rear chassis.

8. Unsolder both ends of the Delay Line (DL224) from the Main board, noting correct polarization for refitting. Remove the two cable clips from Main board.

9. With the instrument still upside down, rotate it so that the front is facing you. Unsolder the wire connected to the Probe Adjust terminal from the Main board.

10. Disconnect the following cables from their respective wire-trap connectors located along the front edge of the Main board:. J1, J2, J3, J4, J5, and J6.

11. Remove the two screws that secure the inner chassis to the center of the Main board.

12. Remove the three screws that secure the Main board to the pillars of the Attenuator/Timebase assembly.

13. Remove the two screws and nuts that secure the Main board to the left hand chassis member.

14. Remove the three screws and nuts that secure the Main board to the right hand chassis member.

15. Lift out Main board from chassis, carefully with-drawing the Multiplier connector through the hole in the inner chassis.

To reinstall the Main circuit board, perform the reverse of the preceding steps. When installing the Main circuit board, ensure that the circuit board is in the guides at the rear of the chassis.