2211 Oscilloscope

OPERATORS MANUAL

Please Check for
CHANGE INFORMATION
at the Rear of This Manual

First Printing DECEMBER 1988
Revised FEB 1989
Revised NOV 1989

Printed in Hong Kong. Specification and price change privileges are reserved.

INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first two digits designate the country of manufacture. The last five digits of the serial number are unique to each instrument. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, U.S.A.
E200000	Tektronix United Kingdom, Ltd., Marlow
G100000	Tektronix Guernsey, Ltd., Channel Islands
HK00000	Hong Kong
H700000	Tektronix Holland, NV, Heerenveen, The Netherlands
J300000	Sony/Tektronix, Japan

Certificate of the Manufacturer/Importer

We hereby certify that the 2211 Oscilloscope
AND ALL INSTALLED OPTIONS
complies with the RF Interference Suppression requirements of Amtsbl.-Vfg 1046/1984.

The German Postal Service was notified that the equipment is being marketed.

The German Postal Service has the right to re-test the series and to verify that it complies.

TEKTRONIX

Bescheinigung des Herstellers/Importeurs

Hiermit wird bescheinigt, daß der/die/das 2211 Oscilloscope
AND ALL INSTALLED OPTIONS
in Übereinstimmung mit den Bestimmungen der Amtsblatt-Verfügung 1046/1984 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhalten der Bestimmungen eingeräumt.

TEKTRONIX

NOTICE to the user/operator:

The German Postal Service requires that Systems assembled by the operator/user of this instrument must also comply with Postal Regulation, Vfg. 1046/1984, Par. 2, Sect. 1.

HINWEIS für den Benutzer/Betreiber:

Die vom Betreiber zusammengestellte Anlage, innerhalb derer dies Gerät eingesetzt wird, muß ebenfalls den Voraussetzungen nach Par. 2, Ziff. 1 der Vfg. 1046/1984 genugen.

TABLE OF CONTENTS

SECTION 4 OPERATING CONSIDERATIONS

SECTION 5 OPERATOR'S CHECKS AND ADJUSTMENTS

SECTION 6 BASIC APPLICATIONS

SECTION 7 OPTIONS AND ACCESSORIES

SECTION 8 PERFORMANCE CHARACTERISTICS

APPENDIX A

APPENDIX B

MANUAL CHANGE INFORMATION

LIST OF ILLUSTRATIONS

LIST OF TABLES

OPERATORS SAFETY SUMMARY

The safety information in this summary is for operating personnel. Warnings and cautions will also be found throughout the manual where they apply.

Terms in this Manual

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

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

Terms as Marked on Equipment

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

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

Symbols in this Manual

This symbol indicates where applicable cautionary or other information is to be found. For maximum input voltage see Table 8-1.

Symbols as Marked on Equipment

DANGER – High voltage.

Protective ground (earth) terminal.

ATTENTION – Refer to manual.

Power Source

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

Grounding the Product

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

Danger Arising From Loss of Ground

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

Use the Proper Power Cord

Use only the power cord and connector specified for your product.

The power cord must be in good condition.

For detailed information on power cords and connectors see Figure 2–2 .

Use the Proper Fuse

To avoid fire hazard, use only a fuse of the correct type, voltage rating and current rating as specified on the back of your product.

Do Not Operate in an Explosive Atmosphere

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

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

SECTION 1

GENERAL INFORMATION

GENERAL INFORMATION

INTRODUCTION

The TEKTRONIX 2211 is a combination analog and digital storage portable oscilloscope. It has dual vertical input channels with an analog bandwidth of DC-to-50 MHz and a digital bandwidth of DC-to-1 MHz, and a CRT readout and cursor measurement display.

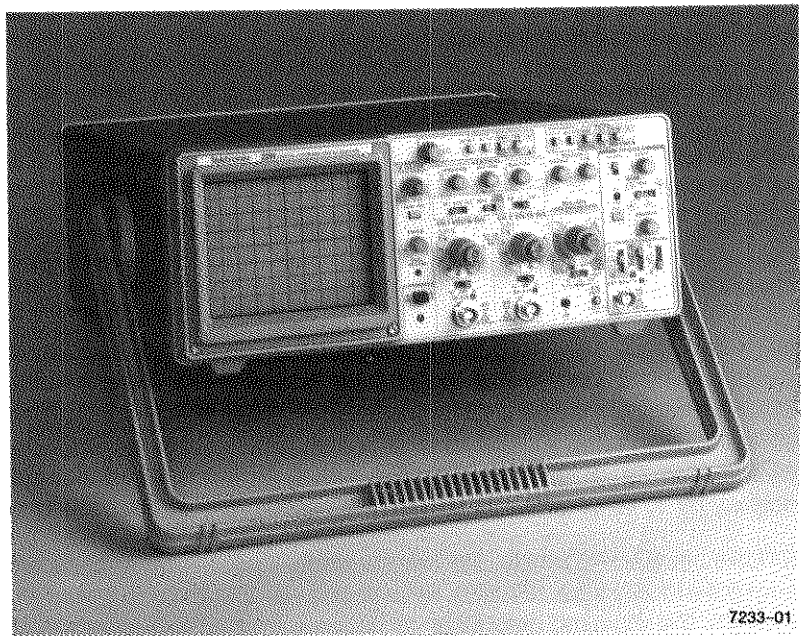


Figure 1-1. The 2211 Oscilloscope.

Vertical

The vertical channels have calibrated deflection factors from 5 mV to 5 V per division at full bandwidth. A vertical magnification feature on

each vertical channel extends the maximum sensitivity of the magnified channel to 500 μV per division. Vertical magnification also reduces the bandwidth to 5MHz and may be used as a bandwidth limiter affecting only the magnified channel. The Variable VOLTS/DIV gain control increases the vertical deflection factor up to 2.5 times the VOLTS/DIV switch setting.

NON-STORE. Vertical channel display modes are CH 1, CH 2, and BOTH. BOTH permits the added choices of ADD, ALT or CHOP display of the two channels. ALT display switches between traces at the end of each sweep, showing each waveform alternately; CHOP switches between the two input signals as the sweep is occurring to display both simultaneously on the crt. ADD algebraically sums the CH 1 and CH 2 input signals.

STORE. The vertical channel display modes are again CH 1, CH 2, and BOTH. With BOTH Vertical MODE, CH 1 and CH 2 are digitized simultaneously. The only exception to this is if the Vertical MODE is ALT and the Trigger MODE is VERT MODE; then, CH 1 and CH 2 are digitized alternately. ADD also functions in STORE mode.

Horizontal

NON-STORE. The horizontal deflection system has calibrated sweep speeds from 0.5 s to 0.05 μs per division. The Variable SEC/DIV control may be used to increase the sweep time per division up to 2.5 times the calibrated time per division set by the SEC/DIV switch. The X1, X10, X50 Magnifier switch expands the horizontal display by 1, 10 or 50 times around the center vertical graticule line.

STORE. In STORE mode, the normal calibrated sweep speeds are from 0.5 s to 20 μs per division. At sweep speeds of 20 μs to 50 ms per division, the digitized display is updated as a full RECORD where all the waveform data points are refreshed at the end of an acquisition period. At STORE mode sweep speeds of 0.1 s to 0.5 s, the display is updated in ROLL mode. In ROLL mode, the waveform is continuously digitized without regard to a trigger signal (except in triggered single-sweep mode). New data points are displayed by shifting the old waveform left to make room for the new data points as they occur. In single-sweep mode with a trigger signal, one RECORD of waveform

data is digitized, then the acquisition stops. If the single-sweep is untriggered, the acquisition continues. At sweep speeds of 10 ms per division and slower, the 100X SEC/DIV multiplier can be enabled by removing the Variable SEC/DIV control from the CAL position. This extends the calibrated sweep speeds over the range of 1 s to 50 s.

Storage Sampling

The maximum sampling rate (digitizing speed) is 20 megasamples per second. A waveform record has 4096 data points (4 Kbytes) per channel for single-channel and dual-channel acquisitions. Waveform acquisition is the digitizing and storing of digital values that represent the analog waveform applied to the vertical input. The complete 4K waveform record is displayed on screen with 400 points per division resolution.

One waveform set (either channel or both) may be stored in the 8K reference memory. When storing new waveform data into the reference memory, previous data is overwritten. The stored reference waveforms may be recalled for analysis or comparison with a newly acquired waveform. The X1, X10, X50 MAG switch functions on the stored reference-waveform displays, and they may be expanded horizontally 10 or 50 times. The REFERENCE POSITION control may be used to reposition the reference waveform display upward from the position at which it was acquired.

Cursor Readout Display

The cursor readout display reports the setting of the CH 1 and CH 2 VOLTS/DIV switches, the SEC/DIV switch, the Voltage and Time cursor separation, the Trigger Level and position of the Trigger COUPLING switch, and the AC position of the AC-GND-DC switch to the user. Parametric information for the waveform display is therefore visible when oscilloscope photography is used to maintain a permanent record of a display of interest. An additional readout area is reserved for STORE mode SAVE/CONTINUE and ROLL mode status.

On the displayed waveforms voltage or time measurements may be made using cursors. The cursors should be positioned on the desired

measurement points, e.g. on the waveform peaks for a peak-to-peak measurement. The ΔV, Δt or 1/Δt crt readouts indicate the voltage difference, timing difference or reciprocal time-difference respectively, between the positions of the cursors.

ACCESSORIES

The instrument is shipped with the following accessories – operators manual, user reference guide, two probe kits, a power cord, and a power-cord clamp. Part numbers for these standard accessories, as well as for other optional accessories, are found in Section 7, Options and Accessories. The probes are built with a sturdy tip that is also replaceable. Compensation is accomplished through a closeable window on the probe body.

FOR MORE INFORMATION

Should you need additional information about your 2211 Oscilloscope or about other Tektronix products:contact the nearest Tektronix Sales Office or Distributor, consult the Tektronix product catalog. In the United States, you may call the Tektronix National Marketing Center, toll free at 1-800-426-2200.

PERFORMANCE CHARACTERISTICS

Performance characteristics for the 2211 Oscilloscope are given in tabular form in Section 8 of this manual. The tables list specifications for the instrument's electrical characteristics, its environmental operating limits, and the physical dimensions and weight of the instrument.

SECTION 2

PREPARATION FOR USE

PREPARATION FOR USE

SAFETY

This section tells how to prepare for and to proceed with the initial start-up of the Tektronix 2211 Oscilloscope.

Refer to the Safety Summary at the front of this manual for power source, grounding, and other safety considerations pertaining to the use of the instrument. Before connecting the oscilloscope to the power source, read both this section and the Operator's Safety Summary at the beginning of this manual.

CAUTION

This instrument may be damaged if operated with the LINE VOLTAGE SELECTOR switch (on the rear panel) set for the wrong applied ac source voltage or if the wrong fuse is installed.

LINE VOLTAGE SELECTION

The oscilloscope operates from either a 115-V or a 230-V nominal ac-power line with any frequency from 48 Hz to 440 Hz. Before connecting the power cord to a power source, verify that the LINE VOLTAGE SELECTOR switch, located on the rear panel, is set correctly and that the proper line fuse is installed. Refer to Figure 2-1 and the instrument rear panel.

To convert the 2211 for operation on either line voltage range, set the LINE VOLTAGE SELECTOR switch to the required position and install the appropriate fuse (listed on the rear panel). The detachable power cord sent with the 2211 is the optional power cord ordered. If it does not match the power-source outlets in your locale, it should be replaced with an appropriate power cord. Part numbers for the optional power cords and matching fuses are listed in Options and Accessories (Section 7).

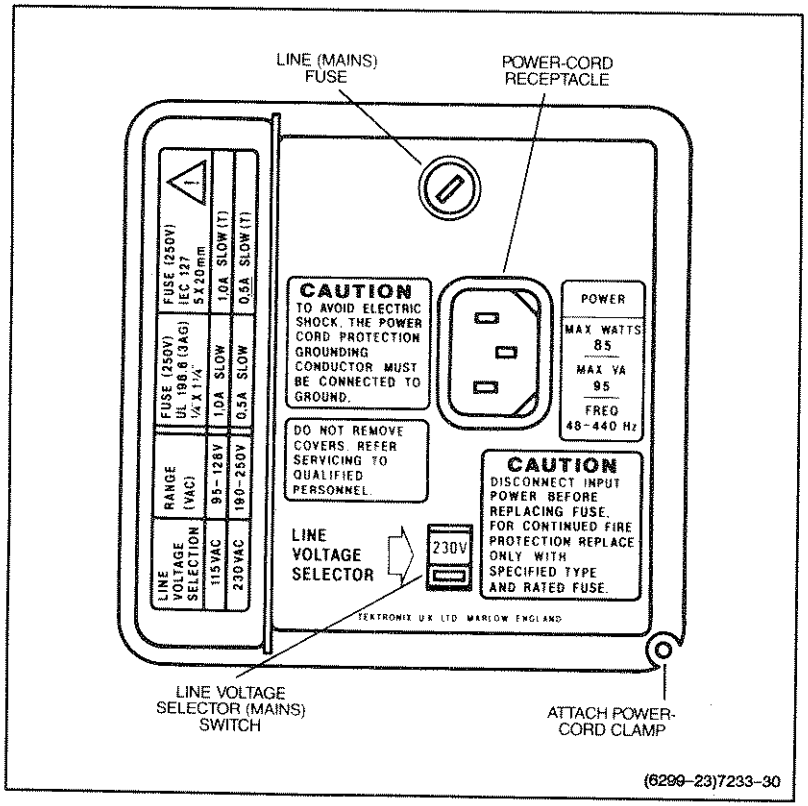


Figure 2–1. Voltage Selector switch, fuse, and power-cord receptacle.

LINE FUSE

A fuse holder containing the instrument's line (mains) fuse is located on the rear panel. Use the following procedure to check that the proper fuse is installed or to install a replacement fuse.

1. Unplug the power cord from the power-input source (if plugged in).

2. Press in the fuse-holder cap and release it with a slight counter-clockwise rotation.

3. Pull the cap (with the attached fuse inside) out of the fuse holder.

4. Verify that the installed fuse is the same type and rating as that listed on the back of the instrument.

NOTE

The UL198.6 and IEC 127 type fuses are not directly interchangeable; they each require a different type fuse cap.

5. Put the fuse (or replacement fuse) back in the fuse holder cap.

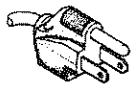
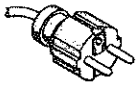
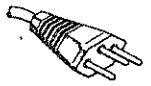
6. Reinstall the fuse and cap in the fuse holder by pressing in and giving a slight clockwise rotation of the cap.

POWER CORD

A detachable three-wire power cord with a three-contact plug is provided with each instrument for connecting to both the power source and protective ground. The protective-ground connector in the plug connects (through the protective-ground conductor)to the accessible metal parts of the instrument. For electrical-shock protection, insert this plug only into a power-source outlet that has a properly grounded protective-ground contact.

After plugging the power cord into its receptacle, secure it to the rear panel using the plastic clamp, screw, and washer provided.

Instruments are shipped with the power cord ordered by the customer. Available power-cord information is presented in Figure 2-2, and part numbers are listed in Options and Accessories (Section 7). Contact your Tektronix representative or local Tektronix Field Office for additional power-cord information.

Plug Configuration	Option	Power Cord/ Plug Type	Line Voltage	Reference Standards [b]
	U.S. Std.	U.S. 120V	120V	ANSI C73.11 NEMA 5-15-P IEC 83 UL 198.6
	A1	EURO 220V	220V	CEE(7), II, IV, VII IEC 83 IEC 127
	A2	UK [a] 240V	240V	BS 1363 IEC 83 IEC 127
	A3	Australian 240V	240V	AS C112 IEC 127
	A4	North American 240V	240V	ANSI C73.20 NEMA 6-15-P IEC 83 UL 198.6
	A5	Switzerland 220V	220V	SEV IEC 127

[a] A 6A, type C fuse is also installed inside the plug of the Option A2 power cord.

[b] Reference Standards Abbreviations:

ANSI—American National Standards Institute
AS—Standards Association of Australia
BS—British Standards Institution
CEE—International Commission on Rules for the Approval of Electrical Equipment
IEC—International Electrotechnical Commission
NEMA—National Electrical Manufacturer's Association
SEV—Schweizervischer Elektrotechnischer Verein
UL—Underwriters Laboratories Inc.

7233-02

Figure 2-2. Optional power cords.

INSTRUMENT COOLING

The 2211 is force-air cooled to keep the internal components from overheating. Check that the fan-exhaust holes on the side panel and the air-intake holes on the sides and rear panel are not blocked before turning it on. After turning on the instrument, make sure that the fan is running.

INITIAL START-UP

Up to now, you should have made the following preparations:

1. Read the safety information.
2. Verified that the LINE VOLTAGE SELECTOR switch is set for the source voltage to be used.
3. Verified the fuse.
4. Attached the power cord.
5. Checked that there is adequate ventilation around the instrument.
6. Plugged the power cord into the appropriate power-source outlet.

Now turn on your oscilloscope by pressing in the POWER button. Observe that the POWER-ON indicator, located below the button, comes on.

REPACKAGING FOR SHIPMENT

If this instrument is shipped by commercial transportation, use the original packaging material. Unpack the instrument carefully from the shipping container to save the carton and packaging material for this purpose.

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

1. Obtain a corrugated cardboard shipping carton having inside dimensions at least six inches greater than the instrument dimensions and having a carton test strength of at least 275 pounds.

2. If the instrument is being shipped to a Tektronix Service Center for repair or calibration, attach a tag to the instrument showing the following:owner of the instrument (with address), the name of a person at your firm who may be contacted if additional information is needed, complete instrument type and serial number, and a description of the service required.

3. Wrap the instrument with polyethylene sheeting or equivalent to protect the outside finish and prevent entry of packing materials into the instrument.

4. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument, allowing for three inches of padding on each side (including top and bottom).

5. Seal the carton with shipping tape or with an industrial stapler.

6. Mark the address of the Tektronix Service Center and your return address on the carton in one or more prominent locations.

SECTION 3

CONTROLS, CONNECTORS AND INDICATORS

CONTROLS, CONNECTORS, AND INDICATORS

The following descriptions are intended to familiarize the operator with the location and function of the instrument's controls, connectors, and indicators.

POWER AND DISPLAY

See Figure 3–1 for location of items 1 through 8.

(1) **INTERNAL GRATICULE**—Eliminates parallax viewing errors between the trace and the graticule lines. Rise time amplitude and measurement points are indicated at the left edge of the graticule.

(2) **INTENSITY Control**—Adjusts the brightness of the NON–STORE trace display.

(3) **READOUT/STORE INTENSITY Control**—Adjusts the brightness of the STORE mode traces, CRT readout and cursor displays. This control is also used to either enable or disable the CRT readout and cursor display. The fully counterclockwise position of the control toggles the readout on and off.

(4) **BEAM FIND Switch**—Compresses the vertical and horizontal deflection to within the graticule area. The traces are intensified to aid the user in locating traces that are overscanned or deflected outside of the crt viewing area.

(5) **FOCUS Control**—Adjusts for optimum display definition. Once set, proper focusing is maintained over a wide range of display intensity.

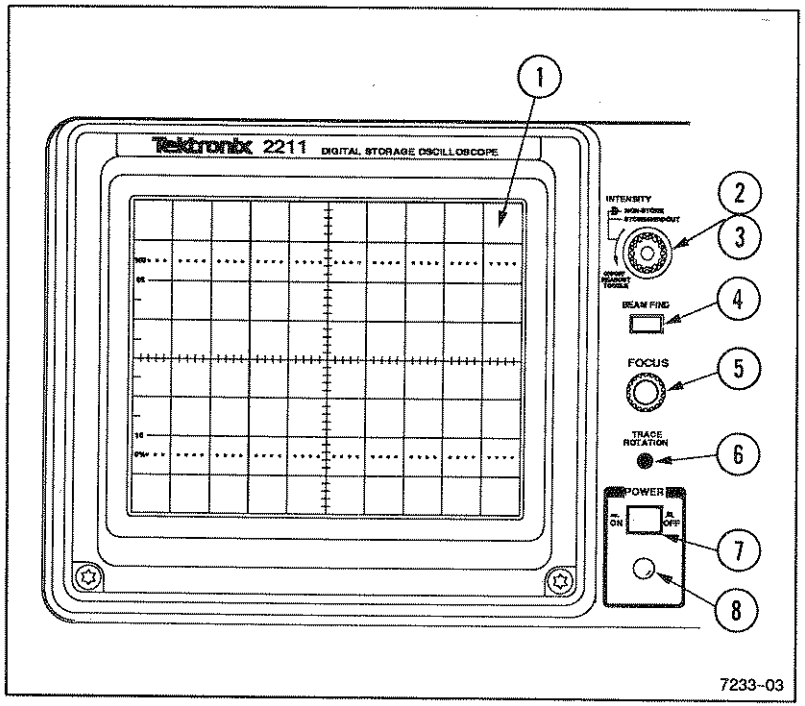


Figure 3–1. Power and Display controls and power-on indicator.

(6) **TRACE ROTATION Control**—Permits alignment of the trace with the horizontal graticule lines. This control is a screwdriver adjustment that, once set, should require little attention during normal operation.

(7) **POWER Switch**—Turns instrument power on or off.

(8) **Power On Indicator**—Lights up while the instrument is operating.

VERTICAL

See Figure 3–2 for the location of items 9 through 17.

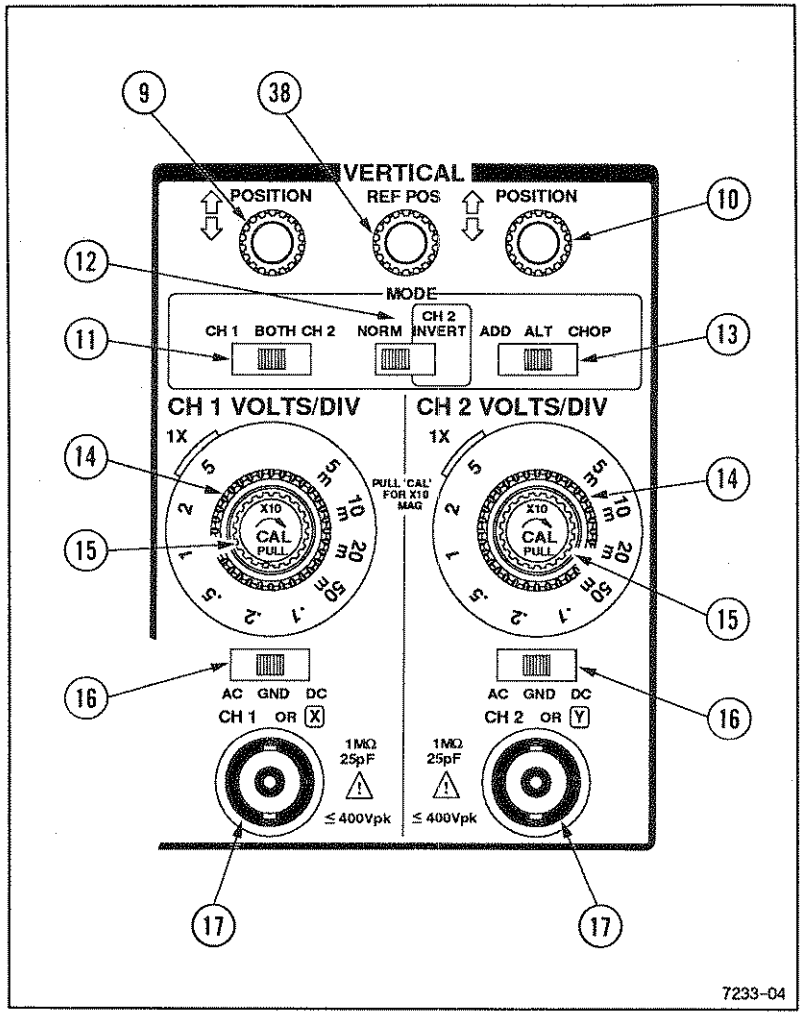


Figure 3–2. Vertical controls and connectors.

(9) **Channel 1 Vertical POSITION Control**—Controls the vertical display position of the Channel 1 signal. This control does not function in the NON-STORE, X-Y mode.

(10) **Channel 2 Vertical POSITION Control**—Controls the vertical display position of the Channel 2 signal. This control also positions the NON-STORE, X-Y mode display vertically.

(11) **CH 1-BOTH-CH 2 Vertical Mode Switch**—Selects the vertical channel(s) for display in both NON-STORE and STORE.

CH 1—Selects only the Channel 1 input signal for display.

BOTH—Selects a combination of Channel 1 and Channel 2 signals for display (CH 1-BOTH-CH 2 switch must be in the BOTH position for ADD, ALT and CHOP operation).

CH 2—Selects only the Channel 2 input signal for display.

(12) **NORM/CH 2 INVERT Switch**—Inverts the Channel 2 display when in the CH 2 INVERT position. With Channel 2 inverted, the oscilloscope may be operated as a differential amplifier when the BOTH-ADD Vertical Mode is selected. In NORM, the Channel 2 display and trigger signals are non-inverted. An invert symbol (↓) is displayed with the CH 2 VOLTS/DIV readout when CH 2 is inverted.

(13) **ADD-ALT-CHOP Vertical Mode Switch**—Selects the display mode for the two input signals when the CH 1-BOTH-CH 2 switch is set to BOTH.

ADD—Displays the sum of Channel 1 and Channel 2 input signals when BOTH is also selected. The difference of the Channel 1 and Channel 2 input signals is displayed when the Channel 2 signal is inverted. In STORE mode ADD, the sum of CH 1 and CH 2 is acquired by Channel 1.

ALT – Alternately displays the NON-STORE Channel 1 and Channel 2 input signals. Switching between channels occurs during retrace at the end of each sweep. ALT Vertical Mode is most useful for viewing both channel input signals at sweep rates of 0.5 ms per division or faster.

CHOP – Switches the display between Channel 1 and Channel 2 vertical input signals during the sweep. The chopped switching rate (CHOP frequency) is approximately 500 kHz.

In STORE mode both signals are acquired simultaneously. There is no functional difference between ALT and CHOP except when VERT MODE trigger is selected. When VERT MODE trigger is selected, each channel is acquired alternately.

(14) **VOLTS/DIV Switches** – Select the vertical channel deflection factors from 5 mV to 5 V per division in a 1-2-5 sequence. The VOLTS/DIV switch setting for both channels is displayed in the crt readout.

1X PROBE – Front-panel marking that indicates the deflection factor set by the VOLTS/DIV switch when a 1X probe or a coaxial cable is attached to the channel input connector.

(15) **Variable VOLTS/DIV Controls** – Provide uncalibrated variable deflection factors between the calibrated settings of the VOLTS/DIV controls. The VOLTS/DIV sensitivity is reduced by at least 2.5 times at the fully counterclockwise rotation of the variable knob. The switch detent at full clockwise rotation is the CAL position of the variable knob. The uncalibrated condition is indicated by a greater-than symbol (>) in front of the affected VOLTS/DIV readout.

Pulling the Variable VOLTS/DIV control multiplies the vertical gain by X10 and limits the bandwidth. This latter condition is indicated in the readout display by the letters B_L.

(16) **AC-GND-DC (Input Coupling) Switches**—Select the method of coupling the input signal from the CH 1 and CH 2 vertical input connectors to the vertical amplifiers.

AC—Capacitively couples the input signal to the vertical amplifier. The dc component of the input signal is blocked. The lower -3 dB bandpass is 10 Hz or less. Selection of AC input coupling is indicated in the readout by a tilde symbol (~) in the associated channel's VOLTS/DIV readout.

GND—Grounds the input of the vertical amplifier, providing a zero (ground) reference voltage display. In GND, the input coupling capacitor charges to the average dc voltage level of the amplifier's input signal.

DC—All frequency components of the input signal are coupled to the vertical amplifiers.

(17) **CH 1 OR X and CH 2 OR Y Input Connectors**—Provide for application of the signals to the inputs of the vertical amplifiers.

In NON-STORE X-Y mode, the signal applied to the CH 1 OR X input connector controls the horizontal deflection, and the signal applied to the CH 2 OR Y input connector controls the vertical deflection.

HORIZONTAL

See Figure 3-3 for the location of items 18 through 23.

(18) **Horizontal POSITION Controls**—Position all the waveforms horizontally over a one-sweep-length range in X1, X10 or X50 Magnification. In STORE mode, with Δt cursors selected, operation of the Horizontal POSITION controls also moves the cursors as they are attached to the waveform(s).

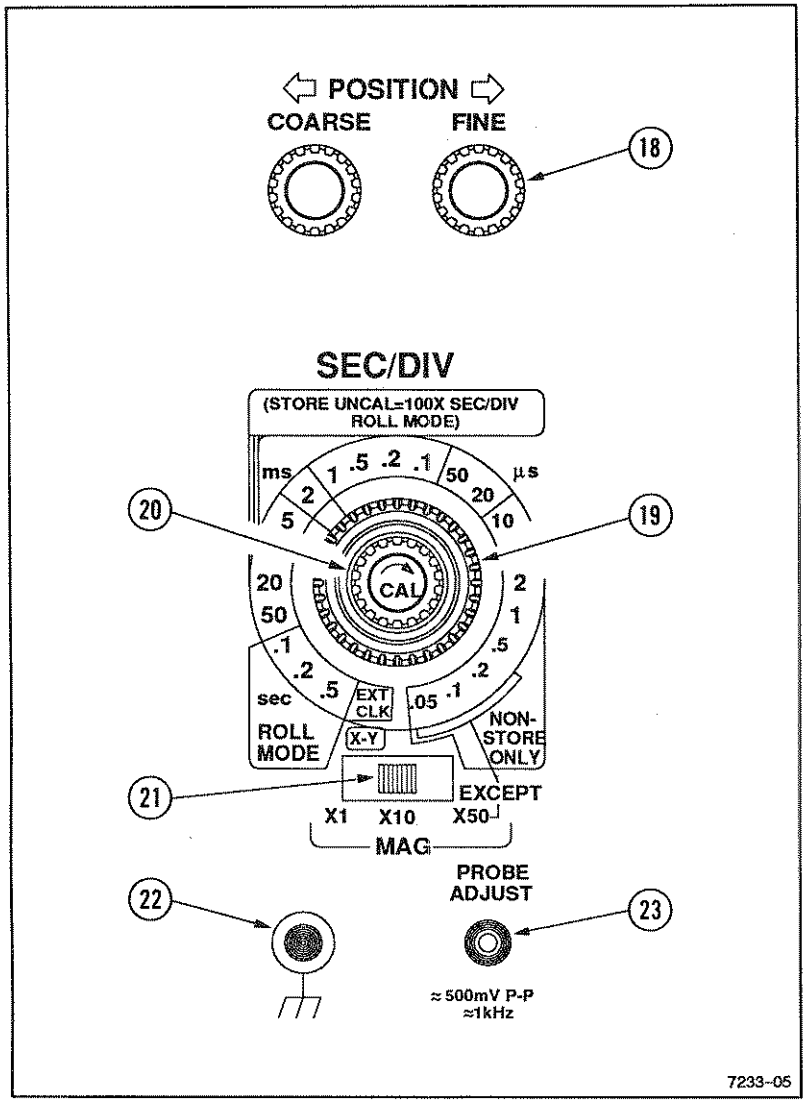


Figure 3–3. Horizontal controls.

(19) **SEC/DIV Switch** – Selects calibrated sweep rates from 0.5 s to 0.05 μs per division in a 1–2–5 sequence of 22 positions. The X–Y position selects the X–Y display in NON–STORE Mode. The CH 1 input signal provides horizontal deflection for X–Y displays, and the CH 2 input signal produces vertical deflection.

In STORE mode, the SEC/DIV switch determines the acquisition and display modes, sets the sampling rate, and establishes the time scale factor of the displayed waveforms. There are two storage modes with respect to the SEC/DIV switch setting (see Table 3–1).

If a SEC/DIV range above 20 μs is selected while in STORE mode, the timebase readout displays Sec/Div?, indicating that an illegal control setting has been selected. The acquisition continues at the 20 μs/div rate.

Table 3–1

Storage Modes

SEC/DIV Switch Setting	SEC/DIV Variable	
	CAL	UNCAL
X–Y (EXTERNAL CLOCK)	RECORD Clock: dc to 10 MHz	ROLL Clock: dc to 4 kHz
0.05 μs to 10 μs	Error Indication [b]	Error Indication [b]
20 μs to 5 ms [a]	RECORD	RECORD
10 ms to 50 ms	RECORD	ROLL (100X) 1 s/div to 5 s/div
0.1 s to 0.5 s	ROLL (1X)	ROLL (100X) 10 s/div to 50 s/div

[a] The Variable SEC/DIV control has no effect in this range.
[b] Sec/Div? is displayed in the crt readout.

RECORD Mode—Updates a full record of the acquired waveform each time a trigger event is recognized.

ROLL Mode—Continuously acquires and displays signals. The waveform display scrolls from right to left across the crt with the latest samples appearing at the right edge of the crt. Triggers are disabled except in SGL SWP.

At SEC/DIV settings of 10 ms and below, when the Variable SEC/DIV control is moved form the CAL position, the selected SEC/DIV setting is multiplied by 100 and the display mode is ROLL.

In STORE mode, X–Y on the SEC/DIV switch selects external clock. In this mode the acquisition rate is controlled by a signal applied to the EXTERNAL CLOCK connector located on the right hand side of the instrument.

The SEC/DIV switch setting is displayed in the crt readout.

(20) **Variable SEC/DIV**—Continuously varies the uncalibrated NON–STORE sweep time per division to at least 2.5 times the calibrated time per division set by the SEC/DIV switch. Full counterclockwise rotation increases the slowest sweep time per division to at least 2 s. The uncalibrated condition is indicated by a greater than symbol (>) in front of the SEC/DIV readout.

In STORE mode (10 ms per division to 0.5 s per division), if the Variable control is switched out of CAL detent, the SEC/DIV switch setting is multiplied by 100 times (see Table 3–2). The control has no effect in STORE mode at SEC/DIV switch settings faster than 10 ms. When the SEC/DIV switch is set to EXT CLK, the Variable SEC/DIV control selects the display mode. In the CAL position, RECORD mode is selected, EXT CLK range DC to 10 MHz. Out of CAL detent, ROLL mode is selected, EXT CLK range DC to 4 kHz, and "ROLL" is displayed on the crt.

Table 3-2
Extended SEC/DIV Ranges

SEC/DIV Variable	
CAL	**UNCAL**
10 ms/div	1 s/div
20 ms/div	2 s/div
50 ms/div	5 s/div
0.1 s/div	10 s/div
0.2 s/div	20 s/div
0.5 s/div	50 s/div

(21) **Horizontal MAG Switch**—Selects the amount of horizontal magnification: X1, X10 or X50. Magnification occurs around the center vertical graticule division in both NON-STORE and STORE. The crt SEC/DIV readout will reflect the settings of both the SEC/DIV switch and the magnification factor. In STORE mode, with Δt cursors selected, operation of the Horizontal MAG switch will also magnify the cursors as they are attached to the waveform(s).

(22) **GND Connector**—Provides an auxiliary ground connection directly to the instrument chassis via a banana-tip jack.

(23) **PROBE ADJUST Connector**—Provides an approximately 0.5 V, negative-going, square-wave voltage (at approximately 1 kHz) for use in compensating voltage probes and checking the vertical deflection system. The PROBE ADJUST output is not intended as a reference in checking either the vertical or horizontal accuracy of the instrument.

TRIGGER

See Figure 3-4 for location of items 24 through 32.

(24) **Trigger SLOPE Switch**—Selects either the positive or negative slope of the trigger signal to start the sweep.

(25) **Trigger LEVEL Control**—Selects the dc level that the Trigger signal must pass through to produce triggering. The Trigger point is displayed as a voltage readout in the display field unless any of the following are selected:

Trigger Source CH 1 and CH 1 is AC coupled, or uncalibrated

Trigger Source CH 2 and CH 2 is AC coupled, or uncalibrated

Trigger Source VERT and Vertical Mode is CHOP

Trigger Source VERT and CH 1 is AC coupled or uncalibrated, or CH 2 is AC coupled or uncalibrated, or CH 1 VOLTS/DIV and MAG are not equal to CH 2 VOLTS/DIV and MAG

Trigger Source EXT

Trigger Coupling is not set to DC

Trigger Mode TV

(26) **TRIG'D/READY Indicator**—A dual-function, light-emitting diode (LED) indicator. In P-P AUTO, NORM, and TV FIELD Trigger modes, the indicator turns on when triggering occurs.

In NON-STORE, for SGL SWP Trigger mode the indicator turns on when the trigger circuit is armed awaiting a triggering event. The indicator turns off again as soon as the single sweep completes.

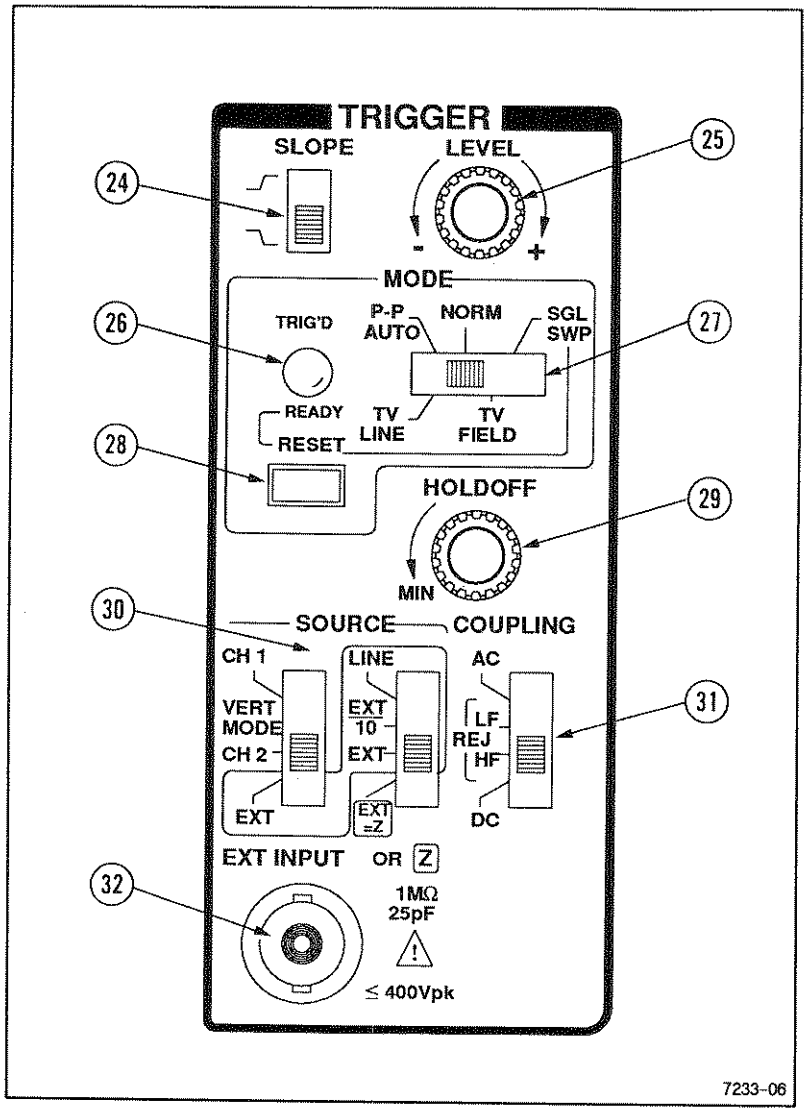


Figure 3–4. Trigger controls.

In STORE mode, selecting SGL SWP and pressing the RESET button starts the sampling to fill the pretrigger portion of the waveform RECORD. The TRIG'D/READY indicator does not come on until the pretrigger part of the RECORD is full. When the indicator comes on, the storage acquisition system is ready to accept a trigger event. Filling the remaining portion of the RECORD begins when that trigger occurs, and the indicator turns off when the RECORD is full. The time needed to fill the pretrigger and post-trigger portions of the RECORD depends on two things: the sampling rate, and the setting of the PRE-TRIG 25%/75% switch. Until a trigger occurs, the pretrigger data is continually updated, but the RECORD display is not updated until a complete new waveform is acquired.

(27) **MODE Switch**—Determines the NON-STORE sweep and STORE acquisition triggering mode. STORE mode triggering operation also depends on the position of the SEC/DIV switch.

P-P AUTO/TV LINE—In NON-STORE mode, the Trigger LEVEL control range is set to the peak-to-peak limits of the input trigger signal. Triggered operation occurs when the trigger signal has enough amplitude and occurs often enough (20 Hz and faster repetition rate) for the peak detectors to determine the signal peaks. If the trigger signal does not meet the requirements to produce a trigger event, an auto-trigger is generated, and the sweep free runs.

In STORE mode, for SEC/DIV settings of 0.5 s per division to 0.1 s per division, the P/P AUTO Trigger Mode is disabled, and the input is continually digitized in the ROLL mode. ROLL mode is also enabled for SEC/DIV settings of 0.5 s to 10 ms if the Variable SEC/DIV control is switched out of the CAL detent (100X SEC/DIV settings). In RECORD mode, at SEC/DIV settings from 50 ms to the maximum STORE mode setting of 20 μs, triggering occurs under the same conditions as for NON-STORE, P-P AUTO Trigger Mode.

NORM—Permits triggering at all NON-STORE sweep speeds. The Trigger LEVEL control must be set correctly to produce a sweep; an autotrigger is not generated if there is no trigger signal. NORM Trigger Mode is especially useful in obtaining a stable display of low-frequency and low-repetition-rate signals.

In STORE mode RECORD, the display is updated once the acquisition is complete; the last waveform acquired remains displayed until that time.

In ROLL, the trigger signal is ignored for all the Trigger modes except in SGL SWP Trigger mode (see Table 3-3). In non-triggered ROLL mode, the display is continually updated at the digitization rate.

TV FIELD—Permits stable triggering on a television field (vertical sync) signal. In the absence of an adequate trigger signal, the sweep (or acquisition) free runs. The instrument otherwise behaves as in P-P AUTO. When TV FIELD is selected, "TV" is displayed in the crt readout.

SGL SWP—Selects single sweep operation.

Table 3-3
ROLL Trigger Modes

TRIGGER MODE	ROLL MODE Trigger Operation
P-P AUTO	Untriggered ROLL
NORM	Untriggered ROLL
TV TRIG (LINE and FIELD)	Untriggered ROLL
SGL SWP	Triggered ROLL

NOTE

To avoid the possibility of losing parts of the sweep, it is advisable to switch the readout system off when doing single sweep measurements at SEC/DIV settings of greater than 0.2 ms in NON-STORE mode.

In RECORD mode, upon entering SGL SWP the last waveform acquired remains displayed. Pressing the RESET button rearms the trigger circuitry to accept the next triggering event. When a trigger event is recognized, the full record is acquired and the display updates. If BOTH-ALT Vertical Mode is selected along with VERT MODE Trigger SOURCE, the triggered channel behaves as just described. The non-triggered channel display is not updated. Pressing the RESET button again causes the second channel to update.

If the display mode is ROLL when SGL SWP is selected, the display continues to roll because the trigger circuit is not armed. When the RESET button is pushed to arm the trigger circuit the display continues rolling until the pretrigger portion of the RECORD is full. The trigger point indicator (intensified dot) then appears on the waveform, and the TRIG'D/READY indicator lights. The display continues to roll as data is acquired to fill the post-trigger portion of the RECORD. The amount of pretrigger information in a RECORD is set by the 25%/75% PRETRIG button. In SGL SWP, if BOTH-ALT Vertical mode is selected along with VERT MODE Trigger Source the triggered channel behaves just as described; the non-triggered channel is blanked. The triggered and non-triggered channel alternates with each press of the RESET button.

(28) **RESET**—Arms the trigger circuit either for a single sweep in NON-STORE SGL SWP or a single acquisition in STORE SGL SWP. Triggering requirements are the same as in NORM Trigger Mode. After the completion of a triggered NON-STORE sweep or a STORE SGL SWP acquisition, pressing in the RESET button rearms the trigger circuitry. In NON-STORE mode, the next

trigger event can then be accepted to start the sweep. For STORE mode, the pretrigger acquisition is started when the RESET button is pressed.

(29) **Variable HOLDOFF Control**—Adjusts the NON-STORE variable holdoff time. NON-STORE variable holdoff starts at the end of the sweep. STORE mode holdoff starts at the end of the acquisition cycle; it ends when the waveform data has been transferred from the acquisition memory to the display memory and the pretrigger portion of the RECORD has been filled. After STORE mode holdoff ends, the next acquisition can be triggered after the next (or current, if one is in progress) NON-STORE holdoff ends. STORE mode holdoff can be much longer than the sweep time so that several NON-STORE holdoff periods may have occurred during STORE holdoff time. This ensures that STORE mode triggering is controllable by the Variable HOLDOFF control and will be stable if the NON-STORE display is stable.

(30) **Trigger SOURCE Switches**—Determines the source of the internal and external trigger signal for the trigger generator circuits.

CH 1—Trigger signal is obtained from the channel 1 input and "CH 1" is displayed in the crt readout.

VERT MODE—Trigger signals are obtained alternately from the CH 1 and CH 2 input signals in ALT Vertical Mode. In CHOP Vertical Mode, the trigger signal source is the sum of the CH 1 and CH 2 input signal. When VERT MODE is selected, "VERT" is displayed in the crt readout.

CH 2—Trigger signal is obtained from the channel 2 input and "CH 2" is displayed in the crt readout. The NORM/CH 2 INVERT switch also inverts the polarity of the internal CH 2 trigger signal when the CH 2 display is inverted.

EXT—Selects external triggers. The actual form these triggers take is selected by the second SOURCE switch. When EXT is selected, "EXT" is displayed in the crt readout.

LINE—Routes a sample of the ac power line signal to the trigger circuit.

EXT/10—Attenuates the external signal applied to the EXT INPUT OR Z connector by a factor of 10 before applying it to the trigger circuit.

EXT—Routes an external signal applied to the EXT INPUT OR Z connector to the trigger circuit.

EXT=Z—Routes the signal from the EXT INPUT OR Z connector to the Z-axis amplifier rather than the trigger circuit. If EXT and EXT=Z are both selected, the signal applied to the EXT INPUT OR Z connector is routed to both the trigger circuit and the Z-axis amplifier.

(31) **COUPLING Switch**—Determines the method of coupling for the signal applied to the trigger circuit.

AC—Input signal is capacitively coupled, and the dc component (below 10 Hz) from the trigger circuit is blocked. "AC" is displayed in the crt readout.

HF REJECT—Rejects (attenuates) the high-frequency components (above 30 kHz) from the trigger circuit. "HF rej" is displayed in the crt readout.

LF REJECT—Rejects (attenuates) the low-frequency components (below 30 kHz) from the trigger circuit. "LF rej" is displayed in the crt readout.

DC—Couples all frequency components of the external signal to the trigger circuit (DC to full bandwidth).

(32) **EXT INPUT OR Z Connector**—Provides for connection of external signals to the trigger circuit or, if EXT=Z is selected, to the Z-axis amplifier.

STORAGE CONTROLS

See Figure 3–5 for locations of items 33 through 37 and Figure 3–2 for location of item 38.

(33) **STORE/NON–STORE Switch**—Selects either the NON–STORE or the STORE waveforms for display. The STORE acquisition system is turned off while NON–STORE is selected so that the last waveform acquired in STORE mode remains in memory. NON–STORE is selected when the button is out; STORE mode when pressed in.

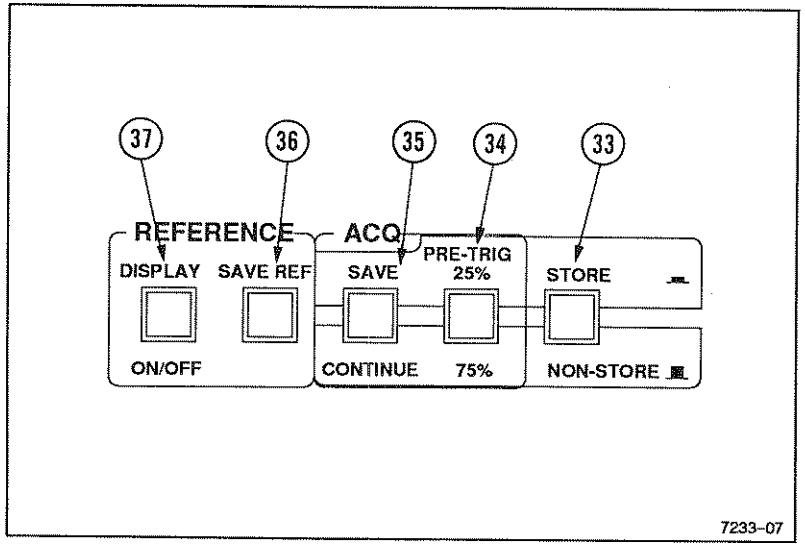


Figure 3–5. Storage controls.

(34) **PRE–TRIG 25%/75% Switch**—Selects either 25% or 75% pretrigger. If either RECORD mode or SGL SWP ROLL mode is selected, the trigger position is shown on the display by an intensified dot. Selects 75% pretrigger when out; 25% when pressed in.

(35) **ACQ SAVE/CONTINUE Switch**—Stops the display from being updated when pressed in. If the display mode is ROLL, the current acquisition is stopped immediately upon pressing the button. Releasing the button causes the acquisition to continue. If the display mode is RECORD, the current display is held immediately upon pressing the button. When the button is released the display is updated with the acquisition that was in progress when the SAVE button was pushed. On returning to the CONTINUE mode, previously acquired waveforms are no longer valid if the control settings were changed while in SAVE mode. The next waveform acquired in CONTINUE mode will reflect any changes made. When SAVE is selected, "SAVE" appears at the bottom of the readout display.

(36) **Reference SAVE REF Switch**—Saves the displayed STORE mode waveform(s) into the reference memory.

NOTE

Only the on-screen portions of the STORE waveform will be correctly saved in the Reference memory.

The saved Reference waveform is displayed on the crt. When the SAVE REF button is pressed, previously saved waveform(s) are over-written by the displayed acquisition waveform(s). The Reference waveform(s) remain in memory when the instrument is switched between STORE and NON-STORE modes. Reference waveforms are NOT saved when the oscilloscope is turned off.

(37) **Reference DISPLAY ON/OFF Switch**—Turns the stored reference waveform display on and off when in STORE mode.

(38) **Reference POSITION Control**—Allows vertical positioning of the saved Reference waveforms. The Reference waveforms may only be positioned in the positive region from the level at which they were saved; they cannot be positioned below that level.

NOTE

Any portions of the STORE waveform that are out of the display area will not be saved correctly in the Reference memory when SAVE REF is pressed. The off-screen portion will be clipped. The clipping effect is seen when saving a waveform that is partially off the bottom of the crt display. When the Reference waveform is positioned upward to bring it on-screen, the bottom of the display will be clipped. The effect cannot be seen on the Reference waveforms clipped at the top because they cannot be positioned downwards.

CURSOR

See Figure 3-6 for the location of items 39 through 43.

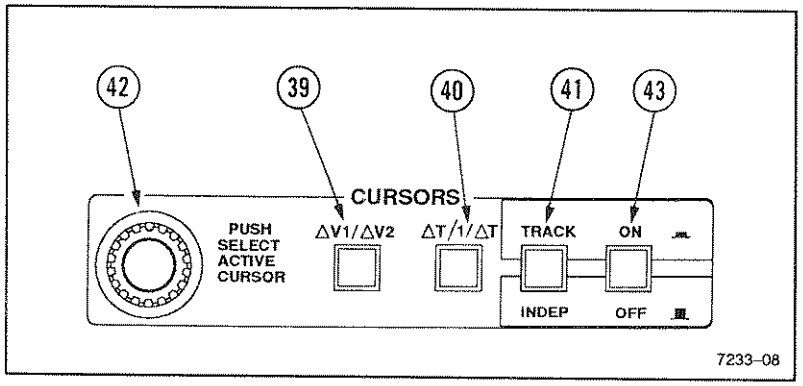


Figure 3-6. Cursor controls.

(39) **DELTA V Switch** – Activates the Delta Volts (ΔV) measurement function and cancels any other Delta measurement function when momentarily pressed. The CRT readout displays the equivalent voltage represented by the separation between the two cursors with VOLTS/DIV scaling defined by the setting of the selected vertical channel's VOLTS/DIV switch. The selection of the VOLTS/DIV switch is defined by the operation of the ΔV

switch such that, when the ΔV function is inactive, depressing the ΔV switch selects the VOLTS/DIV switch previously selected for ΔV measurement mode (CH 1 is selected after switch-on), and, when the ΔV function is active and Vertical MODE is set to BOTH, subsequent depressions of the ΔV button will toggle VOLTS/DIV scaling between CH 1 and CH 2 VOLTS/DIV switches. If CH 1 is not displayed, ΔV1 will not be enabled. Likewise, if CH 2 is not displayed, ΔV2 will not be enabled. Each channel has its own independent cursors and channel selection is indicated in the Readout field. The position of the cursors on the display are set by the Cursor Position control. The DELTA Volts readout is displayed as a percentage ratio (with five divisions corresponding to a 100% ratio) if either one of the following conditions exist:

(1) The selected vertical channel is uncalibrated (VOLTS/DIV CAL control out of detent), or

(2) ADD is selected when the CH 1 and CH 2 deflection factors are not the same (VOLTS/DIV switches are at different settings or at least one is uncalibrated). The setting of the VOLTS/DIV switch must take account of the X10 PULL function.

When the 2211 is in NON-STORE X-Y Mode, the Delta VX and Delta VY cursors can be enabled via the Delta V switch. The ΔV1 cursors become the ΔVX cursors and the ΔV2 cursors become the ΔVY cursors, and pressing the Delta V switch toggles between them. The ΔVX cursors present a voltage measurement dependent upon the difference between the position of the cursors and the CH 1 VOLTS/DIV setting. Likewise, the ΔVY cursors present a voltage measurement dependent upon the difference between the position of the cursors and the CH 2 VOLTS/DIV setting. The ΔVX cursors are similar in appearance to the time cursors, i.e., vertical lines on the crt, whereas the ΔVY cursors are similar in appearance to the voltage (ΔV1, ΔV2) cursors. If the channel VOLTS/DIV switches are in UNCAL, ΔVX and ΔVY measurements will be displayed as ratios with 5 screen divisions equal to 100%.

(40) **DELTA t 1/DELTA t Switch**—Activates the Delta Time (Δt) measurement function and cancels any other Delta measurement functions when momentarily pressed in. When the Δt function is active, momentarily pressing in the Δt button selects the 1/Delta t (1/Δt) function. Subsequent operation of this button toggles between the Δt and 1/Δt functions. The CRT Readout displays the time difference (Δt), or it's reciprocal (1/Δt), between the two vertical cursors with SEC/DIV scaling defined by the positions of the SEC/DIV and MAG switches. When the SEC/DIV switch selects the EXT CLK function, the Δt function displays the difference between the two cursors in graticule divisions, and the 1/Δt function displays it's reciprocal. The positions of the cursors on the display are set by the Cursor Position control. In NON-STORE, if the SEC/DIV CAL control is not in the detent position, Δt cursor difference is expressed as a ratio with five divisions corresponding to a 100% ratio, and 1/Δt as phase with five divisions corresponding to 360 degrees. In STORE, if the SEC/DIV CAL control is not in the detent position, the SEC/DIV switch setting is multiplied by 100 times, except at SEC/DIV switch settings faster than 10 ms, when the SEC/DIV CAL control has no effect. In STORE mode, Δt cursors are attached to the waveform(s) (waveform based cursors). Once on the required measurement points, operation of both the Horizontal POSITION control and/or the Horizontal MAG switch will result in the cursors moving with the waveform rather than independently of it.

(41) **TRACK/INDEP Switch**—Selects either the tracking or independent mode for the Cursor Position control. When in the TRACK mode, the difference between cursors does not change with rotation of the Cursor Position control. When the Cursor Position control is rotated, both cursors move equally until the limit of either is reached. If INDEP is selected, the cursors are independently movable using the Cursor Position control.

(42) **Cursor Position Control**—Positions the Delta time cursors (vertical line) when either the Δt or 1/Δt Measurement Mode is active. When the ΔV Measurement Mode is active, the control

positions the Delta Voltage cursors (horizontal line). Rotating the control clockwise moves the ΔV cursors upwards or the Δt cursors to the right. Pushing the Cursor Position control will toggle the selection of the active cursor.

(43) **ON/OFF Control**—When Cursor Measurement mode is active, depressing this button cancels the cursor measurement mode, extinguishing the cursors and the cursor measurement display. When the Cursor Measurement mode is inactive, depressing this button enables the cursor measurement mode, enabling the cursors and the cursor measurement display. When the instrument is first switched on, the Readout display will indicate the current switch settings, and ΔV1 will be operative: if CH 1 or BOTH is selected, or, if CH 2 is selected, ΔV2 will be operative.

NOTE

The cursors and cursor Delta readout are disabled in the following mode: STORE, ROLL, Delta t cursors, X50 Horizontal MAG and non-SAVE.

REAR PANEL

See Figure 3-7 for the location of items 44 through 46.

(44) **Fuse Holder**—Contains the ac-power-source fuse. See the rear panel nomenclature for fuse rating and line voltage range.

(45) **Detachable Power Cord Receptacle**—Provides the connection point for the ac power source to the instrument.

(46) **Line Voltage Selector (Mains switch)**—Selects the line voltage range either 115 V or 230 V.

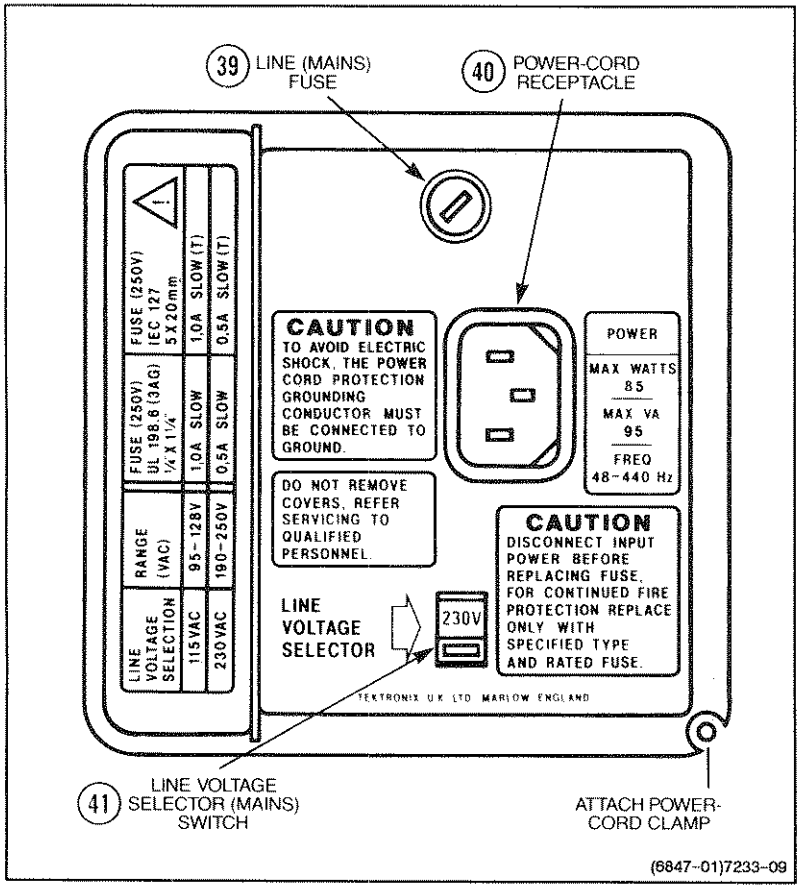


Figure 3–7. Rear panel.

SIDE PANEL

See Figure 3–8 for the location of items 47 through 50.

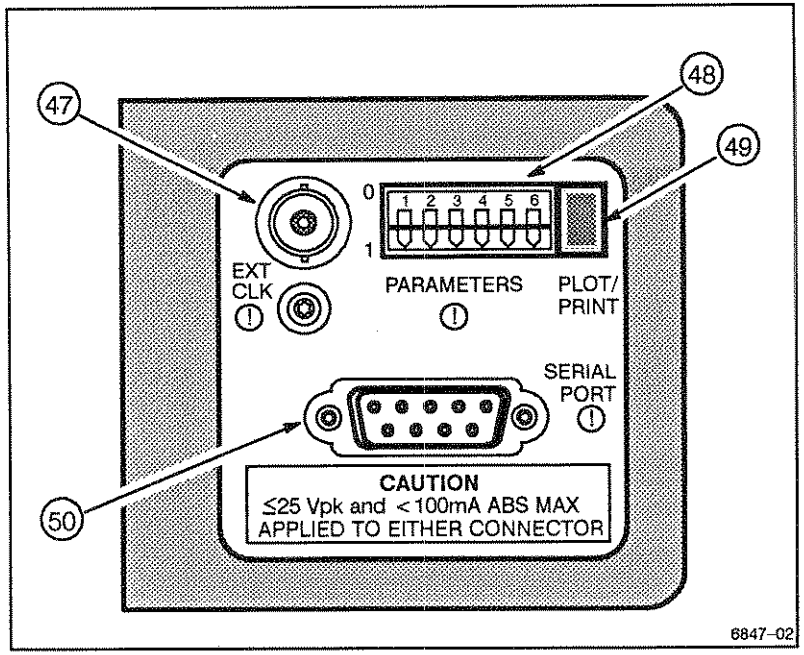
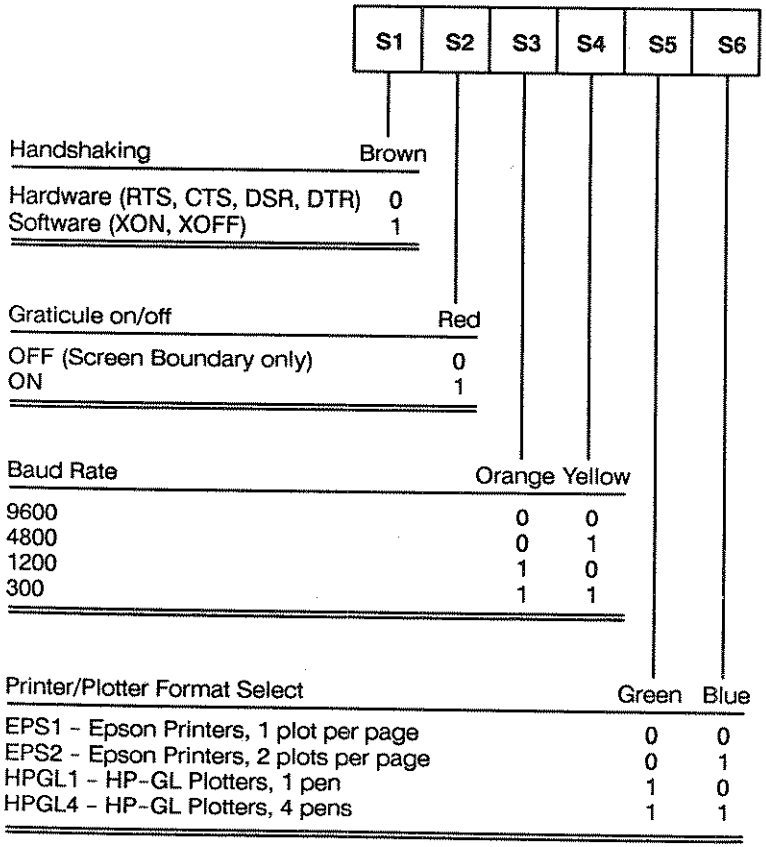


Figure 3–8. Right side panel.

(47) **EXT CLOCK**—Provides a TTL compatible input for external clock signals to the storage acquisition circuit. The EXT CLOCK input signal is selected when the SEC/DIV switch is in the EXT CLK position. The maximum input frequency permitted depends on the display mode (RECORD or ROLL). The mode is selected with the Variable SEC/DIV control. The frequency ranges are dc to 10 MHz in RECORD mode (Variable SEC/DIV control in CAL detent) and dc to 4 kHz in ROLL mode (Variable SEC/DIV control out of the CAL detent position).

(48) **PARAMETER SWITCHES**—The options of the interface are selected using six switches mounted on the side panel. (See Figure 3–8). Switch settings are given in Figure 3–9.

Figure 3–9
Switch Selections



Handshaking (Switch 1)

Both hardware (RTS/CTS and DTR/DSR) and software (XON/XOFF) handshaking are supported and selected via Switch S1.

Hardware handshaking utilizes both the RTS/CTS and DTR/DSR signals as follows:

- **DTR** is asserted when the 2211 Serial Interface Option (SIO) is ready and on-line.
- **RTS** is asserted when print/plot data is ready to transmit.
- **Data** is transmitted when both CTS and DSR are asserted.

Software handshaking makes use of the XON and XOFF flow control characters which are sent across the data channel. This allows for three-wire (Tx, Rx and GROUND) communications to be established.

Graticule On/Off (Switch 2)

Switch 2 is used to enable/disable the printing/plotting of the screen graticule. If disabled, only the graticule border is plotted.

Baud Rate (Switches 3 and 4)

Switches 3 and 4 select the transmit and receive baud rate in bits per second.

Printer/Plotter Digital Format (Switches 5 and 6)

Switches 5 and 6 select the printer/plotter digital data format. A summary of the printer/plotter digital data formats is given as follows:

Epson Printers

The format for Epson printers uses the ESC-L graphics mode.

HP-GL (Hewlett-Packard Graphics Language) Plotter Formats

Both the HP-GL drivers (HPGL1 and HPGL4) use a small subset of the HP-GL command set. The commands used are as follows:

Command arguments are shown in < > brackets.

Scale	SC <scale x, scale y>
Select Pen	SP <pen number>
Pen Up	PU
Pen Down	PD
Set Defaults	DF
Move Absolute	PA <absolute x,y location>
Set Character Size	SR <character width, character height>
Plot Text String <ETX character>	LB <text string>

The fixed pen allocations for the HPGL4 mode are as follows:

Graticule	Pen 1
Acquisition channel 1 data	Pen 2
Acquisition channel 2 data	Pen 3
Reference channel 1 data	Pen 4
Reference channel 2 data	Pen 1

The x, y command arguments for the PA command are restricted to the scale x and scale y limits defined by the scale command.

(49) **PRINT/PLOT SWITCH** – The print/plot switch is used to initiate and terminate waveform dumps to printers and plotters.The switch is located on the side panel next to the Dip-switches.

A print/plot of the displayed waveform data can be initiated in either of the following two ways when the 2211 is in STORE mode:

1. By operating the print/plot push-button.
2. By shorting pin 9 (PB) and pin 5 (GROUND) of the DTE connector. This operation allows for printing/plotting to be remotely initiated and is of particular use in rack-mounted versions.

A print/plot can be aborted in either of the following two ways:

1. By operating the print/plot push-button for more than 3 seconds when a plot is in progress.
2. By shorting pins 9 and 5 of the DTE connector for more than 3 seconds when a plot is in progress.

NOTE

Neither the Horizontal position control nor the Horizontal Magnification switch has any effect on the horizontal position of the plot. The hardcopy output represents the un-magnified (X1 Horizontal MAG) screen and the plotted SEC/DIV scaling reflects the un-magnified horizontal deflection factor.

Trigger Point

The Trigger Point is indicated on a plot or printout by an X bounded by a square.

Cursors and Readout

The Cursors and crt Readout are plotted as displayed on the screen.

(50) **SERIAL COMMUNICATIONS INTERFACE OPTION 12–** Provides a RS–232C communications interface for the instrument. It offers asynchronous transmission at baud rates of 300, 1200, 4800 or 9600, with 8 data bits, one start bit, one stop bit and no parity. Connection is made to the 2211 via a 9–pin DTE connector.

Six interface signals are assigned to the connector as shown in Table 3–4.

Table 3–4
Serial Interface Connector

Signal Name	Abbreviation	Pin Number	Direction[1]
–	–	1	–
Receive Data	Rx	2	In
Transmit Data	Tx	3	Out
Data Terminal Ready	DTR	4	Out
Ground	GND	5	–
Data Set Ready	DSR	6	In
Request To Send	RTS	7	Out
Clear To Send	CTS	8	In
Plot Button	PB	9	In

[1]**Signal directions are as viewed from the serial interface.**

Interconnection Requirements

The interface connector is provided by a standard 9 pin to 25 pin (DCE to DTE) cable (see Figure 3-10).

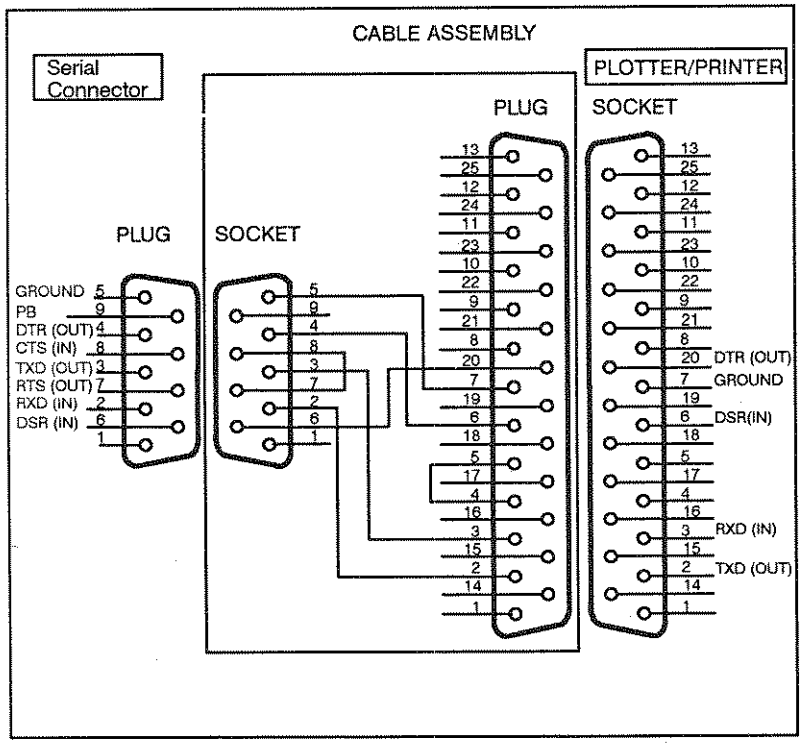


Figure 3-10. Printer-Plotter Connection.

Electrical Specification
Table 3–5
Serial Interface Characteristics

CHARACTERISTICS	PERFORMANCE REQUIREMENTS
Serial Interface	Requirements electrically comply with EIA Standards RS–232–C.
Baud Rates	300, 1200, 4800 or 9600
Serial Format	8 Data Bits 1 Start Bit 1 Stop Bit No parity
Accuracy	<1% error

Table 3–6
Environmental Specifications

CHARACTERISTICS	PERFORMANCE REQUIREMENTS
Temperature	
Operating	0°C to +40°C (+32°F to +93°F).
Nonoperating	–55°C to +75°C (–67°F to +167°F). tested to MIL–T–28800C, para 4.5.5.1.3 and 4.5.5.1.4 (0°C operating Test) except that in para 4.5.5.1.3, steps 4 and 5 are performed before step 2 (–55°C nonoperating test). Equipment shall remain off upon return to room ambient temperature during step 6. Excessive condensation shall be removed before operating during step 7.
Altitude	
Operating	To 4,570 meters (15,000 feet). Maximum operating temperature decreases 1°C per 1000 feet above 5,000 feet.
Nonoperating	To 15,240 meters (50,000 feet).
Humidity, Operating and Nonoperating	5 cycles (120 hours) reference to MIL–T–28800C para 4.5.5.1.2.2 for type III, Class 5 instruments. Operating and nonoperating at 95% –5% to +0% relative humidity. Operating, +30°C to +40°C; nonoperating, –30°C to +60°C.
EMI	Meets radiated and conducted emission requirements per VDE 0871, Class B. Plus FCC section 15, sub part J, Class A. The EMI test was carried out with a 1 meter single shielded cable terminated in 3K with a shielded 9 pin D type connector used at the interface.

Table 3–6 (cont)

CHARACTERISTICS	PERFORMANCE REQUIREMENTS
Vibration, Operating	15 minutes along each of three major axes at a total displacement of 0.015 inch p-p (2.4g at 55 Hz) with frequency varied from 10 Hz to 55 Hz to 10 Hz in one minute sweeps. Hold for 10 minutes at 55 Hz in each of the three major axes. All major resonances must be above 55 Hz.
Shock, Nonoperating	30 g, half-sine, 11 ms duration, three shocks per axis each direction, for a total of 18 shocks.

CRT READOUT

See Figure 3–11 for an indication of the crt readout displays.

The Readout system provides an alphanumeric display of information on the crt along with the waveform displays. The readout is displayed in two rows of characters. One row is within the top graticule division, the other within the bottom graticule division.

Cursor Type—Indicates which Δ function has been selected. Possible values are: ΔV1, ΔV2, ΔT, 1/ΔT, Ratio, Phase, ΔVX, and ΔVY.

Cursor Delta Value—Indicates the distance between the two cursors. Units will depend upon the cursor type.

Trig—Indicates that the following information relates to the Trigger point. This field is used for information only.

Trigger Value—Indicates the value of the Trigger Level. This field is disabled in X-Y mode and a number of other trigger modes as described on page 3–11 of this section.

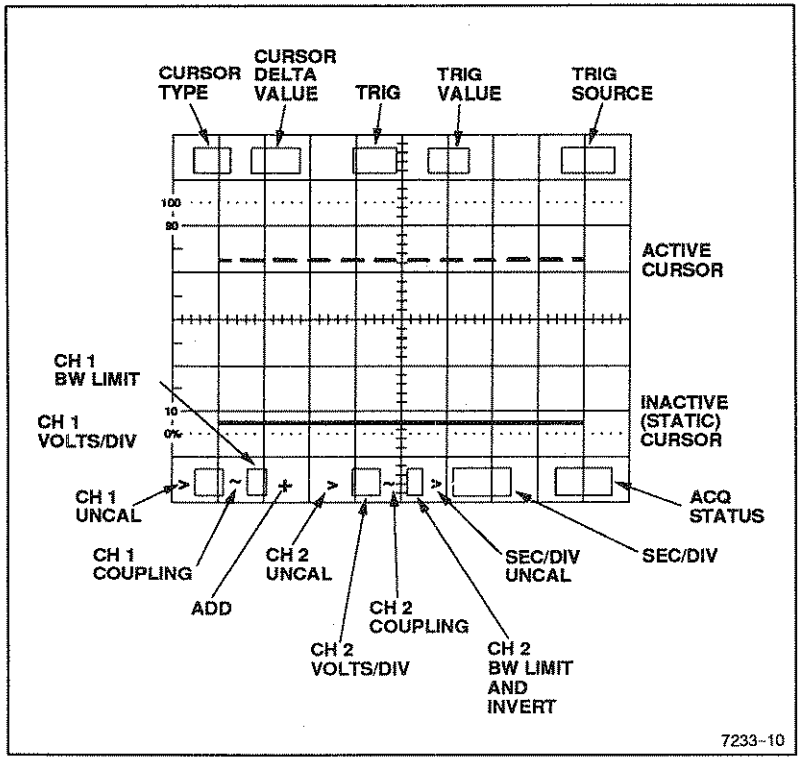


Figure 3-11. CRT Readout display.

Trigger Source—Indicates the current Trigger Source. Possible values are:CH 1, CH 2, VERT and EXT.

CH 1 Vertical Deflection—Indicates the current CH 1 VOLTS/DIV switch setting. A > sign appears before the value if the switch is in the UNCAL position, a ~ sign appears after the value if the input is AC coupled, and B_L appears if the channel bandwidth is limited.

ADD—If the instrument is set for ADD Mode, a + sign appears in this field, otherwise the field is blank.

CH 2 Vertical Deflection – Indicates the current CH 2 VOLTS/DIV switch setting. A > sign appears before the value if the switch is in the UNCAL position, a ~ sign appears after the value if the input is AC coupled, B_L appears if the CH 2 bandwidth is limited, and a down arrow (↓) is displayed if CH 2 is inverted.

Horizontal Deflection – Indicates the current value of the SEC/DIV switch. A > sign appears before the value if the switch is in the UNCAL position.

Acquisition Status – Indicates whether the instrument is in SAVE or ROLL mode. This field is only active in STORE mode.

The ΔT, 1/ΔT, ΔVX, and associated Phase and Ratio cursors are displayed as vertical lines on the crt. The ΔV_1, ΔV_2, ΔVY, and associated Ratio cursors are displayed as horizontal lines on the crt as shown in Figure 3-11.

SECTION 4

OPERATING CONSIDERATIONS

OPERATING CONSIDERATIONS

This section contains basic operating information and techniques that should be considered before attempting to make any measurements with the instrument.

GRATICULE

The graticule is internally marked on the faceplate of the crt to eliminate parallax-viewing errors and to enable measurements (see Figure 4–1).

The graticule is marked with eight vertical and ten horizontal major divisions. Each major division is further divided into five subdivisions. The vertical deflection factors and horizontal timing are calibrated to the graticule for making accurate measurements directly from the crt. Percentage marks to assist the user in making rise and fall time measurements are located on the left side of the graticule.

GROUNDING

The most reliable signal measurements are made when the 2211 and the unit under test are connected by a common reference (ground lead) in addition to the signal lead or probe. The probe's ground lead provides the best grounding method for signal interconnection and provides the maximum amount of signal-lead shielding in the probe cable. A separate ground lead can also be connected from the unit under test to the oscilloscope ground receptacle located on the oscilloscope's front panel.

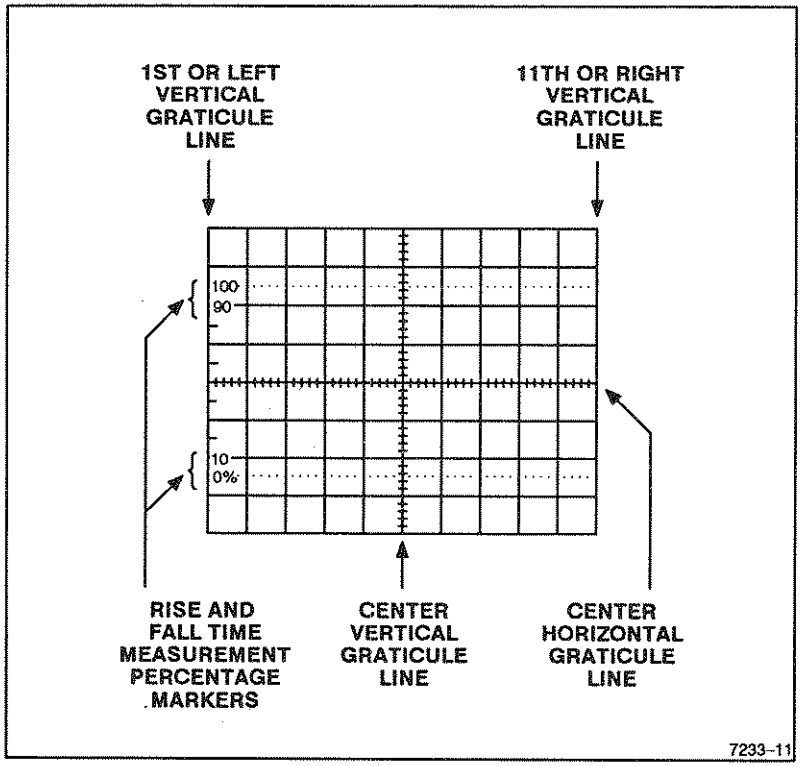


Figure 4–1. Graticule measurement markings.

SIGNAL CONNECTIONS

Probes

Generally, the accessory probes that come with the instrument provide the most convenient way to connect a signal to the oscilloscope. The probe and probe lead are shielded to prevent pickup of stray electromagnetic interference. The high input impedance of the 10X probe also minimizes signal loading in the circuit being tested.

The probe and the probe accessories should be handled carefully to prevent damage to them. Avoid dropping the probe body. Striking a

hard surface can cause damage to both the probe body and the probe tip. Do not allow the cable to be crushed or kinked. Do not place excessive strain on the cable by pulling.

The standard accessory probe is a compensated 10X voltage divider. It is a resistive voltage divider for low frequencies and a capacitive voltage divider for high frequency signal components. Inductance introduced by either a long signal lead or ground lead forms a series-resonant circuit. This circuit affects system bandwidth and will ring if driven by a signal at or near the circuit's resonant frequency. Oscillations (ringing) can then appear on the oscilloscope waveform display, distorting the true signal waveshape. Always keep both the ground lead and the probe signal-input connections as short as possible to obtain the best measurement results.

Uncompensated probes are a common source of measurement error. Due to variations in oscilloscope input characteristics, probes should be compensated whenever the probe is moved from one oscilloscope to another or between channels on the same oscilloscope. See the Probe Compensation procedure in Operator's Checks and Adjustment in this manual or consult the instructions supplied with the probe.

Coaxial Cables

Cables may also be used to connect signals to the vertical input connectors, but they can affect the accuracy of a displayed waveform. To maintain the original frequency characteristics of an applied signal, only high-quality, low-loss coaxial cables should be used. Coaxial cables should be terminated at both ends in their characteristic impedance. If this is not possible, use suitable impedance-matching devices.

INPUT-COUPLING CAPACITOR PRECHARGING

When the Input-Coupling switch is set to the GND position, the input signal is connected to ground through the input-coupling capacitor and a high-value resistance. This series combination forms a

precharging circuit that allows the input-coupling capacitor to charge to the average dc voltage level of the signal applied to the input connector. Thus, any large voltage transients that may accidentally be generated are not applied to the vertical amplifier's input when the input coupling is switched from GND to AC. The precharging network also provides a measure of protection to the external circuitry by reducing the current level that is drawn from the external circuitry while the input-coupling capacitor is charging.

If AC input coupling is in use, the following procedure should be used when connecting the probe tip to a signal source that has a different dc level than the present signal source. This procedure is more important if the dc-level difference is more than ten times the VOLTS/DIV switch setting.

1. Set the AC-GND-DC (input coupling) switch to GND before connecting the probe tip to a signal source.

2. Touch the probe tip to the oscilloscope's ground connector.

3. Wait several seconds for the input-coupling capacitor to discharge.

4. Connect the probe tip to the signal source.

5. Wait several seconds for the input-coupling capacitor to charge to the dc level of the signal source.

6. Set the AC-GND-DC switch to AC. A signal with a large dc component can now be vertically positioned within the graticule area, and the ac component of the signal can be measured in the normal manner.

SECTION 5

OPERATOR'S CHECKS AND ADJUSTMENTS

OPERATOR'S CHECKS AND ADJUSTMENTS

To verify the operation and basic accuracy of your instrument before making measurements, perform the following checks and adjustment procedures. If adjustments are required beyond the scope of these operator's checks and adjustments, refer the instrument to qualified service personnel.

For new equipment checks, before proceeding with these instructions, refer to Preparation for Use in this manual to prepare the instrument for the initial start-up before applying power.

INITIAL SETUP

1. Verify that the POWER switch is OFF (switch is in the OUT position), and the LINE VOLTAGE SELECTOR switch is set for the correct source voltage.

2. Plug the power cord into the ac power outlet.

3. Press in the POWER switch (ON) and set the instrument controls to obtain a baseline trace.

Display

INTENSITY	Midrange
Focus	Best defined display

Vertical (Both Channels)

Vertical MODE	CH 1
POSITION	Midrange
VOLTS/DIV	10 mV
AC-GND-DC	DC
Variable VOLTS/DIV	CAL (in detent)

Horizontal

SEC/DIV	0.5 ms
Variable SEC/DIV	CAL (in detent)
POSITION	Midrange
MAG	X1

Trigger

HOLDOFF	MIN (fully counterclockwise)
SOURCE	VERT MODE
MODE	P-P AUTO
LEVEL	For a suitable display (with signal applied)
SLOPE	Positive
COUPLING	AC

Storage

STORE/NON-STORE	NON-STORE (OUT)
SAVE/CONTINUE	CONTINUE (OUT)
PRE-TRIG	75% (OUT)

Cursor

TRACKING	OFF (OUT)
ON/OFF	ON (IN)

4. Adjust the Vertical and Horizontal POSITION controls to position the trace within the graticule area.

5. Adjust the INTENSITY and FOCUS controls for the desired display brightness and best focused trace.

6. Allow the instrument to warm up for 20 minutes before commencing the adjustment procedures. Reduce the INTENSITY level during the waiting time.

TRACE ROTATION ADJUSTMENT

NOTE

Normally the trace will be parallel to the center horizontal graticule line, and the TRACE ROTATION adjustment will not be required.

1. Preset the instrument controls and obtain a baseline trace as described in Initial Setup.
2. Use the Channel 1 POSITION control to move the baseline trace to the center horizontal graticule line.
3. If the baseline trace is not parallel to the center horizontal graticule line, the TRACE ROTATION potentiometer needs adjusting. Use a small-bladed screwdriver or alignment tool to align the trace with the graticule line.

PROBE COMPENSATION

Probes must be compensated to match the oscilloscope inputs. For the best measurement accuracy, always check probe compensation before making measurements. Use the following procedure to check and compensate the probes.

1. Preset the instrument controls and obtain a baseline trace as described in Initial Setup.
2. Connect two 10X probes to the CH 1 OR X and CH 2 OR Y input connectors.
3. Connect the hook tip to the end of each probe.
4. Connect the CH 1 probe to the PROBE ADJUST terminal.
5. Use the CH 1 POSITION control to vertically center the display. If necessary, adjust the Trigger LEVEL control to obtain a stable display on the positive SLOPE.

NOTE

Refer to the instruction manual supplied with the probe for more complete information on the probe and probe compensation.

6. Check the waveform display for overshoot and rounding (see Figure 5–1). If the probe needs to be compensated, use a small-bladed screwdriver or alignment tool to adjust for a square front corner on the waveform.
7. Take the CH 1 probe off the PROBE ADJUST terminal.
8. Connect the CH 2 probe to the PROBE ADJUST terminal.
9. Use the CH 1–BOTH–CH 2 switch to select CH 2 for display.
10. Use the CH 2 POSITION control to vertically center the display.
11. Check the waveform display for overshoot and rounding (see Figure 5–1). If compensation is needed, use a small-bladed screwdriver or alignment tool to adjust for a square front on the waveform.

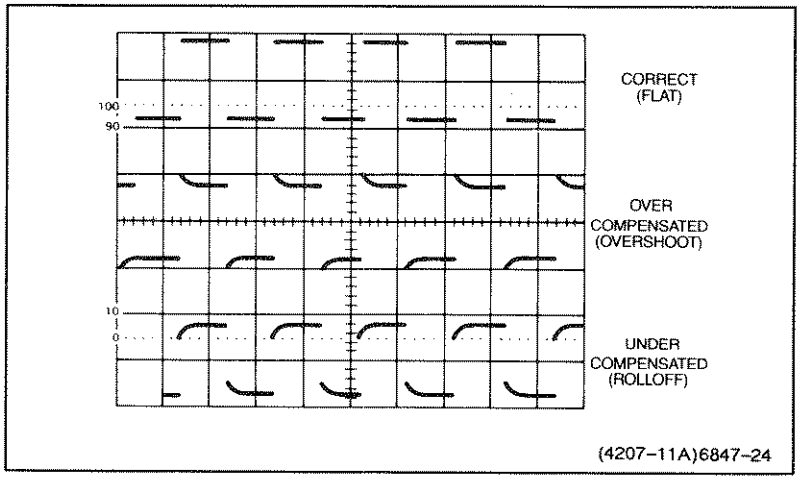


Figure 5–1. Probe compensation.

SECTION 6

BASIC APPLICATIONS

BASIC APPLICATIONS

INTRODUCTION

The procedures in this section enable the operator to make basic measurements using the capabilities of the oscilloscope.

Many of these measurements can be obtained with either the NON-STORE mode or the STORE mode. After becoming familiar with the capabilities of the instrument, the operator can choose the best method for making a particular measurement. Read the Operating Considerations part of this manual for information on signal connections, grounding, and other general operating information that may be useful in your application.

When the procedures call for obtaining a baseline display, refer to Initial Setup in the Operator's Checks and Adjustments part of the manual. The control settings listed in the Initial Setup procedure are considered the basic control settings for obtaining a display. Further control settings are usually needed to make a specific measurement. The operator must determine the correct control settings for the VOLTS/DIV, SEC/DIV, TRIGGER, and other controls to get a stable display of the signal applied. The display intensity, focus, and waveform positioning will also have to be controlled as needed.

The following procedures will allow the operator to set up and operate the instrument to obtain the most commonly used oscilloscope displays. Verify that the POWER switch is OFF (push button OUT), then plug the power cord into the ac-power-input source outlet.

NON-STORE DISPLAYS

The following procedures are used to obtain the most commonly used conventional oscilloscope displays.

Normal Sweep Display

1. Preset the instrument controls and obtain a baseline display in NON-STORE mode.

2. Using a 10X probe or a properly terminated coaxial cable, apply a signal to the CH 1 OR X input connector. Check the signal-source output impedance to find the termination impedance needed at the oscilloscope input when a coaxial cable is used to interconnect test equipment.

NOTE

Instrument warm-up time required to meet all specification accuracies is 20 minutes.

3. Increase INTENSITY until you can see the display. If the display cannot be seen with the INTENSITY control at midrange, press the BEAM FIND button and hold it in while adjusting the CH 1 VOLTS/DIV switch to reduce the vertical display size. Center the compressed display using the Vertical and Horizontal POSITION controls. Release the BEAM FIND button.

4. Set the CH 1 VOLTS/DIV switch and adjust the Vertical and Horizontal POSITION controls to position the display where you want it in the graticule area.

5. Adjust the Trigger LEVEL control for a stable, triggered display.

6. Set the SEC/DIV switch to get the number of cycles (or periods) of displayed signal you need to make your measurement.

NOTE

Amplitude measurements are usually made with many complete cycles displayed. Period and rise- and fall-time measurements are made at the fastest sweep speed that allows only the area of measurement to be seen on screen.

Magnified Sweep Display

1. Preset the instrument controls and obtain a baseline trace.
2. Set the SEC/DIV switch for a sweep speed that permits the area you want to magnify to be seen.
3. Adjust the Horizontal POSITION control to move the area to the center crt graticule division. The actual magnified portion on either side of the center graticule line is equal to ±0.5 divisions with X10 MAG.
4. Set the Horizontal MAG switch to X10.
5. Set the MAG switch back to X1 and disconnect the test signal.

X–Y Display

1. Preset the instrument controls and obtain a baseline display.
2. Rotate the INTENSITY control fully counterclockwise.
3. Using two coaxial cables or probes of equal delay, apply the vertical signal (Y-axis) to the CH 2 OR Y input connector. Apply the horizontal signal (X-axis) to the CH 1 OR X input connector.
4. Set the SEC/DIV switch to X-Y (fully counterclockwise).
5. Increase the INTENSITY until you can see the display. If the display cannot be seen with the INTENSITY control at midrange, press and hold in the BEAM FIND button while adjusting the CH 1 and CH 2 VOLTS/DIV switches until the display is reduced in size, both vertically and horizontally.
6. With the BEAM FIND button still pressed in, center the compressed display with the POSITION controls (CH 2 POSITION control for vertical movement; Horizontal POSITION control for horizontal movement).
7. Release the BEAM FIND button and adjust the FOCUS control for a well-defined display.

NOTE

The display obtained when sinusoidal signals are applied to the X- and Y-axis is called a Lissajous figure. This display is commonly used to compare the frequency and phase relationship of two input signals. The frequency relationship of the two input signals determines the pattern seen. The pattern will be stable only if a common divisor exists between the two frequencies.

8. Set the SEC/DIV switch to 0.5 ms and disconnect the input signals from the vertical input connectors.

Single Sweep Display

1. Preset the instrument controls and obtain a baseline display.

NOTE

The critical part of single-sweep operation is setting the trigger point to get a sweep on a random event. You must know the characteristics of the signal that you want to trigger the sweep in order to set the Trigger controls correctly. You must also determine the correct slope to trigger on and set the Trigger SLOPE control to match.

2. Apply a test signal to the CH 1 OR X input to use for setting the Trigger LEVEL control. The test signal should be of the same amplitude and general type (negative or positive pulse or sinusoidal) as the signal you want to trigger on.

3. Set the CH 1 VOLTS/DIV control and adjust the vertical POSITION control to display the waveform correctly within the graticule area. The Horizontal POSITION control should be adjusted to place the beginning of the sweep about one division in from the left edge of the crt.

4. Switch the Trigger MODE to NORM and adjust the Trigger LEVEL control carefully until the display is stable.

5. Switch the Trigger MODE to SGL SWP and check that the sweep triggers when the RESET button is pressed. If it does not, readjust the Trigger LEVEL control slightly so that the sweep triggers each time the RESET button is pressed.

6. Disconnect the test signal from the CH 1 OR X input and apply the random signal to the input.

NOTE

The INTENSITY must be increased to see the single-sweep trace. At very fast sweep speeds, the trace may not be visible. Reducing the background lighting improves viewing of the single-sweep trace.

7. Press RESET. When the random trigger pulse occurs, a sweep will be started, and a single trace will be displayed. Until the trigger event occurs, the TRIG'D/READY light will be on to show that the oscilloscope is armed and ready to start the sweep when the trigger occurs.

8. When the single sweep has been triggered and completed, another sweep cannot be started until the RESET button is again pressed to rearm the sweep circuit.

DIGITAL STORAGE DISPLAYS

The following procedures explain how to set up and use the digital-storage capabilities of the instrument. The front-panel control selections set the conditions under which a waveform is acquired for display. Display amplitude is controlled by the VOLTS/DIV switches. The storage time base is controlled by the SEC/DIV switch. The SEC/DIV switch and the Trigger MODE switch will acquire and display waveforms using the parameters given in Table 3-3 (see Section 3).

STORE Mode Display

1. Preset the instrument controls and obtain a baseline trace.
2. Apply the signal to be displayed to the CH 1 OR X input.
3. Set the STORE/NON-STORE switch to the STORE position (button in).
4. Select either 25% (button in) or 75% (button out) pretrigger as needed for your measurement.
5. STORE mode displays may be expanded horizontally with the Horizontal MAG switch.

SAVE Mode Display

1. Acquire a waveform using the STORE Mode Display procedure.
2. Press in the ACQ SAVE/CONTINUE button to save the displayed waveform.
3. Pressing the switch again exits the SAVE Mode and continues the acquisition.

SAVE REFERENCE Display

1. Acquire the waveform to be used as a reference using the previous STORE Mode Display procedure.
2. Press the SAVE REF button to copy the displayed waveform into the Reference memory. The reference waveform copy is displayed along with the original waveform. A new reference waveform is saved each time the SAVE REF button is pressed.
3. Press the REFERENCE DISPLAY ON/OFF button to turn the stored reference waveform on or off. The reference remains stored in memory when switching to NON-STORE mode. It may be recalled at any time STORE mode is active. The reference is not saved when the oscilloscope is turned off.

4. Use the Reference POSITION control to position the reference display. It may be positioned only above the level of the signal it was copied from. No positioning below that level is possible. The channel Vertical POSITION controls do not affect the position of the reference display after it is saved, but they do set the base level of the reference at the time it is copied.

5. The reference display can be expanded horizontally along with the active acquisition display when the Horizontal MAG switch is changed to the X10 or X50 position.

MAKING NON-STORAGE MEASUREMENTS

The following procedures will enable you to perform some basic measurements and become familiar with the conventional oscilloscope capabilities of the 2211.

AC Peak-to-Peak Voltage

To make a peak-to-peak voltage measurement, use the following procedure:

NOTE

This procedure may also be used to make voltage measurements between any two points on the waveform.

1. Preset the instrument controls and obtain a baseline trace.

2. Apply the AC signal to either vertical-channel input connector and set the Vertical MODE switches to display the channel used.

3. Set the appropriate VOLTS/DIV switch to display about five divisions of the waveform. Make sure the Variable VOLTS/DIV control is in the CAL detent.

4. Adjust the Trigger LEVEL control to obtain a stable display.

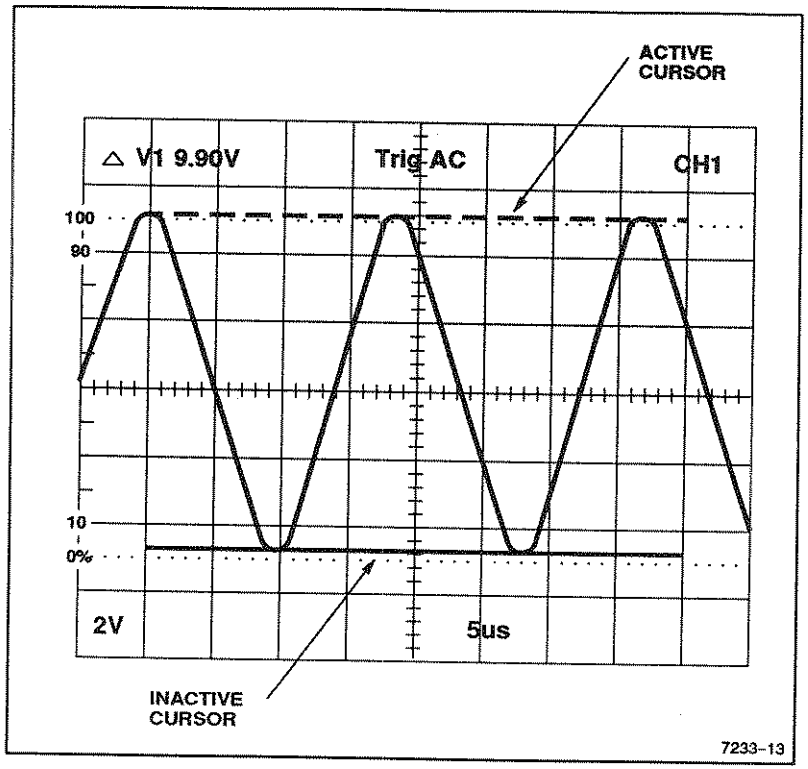


Figure 6-1. Peak-to-peak waveform voltage.

5. Adjust the SEC/DIV switch to display several cycles of the waveform.

6. Activate the Delta Volts measurement function by momentarily pressing in the ΔV button. Two horizontal, cursors should appear on the screen.

7. Position one cursor on the top of the waveform and the other on the bottom of the waveform, using the Cursor Position control. Rotate the control to move the active cursor, then press the control to change selection of the active cursor.

8. Read the voltage difference between the two cursors from the crt readout.

NOTE

In certain circumstances, such as comparing a test-signal amplitude to a reference amplitude, it may be more convenient to position the cursors in the Track mode. To activate Track, ensure that the TRACK/INDEP button is in. In this mode, the Cursor Position control will move both cursors equally.

Voltage Ratio

The Delta Volts function may also be used to measure and compute the ratio, in terms of percent, between two different signal voltages. To measure a voltage ratio in the general case situation of two separate signals use the following procedure:

1. Preset the instrument controls and obtain a baseline trace.
2. Apply the reference signal to either the CH 1 OR X or CH 2 OR Y input connector and select the Vertical MODE switch to display the channel used.
3. Set the appropriate VOLTS/DIV switch to display more than five divisions of the waveform.
4. Adjust the Trigger LEVEL to obtain a stable display.
5. Adjust the VOLTS/DIV control so that the reference waveform is exactly five divisions peak-to-peak.
6. Select Delta V and CURSORS ON and place the cursors at the top and bottom of the reference waveform. The cursors must be exactly five divisions apart ("Ratio 100%" will appear in the crt readout). If necessary, use the variable VOLTS/DIV control to adjust the reference waveform.
7. Remove the reference signal and apply the test signal to the same input connector. DO NOT change the VOLTS/DIV or variable VOLTS/DIV setting.

8. Align one cursor with the top of the waveform and the other cursor with the bottom of the waveform (see Figure 6-2).
9. Read the ratio between the test signal and the reference signal on the crt readout.

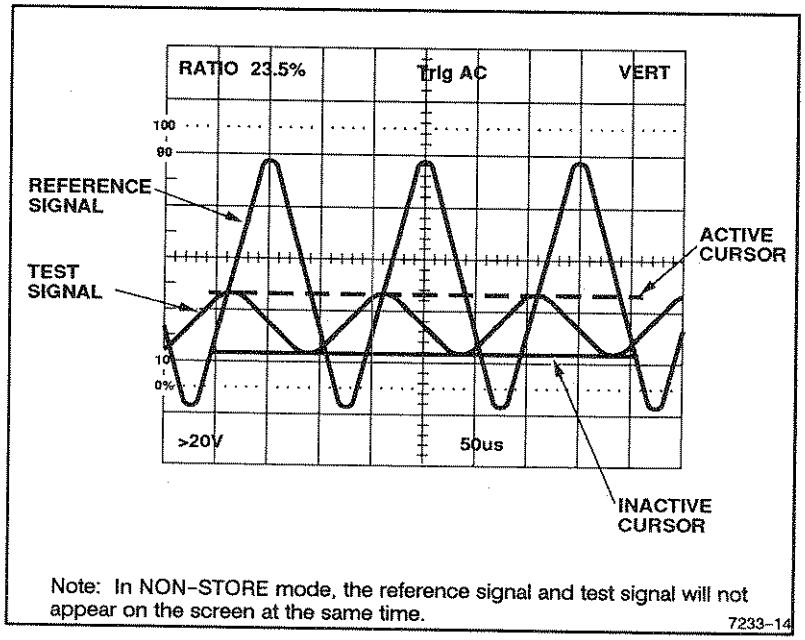


Figure 6-2. Voltage ratios.

Algebraic Addition

With the Vertical MODE switches set to add the signals (BOTH-ADD), the waveform displayed represents the algebraic sum of the signals applied to the CH 1 OR X and CH 2 OR Y input connectors (CH 1 + CH 2). If the NORM/CH 2 INVERT switch is in the invert position, the resulting waveform is the difference of the two input signals (CH 1 - CH 2). The deflection factor in ADD mode is the deflection factor indicated by either VOLTS/DIV switch only when both are set to the same setting. A common use for the ADD mode is to provide a dc offset for viewing an ac signal riding on top of a dc level.

The following general precautions should be observed when using the ADD mode:

1. Do not exceed the input voltage rating of the oscilloscope.

2. Do not apply signals that exceed the equivalent of about eight times the VOLTS/DIV switch setting, since large voltages may distort the display. For example, with a VOLTS/DIV switch setting of 0.5 V, the voltage applied to the input channel should not exceed 4 volts.

   EXAMPLE: Using the graticule center line as 0 V, the CH 1 signal is at a 3-division, positive dc level (see Figure 6-3A).

   a. Multiply 3 divisions by the VOLTS/DIV switch setting to determine the dc-level value.

   b. Apply a negative dc level (or positive level, using the CH 2 INVERT switch) of the value determined in part a (see Figure 6-3B) to the CH 2 OR Y input connector.

   c. Select ADD and BOTH Vertical MODE to place the resultant display within the operating range of the Vertical POSITION controls (see Figure 6-3C).

Common-Mode Rejection

The ADD mode can also be used to display signals that contain undesirable frequency components. The undesirable components can be eliminated through common-mode rejection. The precautions given under the preceding Algebraic Addition procedure should be observed.

EXAMPLE: The signal applied to the CH 1 OR X input connector contains unwanted frequency components (see Figure 6-4A).

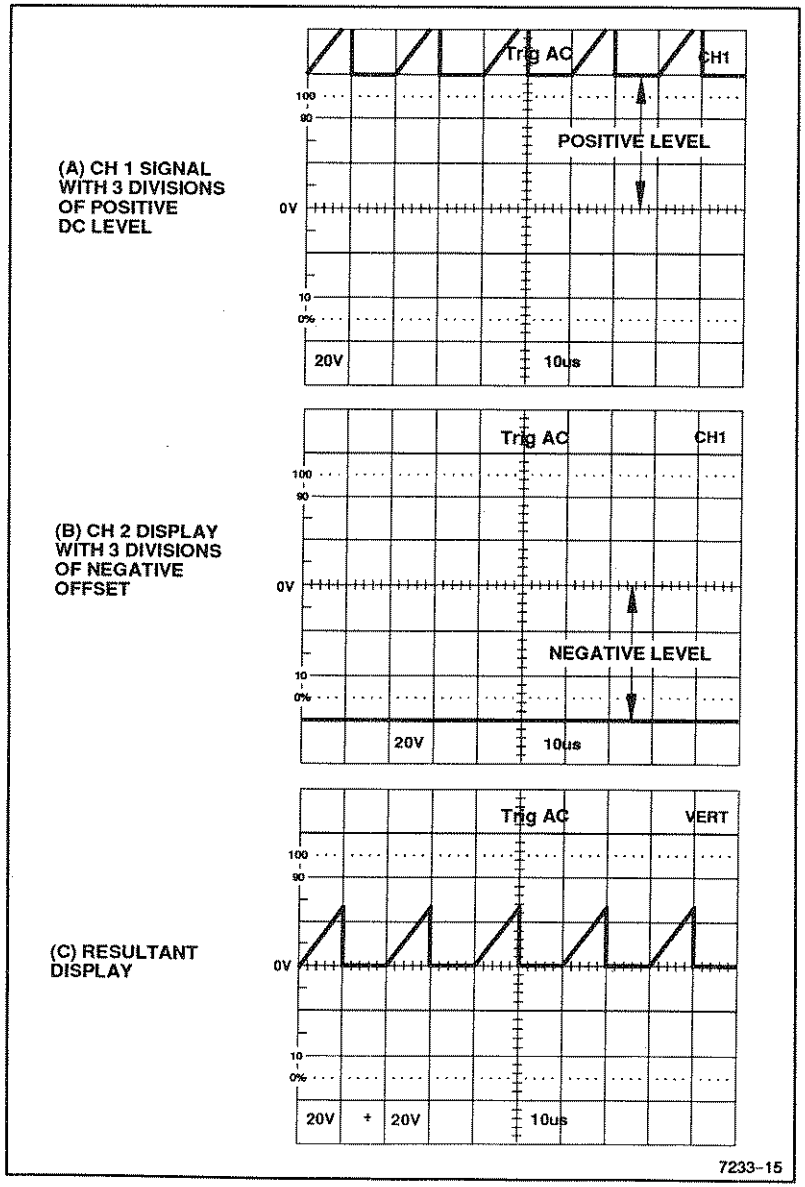


Figure 6-3. Algebraic addition.

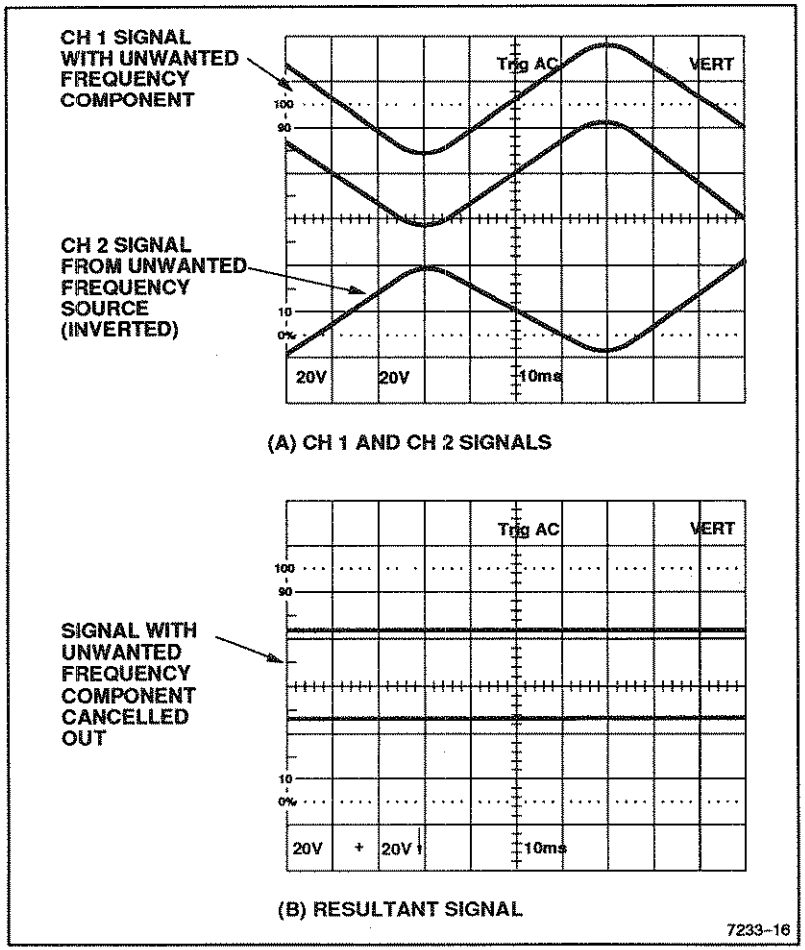


Figure 6–4. Common-mode rejection.

To remove the undesired components, use the following procedure:

1. Preset the instrument controls and obtain a baseline trace.
2. Apply the signal containing the unwanted components to the CH 1 input.

3. Apply the unwanted signal to the CH 2 OR Y input.

4. Select BOTH and ALT Vertical MODE and set the NORM/CH 2 INVERT switch to invert the signal.

5. Adjust the CH 2 VOLTS/DIV switch and Variable control to make the CH 2 display approximately the same amplitude as the undesired portion of the CH 1 display (see Figure 6-4A).

6. Select ADD Vertical MODE and slightly readjust the CH 2 Variable VOLTS/DIV control for maximum cancellation of the undesired signal component (see Figure 6-4B).

Rise Time

To measure the rise time of a waveform, use the following procedure:

1. Preset the instrument controls and obtain a baseline trace.

2. Apply the signal to either vertical-channel input connector and set the Vertical MODE switches to display the channel used.

3. Adjust the Trigger LEVEL control to obtain a stable display.

4. Use the VOLTS/DIV, Variable VOLTS/DIV, and POSITION controls to set the zero reference of the waveform to the 0% graticule line and the top of the waveform to the 100% graticule line. Make sure the Variable SEC/DIV control is in CAL detent and use the SEC/DIV control to expand the rise time horizontally if necessary.

5. Activate the Delta Time measurement function by momentarily pressing in the $\Delta T/1/\Delta T$ button. Set CURSORS ON. Two vertical cursors will appear on the crt screen.

6. Position the cursors to the 10% and 90% points of the waveform using the Cursor Position and Select Active Cursor controls (see Figure 6-5).

7. Read the time difference between the two cursors from the crt readout.

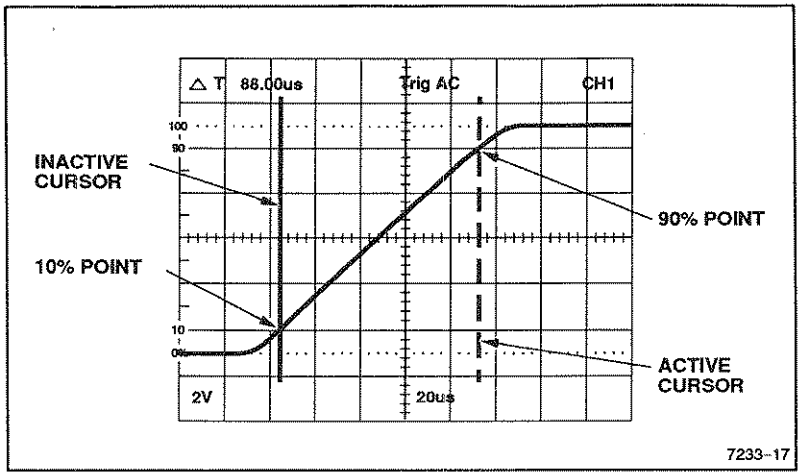


Figure 6-5. Rise Time.

Frequency

To measure the frequency of a waveform, use the following procedure.

1. Preset the instrument controls and obtain a baseline trace.
2. Apply the signal to either vertical channel input connector and set the Vertical MODE switches to display the channel used.
3. Adjust the Trigger LEVEL control to obtain a stable display.
4. Set the SEC/DIV control to display one complete period of the waveform. Make sure that the Variable SEC/DIV control is in CAL detent.
5. Activate the 1/Delta Time measurement function by pressing the ΔT/ 1/ΔT button twice. Observe that two vertical cursors appear on the crt.
6. Position the cursors to the zero-crossing points of the waveform using the Cursor Position control (see Figure 6-6).

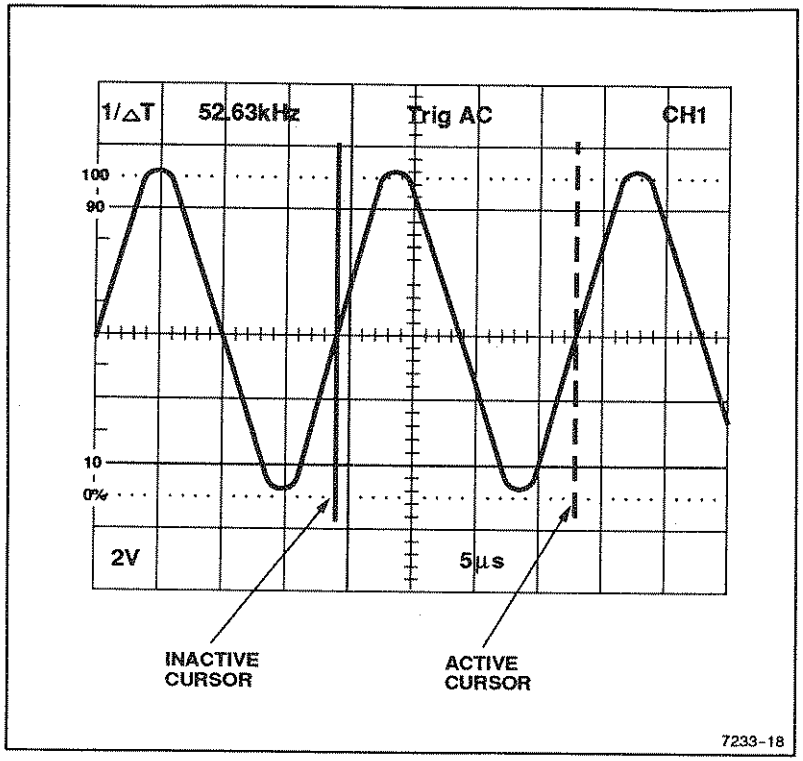


Figure 6–6. Measuring frequency.

Time Difference Between Two Time–Related Pulses

The calibrated sweep speed and dual–trace features of the instrument allow measurement of the time difference between two separate events. To measure time difference, use the following procedure:

1. Preset the instrument controls and obtain a baseline trace.
2. Set the Trigger SOURCE switch to CH 1.

3. Set both AC–GND–DC switches to the same position, depending on the type of input coupling desired (AC or DC).
4. Using either probes or cables with equal time delays, connect the reference signal to the CH 1 OR X input and the comparison signal to the CH 2 OR Y input.
5. Select BOTH Vertical Mode; then select either ALT or CHOP, depending on the frequency of the input signals.
6. Set both VOLTS/DIV switches for a 4- or 5-division display.
7. Adjust the Trigger LEVEL control for a stable display.
8. Set the SEC/DIV switch to a sweep speed which provides three or more divisions of horizontal separation between the reference points on the two displays. Center each of the displays vertically (see Figure 6–7).

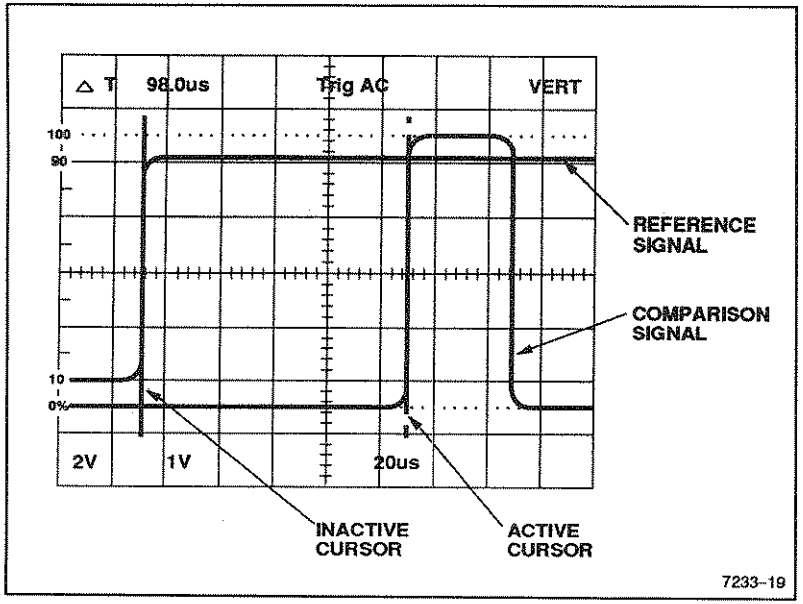


Figure 6–7. Time difference between two time-related pulses.

9. Activate the Delta Time measurement function and set the cursors to similar reference points (such as leading edges) on the two signal displays.

10. Read the time difference from the crt readout.

Time Ratio

The Delta Time function can also be used to measure and compute the ratio, in terms of percent, between two different time intervals. To measure a time ratio, use the following procedure:

1. Preset the instrument controls and obtain a baseline trace.

2. Apply the reference signal to either the CH 1 OR X or CH 2 OR Y input connector and select the Vertical MODE to display the channel used.

3. Set the appropriate VOLTS/DIV switch for a convenient amplitude display of the waveform.

4. Adjust the Trigger LEVEL control to obtain a stable display.

5. Set the SEC/DIV and Variable SEC/DIV controls to give a reference interval of exactly five horizontal divisions.

6. Select ΔT and CURSORS ON and position the cursors to the five-division (Ratio 100%) reference interval.

7. If the test interval is part of a different signal, apply the test signal to the unused vertical input and select the Vertical MODE to display the channel used. Do not change the SEC/DIV or Variable SEC/DIV setting.

8. Position one cursor to the left edge of the test interval and the other cursor to the right edge, using the Cursor Position and Select Active Cursor controls (see Figure 6-8).

9. Read the Ratio between the test interval and the reference interval from the crt readout.

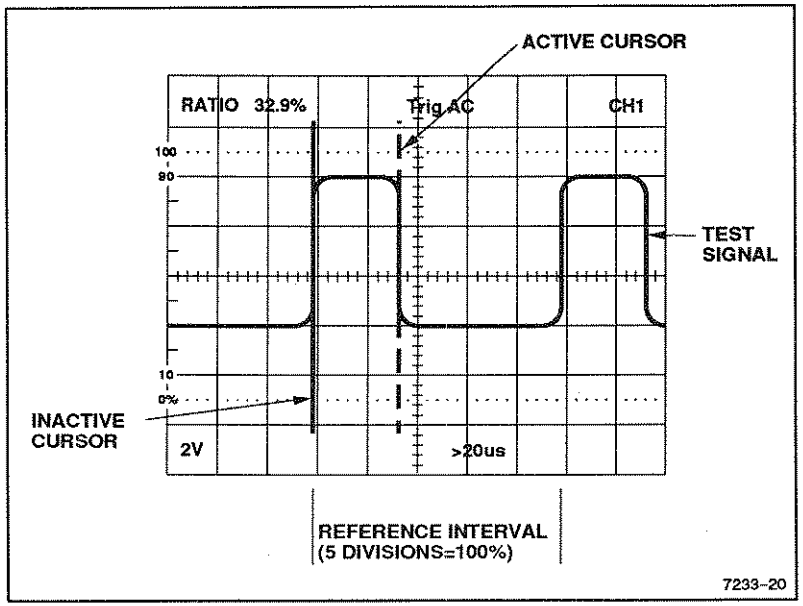


Figure 6-8. Time ratios.

Phase Difference

Phase comparison between two signals of the same frequency can be made using the dual-trace feature of the instrument. The method is similar to a time-difference measurement. The phase-difference measurement can be made up to the frequency limit of the vertical system. To make a phase comparison, use the following procedure:

1. Preset the instrument controls and obtain a baseline trace, then set the Trigger SOURCE switch to CH 1.

2. Set both AC-GND-DC switches to the same position, depending on the type of input coupling desired (AC or DC).

3. Using either probes or coaxial cables with equal time delays, connect a known reference signal to the CH 1 OR X input and the unknown signal to the CH 2 OR Y input.

4. Select BOTH Vertical Mode; then select either ALT or CHOP, depending on the frequency of the input signals. The reference signal should precede the comparison signal in time.

NOTE

If the two signals are of opposite polarity, you can set the CH 2 INVERT switch to invert the CH 2 display to make the phase measurement. You must remember to add 180 degrees to the phase difference to get the total phase shift between the two signals.

5. Set both VOLTS/DIV switches and both Variable controls so that the displays are equal in amplitude.

6. Adjust the Trigger LEVEL control for a stable display.

7. Set the SEC/DIV and Variable SEC/DIV controls for one period of the reference waveform to be exactly five divisions. Position the waveform to the zero-crossing point.

8. With the SEC/DIV control out of CAL detent, press the ΔT/1/ΔT button once or twice until "Phase" appears in the upper left corner of the crt screen. Set the cursors for one period of exactly five divisions (Phase 360.0 degrees) on the reference waveform. Readjust or position the reference waveform as necessary.

9. Do not change the SEC/DIV or Variable SEC/DIV controls. Position one cursor to the first zero-crossing point on the test waveform (see Figure 6-9).

10. Read the phase difference in degrees from the crt readout.

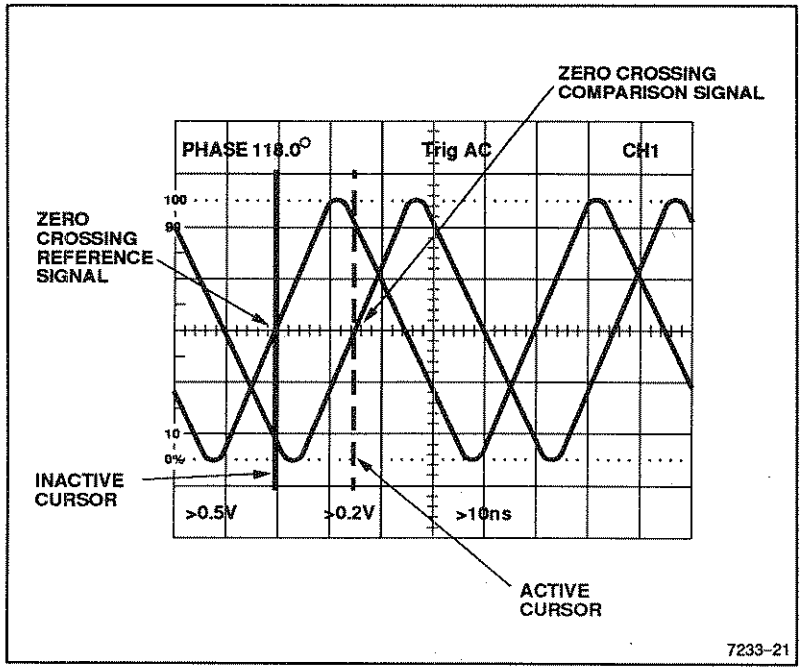


Figure 6-9. Phase difference between two time-related signals.

Small-Angle Phase Difference

If the phase difference between the two signals being measured is small, increased resolution for setting the cursors can be obtained by using the X10 MAG feature.

1. Perform steps 1 through 6 of the preceding "Phase Difference" procedure to obtain a five-division display of one cycle of the reference and comparison signals.

2. Use the Horizontal POSITION control to move the zero-crossing points of the signals being measured to the center vertical graticule line.

3. Select X10 MAG and use the Horizontal POSITION and the Cursor Position control to align the reference zero-crossing with one cursor.

4. Align the other cursor with the second comparison zero-crossing (see Figure 6-10).

5. Read the magnified phase difference in degrees from the crt readout. Divide the reading by 10 to obtain the correct phase difference between the two signals.

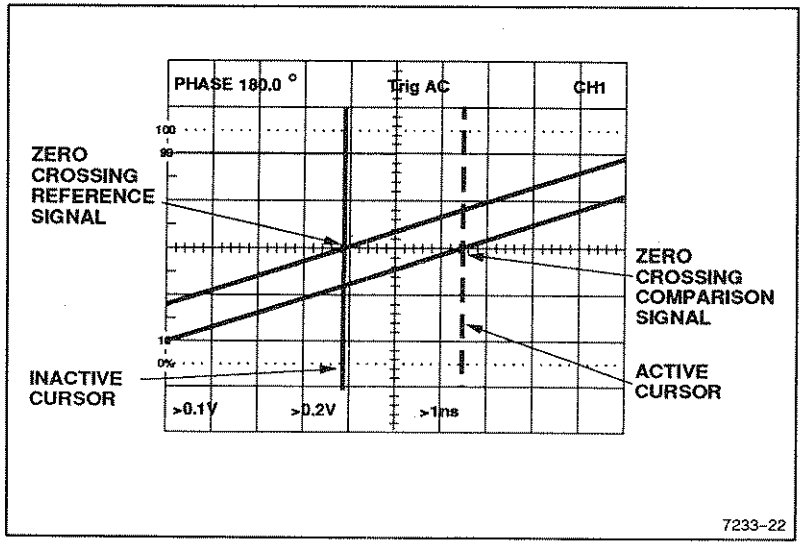


Figure 6-10. Small-angle phase difference.

Percent Modulation

To measure percent modulation, the following procedure should be adopted:

1. Preset the instrument controls and obtain a baseline trace.

2. Apply the signal to either vertical channel input connector and set the Vertical MODE switches to display the channel used.

3. Adjust the Trigger LEVEL control to obtain a stable display.

4. Using the VOLTS/DIV and Vertical position controls, position the waveform such that dimension C (see Figure 6-11) is equal to 100%.

5. Activate the Delta Volts measurement function and remove the VOLTS/DIV switch and the SEC/DIV switch from CAL detent. This will activate Ratio.

6. Position the cursors, using the Cursor Position control, as shown by dimension D in Figure 6-11.

7. The 2211 will display the percentage modulation in the top left-hand corner of the crt.

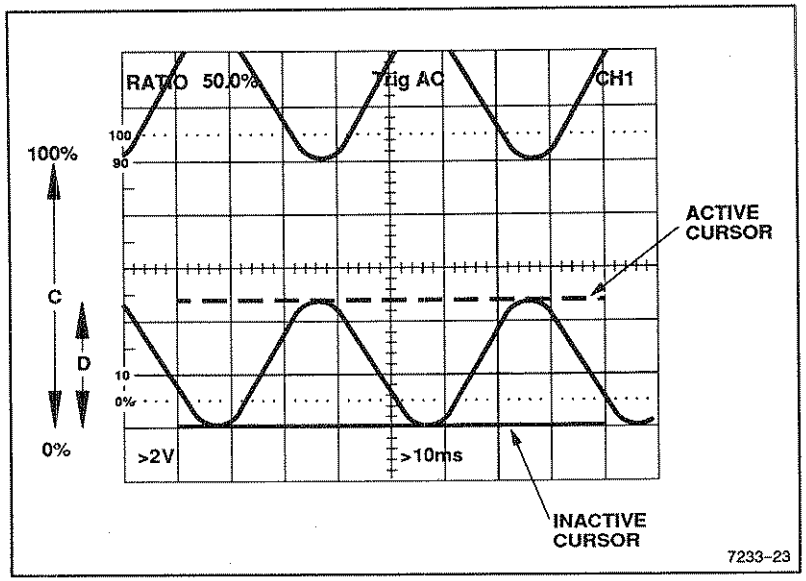


Figure 6-11. Percentage Modulation.

TV Line Signal

The following procedure is used to display a TV Line signal:

1. Preset the instrument controls and select P-P AUTO/TV LINE Trigger Mode.
2. Apply the TV signal to either vertical channel input connector and set the CH 1-BOTH-CH 2 Vertical MODE switch to display the channel used.
3. Set the appropriate VOLTS/DIV switch to display 0.3 divisions or more of the composite video signal.
4. Set the SEC/DIV switch to 10 μs.
5. Set the Trigger SLOPE switch to either positive slope for positive-going TV signal sync pulses or negative slope for negative-going TV signal sync pulses.

NOTE

To examine a TV Line signal in more detail, set the Horizontal MAG switch to X10.

TV Field Signal

The television feature of the instrument can also be used to display TV Field signals.

1. Preset the instrument controls and obtain a baseline trace.
2. Set the Trigger MODE switch to TV FIELD and set the SEC/DIV switch to 2 ms.
3. To display a single field, connect the TV signal to either vertical-channel input connector and set the CH 1-BOTH-CH 2 Vertical MODE switch to display the channel used.
4. Set the appropriate VOLTS/DIV switch to display 2.5 divisions or more of the composite video signal.

5. Set the Trigger SLOPE switch to either positive slope for positive-going TV signal sync pulses or negative slope for negative-going TV signal sync pulses.

6. To change the field that is displayed, momentarily interrupt the trigger signal by setting the AC-GND-DC switch to GND and then back to AC until the desired field is displayed.

NOTE

To examine a TV Field signal in more detail, set the Horizontal MAG switch to X10.

7. To display either Field 1 or Field 2 individually, connect the TV signal to both the CH 1 OR X and CH 2 OR Y input connectors and select BOTH and ALT Vertical Modes.

8. Set the SEC/DIV switch to a faster sweep speed (displays of less than one full field). This will synchronize the CH 1 display to one field and the CH 2 display to the other field.

MAKING DIGITAL STORAGE MEASUREMENTS

The following procedures will enable the operator to perform some basic measurements and familiarize themselves with digital-storage techniques. The preceding NON-STORE measurements, except Time ratio and phase, may be performed in STORE mode. However, if you are not familiar with acquiring a signal in digital storage, you may wish to review the previous information on Digital Storage Displays in this section.

1. After presetting the instrument controls and obtaining a display of the signal to be measured in NON-STORE mode, set the STORE/NON-STORE switch to the STORE position (button in).

2. Prior to making measurements on the acquired waveform, press on the ACQ SAVE/CONTINUE button to hold the acquired waveform and to provide a more stable display for measurement.

Waveform Comparison

Repeated comparisons of the newly acquired signals with a reference signal for amplitude, timing, or pulse-shaped analysis may be easily and accurately made using the Save Reference function of the instrument.

1. Preset the instrument controls and obtain a display of the reference signal.
2. Set the STORE/NON-STORE switch to the STORE position (button in).
3. Select a VOLTS/DIV switch setting that gives the desired vertical deflection.
4. Set the SEC/DIV switch to display the reference signal with the desired sweep rate (the fastest STORE mode sweep rate is 20 μs per division).
5. Push in the Reference SAVE REF button to store the reference waveform into reference memory.
6. Acquire the waveform that is to be compared with the reference waveform.

NOTE

A store reference will remain displayed until the Reference DISPLAY ON/OFF button is pushed again. Switching the instrument to NON-STORE removes stored waveforms from the display, but the saved reference waveforms remain in the digital memory for use upon return to a STORE mode. A new reference waveform is saved each time the SAVE REF button is pressed while in STORE mode. The reference waveforms are NOT saved during power off.

7. Use the Reference POSITION control to overlay the reference waveform on the newly acquired waveform for making the comparison (see Figure 6-12). The STORE mode vertical deflection and sweep rate are calibrated to allow direct measurement from the graticule.

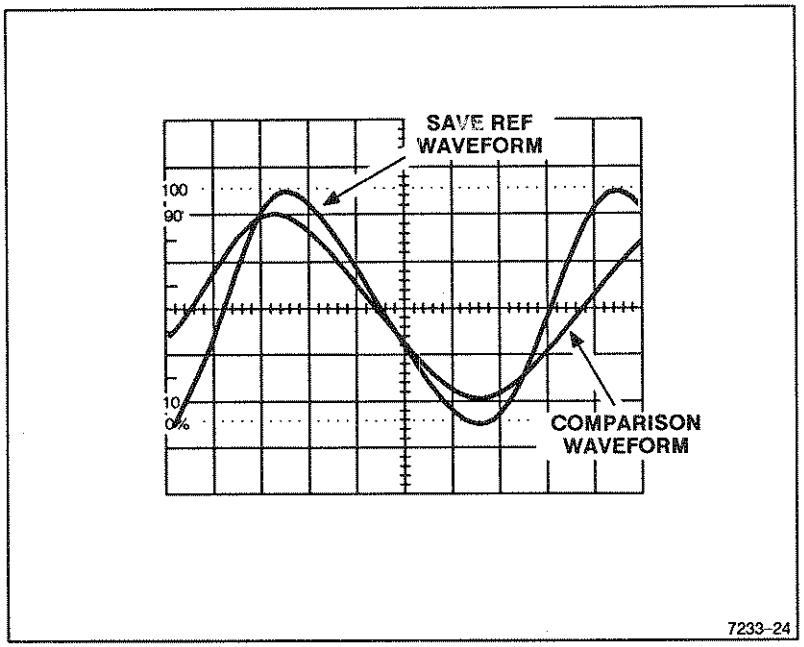


Figure 6-12. Waveform comparison.

Waveform-Based Cursors

The 2211 can be used to make very accurate timing measurements if the Delta T cursors are enabled in STORE mode. This facility "attaches" the cursors to the waveform and can prove especially useful when signals need to be measured which require a SEC/DIV setting of <20 µs. An example is outlined below.

RISE TIME MEASUREMENTS IN STORE MODE. To measure the rise time of the waveform, use the following procedure:

1. Preset the instrument controls and obtain a baseline trace.

2. Apply the signal to either vertical-channel input connector and set the Vertical MODE switches to display the channel used.

3. Adjust the Trigger LEVEL control to obtain a stable display.

4. Set the SEC/DIV control and alter the position controls so that the zero reference of the waveform touches the 0% graticule line and the top of the waveform the 100% graticule line. Make sure that the Variable SEC/DIV control is in the CAL detent position.

5. Activate the Delta Time measurement function by momentarily pressing in the ΔT/1/ΔT button. Observe that two vertical cursors appear on the crt screen.

6. Press STORE/NON-STORE to STORE. This will result in the cursors become "attached" to the waveform with the site of attachment being indicated by a bright dot.

7. Position the cursors to the approximate positions required on the waveform using the Cursor Position control.

8. Select X10 or X50. The cursors will be magnified with the waveform and may disappear off-screen.

9. Using the Horizontal POSITION control, position the trace so that one of the cursors appears on the screen.

10. The Cursor Position control can now be used to position the active cursor on the expanded trace to a high accuracy.

11. Position the other cursor on the crt screen, using the Horizontal POSITION control and reposition it on the waveform, if required, using the Cursor Position control.

12. Read the time difference between the two cursors from the crt readout.

NOTE

When switching from NON-STORE to STORE, the resolution of the Delta T readout display increases by one decimal place to reflect the greater accuracy of waveform-based cursor measurements.

OBSERVING AND REMOVING ALIASES IN STORE MODE

Aliasing

In digital sampling, a more accurate reproduction of a signal is possible when more samples of the signal are obtained. The instrument samples 4000 times across the 10 horizontal divisions of the graticule. This means that a sine wave spread across the full screen will be sampled 4000 times, but if the sine wave is only one graticule division in width, it will be sampled one-tenth as many times (400 samples). This number is still adequate for accurate reproduction of the stored waveform.

If the SEC/DIV switch is set so that the entire sine-wave period fills one-tenth of a graticule division, it will be sampled only 40 times during its acquisition. This means that only 40 samples of the waveform will be available to reproduce the waveform for display. In theory, if a sine wave is sampled at least two times during its period, it may be accurately reproduced. In practice, the sine wave can be reconstructed, using special filters, from slightly more than two samples.

At 20 µs per division, and with a horizontal magnification of X10, a signal of 2 MHz will be sampled 10 times during the sine-wave period. Consequently the waveform will be accurately reproduced within 95% of its true amplitude. This is the accuracy required for useful storage bandwidth.

If the input frequency is increased beyond 8 MHz, the samples will soon become less than two times per period. This occurs at 10 MHz for a 20 MHz sample rate. Past this point, information sampled from two different sine-wave periods will be used to reconstruct the displayed waveform. This waveform will not be a correct reproduction of the input signal. At certain input frequencies, the data sampled will reproduce what appears to be a correct display, when in fact it is only related to the input signal by some multiple or part of a multiple of the input signal. This type of display is one type of "alias" (see Figure 6-13A).

The example given is for the maximum sampling rate of 20 MHz. However, the sampling rate is controlled by the SEC/DIV switch, and it decreases when the SEC/DIV switch is set to slower settings. Whenever the SEC/DIV switch is set so that the input signal is sampled less than 10 times per period of the fastest frequency component, observable aliases will occur.

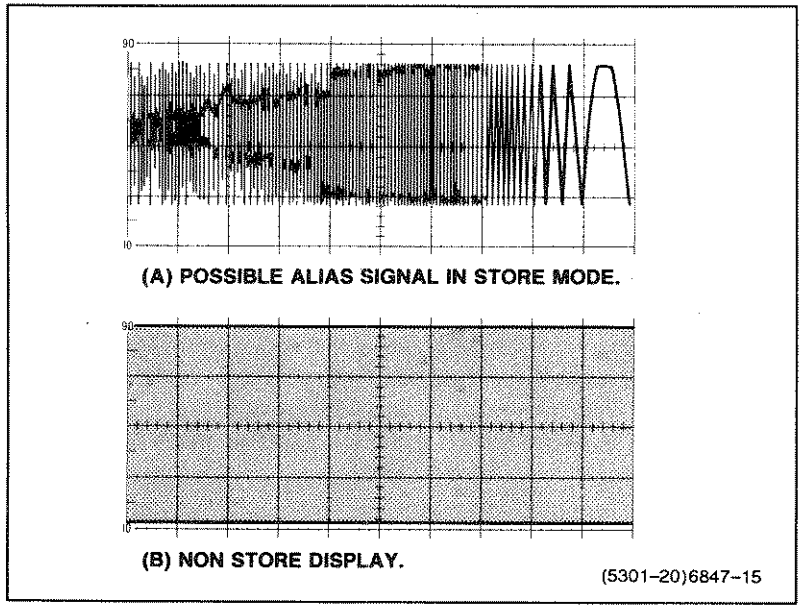


Figure 6-13. Anti-aliasing.

Anti–Aliasing

In the event that an alias is suspected, two things may be done to determine whether the display is of an alias. The first is to switch back to NON–STORE mode to determine if the input signal is higher in frequency than the apparent signal being displayed (see Figure 6–13B). Ensure that this display is being triggered; indicated by the TRIG'D/READY light being on.

The SEC/DIV switch may also be set for a faster sweep rate so that the number of samples per cycle of the input signal is increased. The maximum digital sweep speed available on the 2211 for STORE mode is 20 μs per division.

SECTION 7

OPTIONS AND ACCESSORIES

OPTIONS AND ACCESSORIES

INTRODUCTION

This part contains a general description of instrument options available at the time of publication of this manual. Also included is a complete list (with Tektronix part numbers) of standard accessories included with each instrument and a partial list of optional accessories. Additional information about instrument options, option availability, and other accessories can be obtained either by consulting the current Tektronix Product Catalog or by contacting your local Tektronix Field Office or representative.

STANDARD ACCESSORIES

The following standard accessories are provided with each instrument:

Qty	Description	Part Number
2	10X, P6109 Probe packages	P6109
1	Power Cord and Fuse	As Ordered
1	Operator's Manual	070-7233-00
1	User Reference Guide	070-7235-00
1	Loop Clamp	343-0003-00
1	Flat Washer	210-0803-00
1	Self-Tapping Screw	213-0882-00

OPTIONS

Option 02

This option is intended for users who need added front-panel protection and accessories-carrying ease demanded by frequent travel to remote service sites. It includes a protective front-panel cover and an accessories pouch that attaches to the top of the instrument.

Option 1R

When the oscilloscope is ordered with Option 1R, it is shipped in a configuration that permits easy installation into virtually any 19-inch-wide, electronic-equipment rack. All hardware is supplied for mounting the instrument into the rack.

Complete rack-mounting instructions are provided in a separate document. These instructions also contain the procedures for converting a standard instrument into the Option 1R configuration by using the separately ordered rack-mounting conversion kit.

Option 07

When the instrument is ordered with Option 07, it is supplied fitted with a dc power supply, for applications where mains power may not be accessible. See Appendix B for Instructions.

POWER CORD OPTIONS

Instruments are shipped with the detachable power-cord configuration ordered by the customer. Information about the international power-cord options is provided in Section 2, Preparation for Use. The following list identifies the Tektronix part number for the available power cords.

Standard (United States)

Power Cord, 2.5 m	161-0104-00
Fuse, 1.0 A, 250 V, 3AG 1/4 x 1/4 inch, slow-blow	159-0019-00

Option A1 (Universal Euro)

Power Cord, 2.5 m	161-0104-06
Fuse, 0.5 A, 250 V, 3AG 1/4 x 1/4 inch, slow-blow	159-0032-00

Option A2 (United Kingdom)

Power Cord, 2.5 m	161-0104-07
Fuse, 0.5 A, 250 V, 3AG 1/4 x 1/4 inch, slow-blow	159-0032-00

Option A3 (Australia)

Power Cord, 2.5 m	161-0104-05
Fuse, 0.5 A, 250 V, 3AG 1/4 x 1/4 inch, slow-blow	159-0032-00

Option A4 (North America)

Power Cord, 2.5 m	161-0104-08
Fuse, 0.5 a, 250 V, 3AG 1/4 x 1/4 inch, slow-blow	159-0032-00

Option A5 (Switzerland)

Power Cord, 2.5 m	161-0167-00
Fuse, 0.5 A, 250 V, 3AG 1/4 x 1/4 inch, slow-blow	159-0032-00

OPTIONAL ACCESSORIES

The following optional accessories are recommended for use with the instrument.

Instrument Enhancements	Part Number
Front-panel Protective Cover	200-3397-00
Accessory Pouch	016-0677-02
Front-panel Protective Cover and Accessory Pouch	020-1514-00
Carrying Case	016-0792-01
CRT Light Filter, Clear	337-2775-01
Rack Mount Conversion Kit	016-1023-00
Portable Instrument Cart	K212
Service Manual	070-7234-00

Viewing Hoods	Part Number
Collapsible	016-0592-00
Polarized	016-0180-00
Binocular	016-0566-00

Alternative Power-Cords	Part Number
European	020-0859-00
United Kingdom	020-0860-00
Australian	020-0861-00
North American	020-0862-00
Swiss	020-0863-00

Attenuator Voltage Probes	Part Number
10X Standard	P6109
10X Subminiature	P6121
10X Environmental	P6008
1X-10X Selectable	P6062B
100X High Voltage	P6009
1000X High Voltage	P6015

Current Probes	Part Number
Low-current	P6021, P6022
High-current	A6302/AM503
	A6303/AM503
Current-Probe Amplifier	134
Active Probe, 10X FET	P6202A
Active Probe Power Supply	1101A
Ground Isolation Monitor	A6901
Isolator (for multiple independently referenced differential measurements)	A6902B

Power Accessories	
DC Inverter	1107
DC Inverter Mounting Kit	016-0785-00
Portable Power Supply	1105
Battery Pack	1106

Oscilloscope Cameras

Low–cost C–5C	Option 04
Motorized C–7	Option 03 with Option 30

SECTION 8

PERFORMANCE CHARACTERISTICS

PERFORMANCE CHARACTERISTICS

INTRODUCTION

The following electrical characteristics (Table 8–1) are valid when the instrument has been adjusted at an ambient temperature between +20°C and +30°C, has had a warm-up period of at least 20 minutes, and is operating at an ambient temperature between 0°C and +40°C (unless otherwise stated).

Items listed in the Performance Requirements column are verifiable limits that define the measurement capabilities of the instrument.

Environmental characteristics are given in Table 8–2. This instrument meets the requirements of MIL–T–28800C for Type III, Class 5 equipment, except where noted otherwise.

Mechanical characteristics of the instrument are listed in Table 8–3.

SPECIFICATION TABLES

Table 8–1

Electrical Characteristics

Characteristics	Performance Requirements
VERTICAL DEFLECTION SYSTEM	
Deflection Factor	
Range	5 mV per division to 5 V per division in a 1–2–5 sequence. Sensitivity increases to 500 μV per division in X10 mag.
DC Accuracy	**X1** | **X10** ±3% | ±5% For 5 mV per division to 5 V per division the gain is set with the VOLTS/DIV switch at 5 mV per division.
Storage Acquisition	
Vertical Resolution	8–bits, 25 levels per division.
Dynamic Range	10.24 division.
Range of Variable VOLTS/DIV Control	Continuously variable between settings. Increases deflection factor by at least 2.5 to 1.
Step Response (NON–STORE Mode)	
Rise Time	
5°C to +35°C	
5 mV per division to 5 V per division	7.0 ns or less.

Table 8-1 (cont)

Characteristics	Performance Requirements
Step Response (NON-STORE Mode) (cont)	
Rise Time (cont)	
0°C to +40°C	
5 mV per division to 5 V per division	8.8 ns or less. Rise time is calculated from this formula: $\text{Rise Time} = \frac{0.35}{\text{Bandwidth (-3 dB)}}$
Step Response (STORE Mode)	
Useful Storage Rise Time	$\frac{\text{SEC/DIV X 1.6}}{400}$ s Rise time is limited to 35 ns minimum.
Aberrations (NON-STORE and STORE)	At +25°C with cabinet installed.
5 mV per division	6% or less.
10 mV per division to 0.2 V per division	4% or less.
0.5 V per division	6% or less.
NON-STORE Bandwidth (-3 dB)	
5°C to +35°C	
5 mV per division to 5 V per division	DC to at least 50 MHz.

Table 8–1 (cont)

Characteristics	Performance Requirements
NON–STORE Bandwidth (–3 dB) (cont)	
0°C to +40°C	
5 mV per division to 5 V per division	DC to at least 40 MHz. Measured with a vertically centered six–division reference signal, from a 50–Ω source driving a 50–Ω coaxial cable terminated in 50 Ω at the input connector and the VOLTS/DIV Variable control in the CAL detent.
X10 Bandwidth (–3 dB)	DC to at least 5 MHz.
AC Coupled Lower Cutoff Frequency	10 Hz or less at –3 dB.
Useful Storage Performance	
20 µs per division to 50 s per division	$\frac{20}{\text{SEC/DIV}}$ Hz. Accuracy at useful storage performance limit is measured with respect to a six–division, 50 kHz reference sine wave.
EXT CLOCK (up to 10 MHz)	EXT/20 Hz.
NON–STORE CHOP Mode Switching Rate	500 kHz ±30%.
A/D Converter Linearity	Monotonic with no missing codes.

Table 8-1 (cont)

Characteristics	Performance Requirements
Input Characteristics	
Resistance	1 MΩ ±2%.
Capacitance	25 pF ±2.0 pF.
Maximum Safe Input Voltage	
DC and AC coupled	400 V (dc + peak) or 800 V ac p-p at 10 kHz or less. See Figure 8-1 for maximum input voltage vs. frequency derating curve.
Common-Mode Rejection Ratio (CMRR)	Checked at 5 mV per division for common-mode signals of six divisions or less with VOLTS/DIV Variable control adjusted for the best CMRR at 50 kHz.
NON-STORE	At least 10:1 at 20 MHz.
X10 MAG	At least 10:1 at 1 MHz. (Checked at 500 μV setting).
STORE	At least 10:1 at 10 MHz.
X10 MAG	At least 10:1 at 1 MHz. (Checked at 500 μV setting).
Trace Shift with VOLTS/DIV Switch Rotation	0.25 divisions or less; Variable VOLTS/DIV control in CAL detent.
Trace Shift as the VOLTS/DIV Variable control is rotated	1 division or less.

Table 8–1 (cont)

Characteristics	Performance Requirements
Trace Shift with INVERT	1.5 divisions or less.
Trace Shift with X10 MAG	2.0 divisions or less.
NON–STORE Channel Isolation	Greater than 100:1 at 10 MHz.
STORE Channel Isolation	Greater than 100:1 at 10 MHz.
TRIGGERING SYSTEM	
Trigger Sensitivity	
P–P AUTO and NORM	**5 MHz** / **50 MHz**
Internal	0.35 div / 1.0 div
External	40 mV p–p / 150 mV p–p
	External trigger signal from a 50–Ω source driving a 50–Ω coaxial cable terminated in 50–Ω at the input connector.
TV LINE	**Internal** / **External**
	0.35 div / 40 mV p–p
TV FIELD	1 division of composite sync.
P–P AUTO Lowest Usable Frequency	20 Hz with 1 division internal or 100 mV p–p external.

Table 8–1 (cont)

Characteristics	Performance Requirements
EXT INPUT	
Maximum Input Voltage	400 V (dc + peak ac) or 800 V ac p–p at 10 kHz or less. See Figure 8–1 for maximum input voltage vs. frequency derating curve.
Input Resistance	1 MΩ ±10%.
Input Capacitance	25 pF ±2.5 pF.
LEVEL Control Range (NORM Trigger Mode)	
Internal Trigger	May be set to any voltage level of the trace that can be displayed.
EXT, DC Coupling	At least ±1.2 V, 2.4 V p–p.
EXT/10, DC Coupling	At least ±12 V, 24 V p–p.
Variable HOLDOFF Control	Increases Sweep holdoff time by at least a factor of 8, with the SEC/DIV switch set to 1 ms.
DC Coupled Bandwidth	DC to full bandwidth.
Acquisition Window Trigger Point	
25% PRETRIG	25% of the trace is prior to the trigger.
75% PRETRIG	75% of the trace is prior to the trigger.

Table 8–1 (cont)

Characteristics	Performance Requirements		
HORIZONTAL DEFLECTION SYSTEM			
NON–STORE Sweep Rates			
Calibrated Range	0.5 s per division to 0.05 μs per division in a 1–2–5 sequence of 22 positions. The X10 magnifier extends maximum sweep speed to 5 ns per division.		
STORE Mode Ranges			
RECORD	20 μs per division to 50 ms per division.		
ROLL	0.1 s per division to 0.5 s per division; 1 s per division to 50 s per division in 100X.		
NON–STORE/STORE Accuracy	**X1**	**X10**	**X50**
+15°C to + 35°C	±3%	±4%	±5%
0°C to + 40°C	±4%	±5%	±8%
	Sweep accuracy applies over the center eight divisions. Exclude the first 50 ns of the sweep for X10 magnified sweep and the first 100 ns of the X50 magnified sweep. Exclude anything past the 10th division of unmagnified sweeps.		
Horizontal POSITION Control Range	Start of the 10th division will position past the center vertical graticule line in X10 (100th division in X10 Mag).		

Table 8-1 (cont)

Characteristics	Performance Requirements		
STORE/NON-STORE Sweep Linearity	**X1**	**X10**	**X50**
	±5%	±8%	±9%
	Linearity measured over any two of the center 8 divisions. Exclude the first 50 ns of the X10 magnified sweep and the first 100 ns of the X50 magnified sweep. Exclude anything past the 10th division of the unmagnified sweep.		
Digital Sample Rate 20 µs/div to 50 s/div	$\frac{400}{\text{SEC/DIV}}$ Hz.		
External Clock Input Freq.			
RECORD	DC to 10 MHz.		
ROLL	DC to 4 kHz.		
Digital Sample Rate	Equal to the input frequency.		
Duty Cycle	**LO (min)**	**HI (min)**	
RECORD	50 ns	50 ns	
ROLL	50 µs	125 ns	
Logic Thresholds			
LOW	0.7 V.		
HIGH	2.1 V.		
Maximum Safe Input Voltage	25 V (dc + peak ac) or 25 V p-p ac at 100 kHz or less. See Figure 8-2 for the maximum input voltage vs. frequency derating curve.		

Table 8-1 (cont)

Characteristics	Performance Requirements
Input Resistance	1 MΩ ±10%.
Input Capacitance	25 pF ±2.5 pF.
STORE Mode Resolution	
Acquisition Record Length	4096 data points.
Waveform Acquisition Display	4095 data points (400 data points/div across the graticule area).
Variable SEC/DIV Control Range	
NON-STORE	Continuously variable between calibrated settings of the SEC/DIV control. Extends the Sweep speeds by at least a factor of 2.5 times over the calibrated SEC/DIV switch settings.
STORE	At SEC/DIV switch settings between 0.5 s and 10 ms, when the Variable SEC/DIV control is removed from the detent position, the SEC/DIV setting is multiplied by 100 and the STORE display is set to ROLL. When the SEC/DIV switch is set to EXT CLK, the Variable SEC/DIV control selects the display mode as shown below.

Variable Position	Display Mode	Frequency Range
CAL	RECORD	DC to 10 MHz
UNCAL	ROLL	DC to 4 kHz

Table 8-1 (cont)

Characteristics	Performance Requirements
Displayed Trace Length	Greater than 10 divisions.
Registration of Magnified and Unmagnified Traces	Registration of unmagnified trace with magnified trace aligned to the center vertical graticule line is better than 0.2 division.
DIGITAL STORAGE DISPLAY	
Vertical	
Resolution	8-bit (1 part in 256). Display waveforms calibrated for 25 points per division.
Position Registration	
NON-STORE to STORE	Within ±0.5 division at graticule center at VOLTS/DIV switch settings from 5 mV/div to 5 V/div.
REFERENCE POSITION Control Range	At least +3 divisions.
Horizontal	
Digital Sweep	Calibrated to 400 points per division.
Expansion Range	1, 10 or 50 times as determined by the MAG switch.

Table 8-1 (cont)

Characteristics	Performance Requirements		
DIGITAL READOUT DISPLAY			
Cursor Accuracy			
Voltage Difference	Within ±3% of the ΔV readout value, (±5% in X10 MAG) measured over the center six divisions.		
Time Difference			
NON-STORE	**X1**	**X10**	**X50**
15° to 35°C	±4%	±5%	±6%
0° to 40°C	±5%	±6%	±9%
	Measured over the center eight divisions.		
STORE			
0° to 40°C	±0.1% of unmagnified sweep.		
Trigger Level Readout Accuracy			
15° to 35°C	Within ±0.3 division +5% of reading with less than 8 divisions vertical input signal.		
X-Y OPERATION (X1 MAG AND NON-STORE ONLY)			
Deflection Factors	Same as vertical deflection system with the VOLTS/DIV Variable controls in the CAL detent positions.		
Accuracy			
X-Axis	Measured with a dc-coupled, five-division reference signal. Within ±5%.		
Y-Axis	Same as vertical deflection system.		

Table 8-1 (cont)

Characteristics	Performance Requirements
Bandwidth (-3 dB)	
X-Axis	Measured with a five-division reference signal. DC to at least 2 MHz.
Y-Axis	Same as vertical deflection system.
NON-STORE Phase Difference between X-Axis and Y-Axis Amplifiers	±3° from dc to 150 kHz. Vertical Input Coupling set to dc.
PROBE ADJUST	
Output Voltage on Probe Adjust Jack	0.5 V ±5%.
Repetition Rage	1 kHz ±20%.
Z-AXIS	
Sensitivity (NON-STORE Only)	5 V causes noticeable modulation. Positive-going input decreases intensity.
Usable Frequency Range	DC to 5 MHz.
Maximum Safe Input Voltage	Same as External Trigger.

Table 8-1 (cont)

Characteristics	Performance Requirements
POWER SUPPLY	
Line Voltage Ranges	95 Vac to 128 Vac and 190 Vac to 250 Vac.
Line Frequency	48 Hz to 440 Hz.
Maximum Power Consumption	85 Watts (95 VA).
Line Fuse	
115 V operation	1 A, slow-blow.
230 V operation	0.5 A, slow-blow.
CRT DISPLAY	
Display Area	8 X 10 cm.
Standard Phosphor	P31.
Nominal Accelerating Voltage	12.6 kV.

Table 8-2

Environmental Specification

Characteristics	Performance Requirements
Temperature	
Operating	0°C to +40°C (+32°F to +93°F).
Nonoperating	-55°C to +75°C (-67°F to +167°F). Tested to MIL-T-28800C, para 4.5.5.1.3 and 4.5.5.1.4 (0°C operating test) except that in para 4.5.5.1.3, steps 4 and 5 are performed before step 2 (-55°C nonoperating test). Equipment shall remain off upon return to room ambient temperature during step 6. Excessive condensation shall be removed before operating during step 7.
Altitude	
Operating	To 4,500 meters (15,000 feet). Maximum operating temperature decreases 1°C per 1000 feet above 5,000 feet.
Nonoperating	To 15,000 meters (50,000 feet).
Humidity, (Operating and Nonoperating)	5 cycles (120 hours) referenced to MIL-T-28800C para 4.5.5.1.2.2 for type III, Class 5 instruments. Operating and nonoperating at 95% -5% to +0% relative humidity. Operating, +30° C to +40°C; nonoperating, -30°C to +60°C.

Table 8-2 (cont)

Characteristics	Performance Requirements
EMI	Meets radiated and conducted emission requirements per VDE 0871, Class B. Plus FCC section 15, sub part J, Class A.
Vibration, Operating	15 minutes along each of three major axes at a total displacement of 0.015 inch p-p (2.4 g at 55 hz) with frequency varied from 10 Hz to 55 Hz to 10 Hz in one minute sweeps. Hold for 10 minutes at 55 Hz in each of the three major axes. All major resonances must be above 55 Hz.
Shock, Nonoperating	30 g, half-sine, 11 ms duration, three shocks per axis each direction, for a total of 18 shocks.

Table 8–3

Mechanical Specification

Characteristics	Performance Requirements
Weight	
With Power Cord	8.15 kg (18.0 lb).
Domestic Shipping Weight	10.65 kg (23.5 lb).
Height	138 mm (5.4 in).
Width	
With Handle	380 mm (15.0 in).
Without Handle	327 mm (12.9 in).
Depth	445 mm (17.5 in).
With Handle Extended	515 mm (20.3 in).

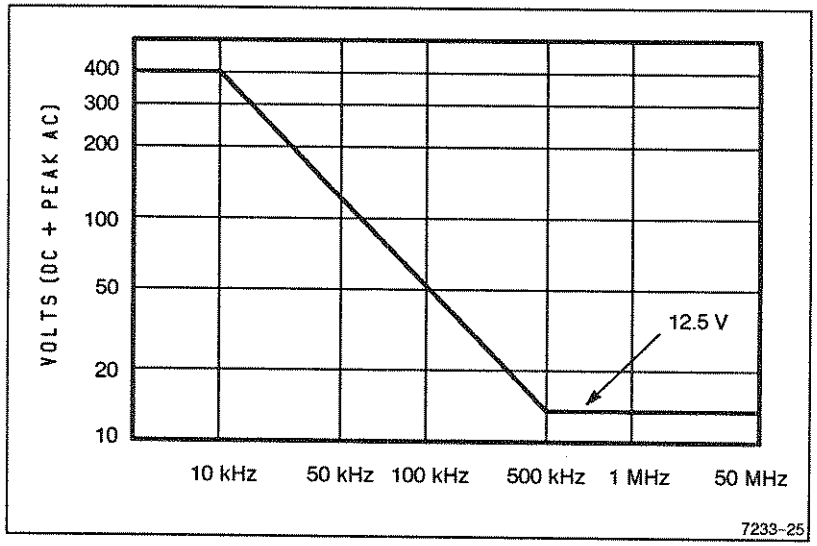


Figure 8–1. Maximum voltage versus frequency derating curve for the CH 1 OR X, CH 2 OR Y, and EXT INPUT OR Z connectors.

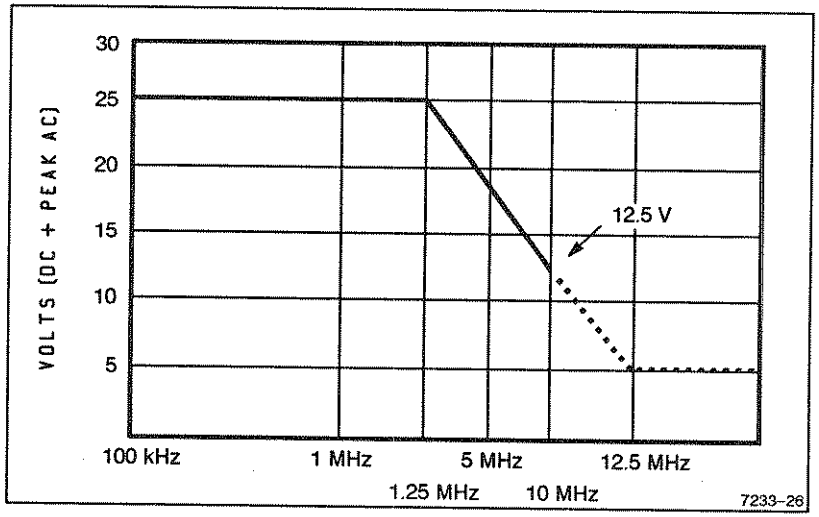


Figure 8–2. Maximum input voltage versus frequency derating curve for the EXT CLK connector.

APPENDIX A

PERFORMANCE CHECK PROCEDURE

INTRODUCTION

Purpose

The "Performance Check Procedure" is used to verify the instrument's Performance Requirements statements listed in Table 1–1 and to determine the need for calibration. The performance checks may also be used as an acceptance test or as a preliminary troubleshooting aid.

Performance Check Interval

To ensure instrument accuracy, check its performance after every 2000 hours of operation or once each year, if used infrequently. A more frequent interval may be necessary if the instrument is subjected to harsh environments or severe usage.

Structure

The "Performance Check Procedure" is structured in subsections to permit checking individual sections of the instrument whenever a complete Performance Check is not required. At the beginning of each subsection there is an equipment-required list showing only the test equipment necessary for performing the steps in that subsection. In this list, the item number that follows each piece of equipment corresponds to the item number listed in Table A–1.

Also at the beginning of each subsection is a list of all the front-panel control settings required to prepare the instrument for performing Step 1 in that subsection. Each succeeding step within a particular subsection should then be performed, both in the sequence presented and in its entirety, to ensure that control-setting changes will be correct for ensuing steps.

Test Equipment Required

The test equipment listed in Table A–1 is a complete list of the equipment required to accomplish both the "Performance Check Procedure" in this section and the "Adjustment Procedure" in Section 5. Test equipment specifications described in Table A–1 are the minimum necessary to provide accurate results. Therefore, equipment used must meet or exceed the listed specifications. Detailed operating instructions for test equipment are not given in this procedure. If more operating information is required, refer to the appropriate test equipment instruction manual.

When equipment other than that recommended is used, control settings of the test setup may need to be altered. If the exact item of equipment given as an example in Table A–1 is not available, check the "Minimum Specification" column to determine if any other available test equipment might suffice to perform the check or adjustment.

Limits And Tolerances

The limits and tolerances given in this procedure are valid for an instrument that is operating in and has been previously calibrated in an ambient temperature between +20°C and 30°C. The instrument also must have had at least a 20–minute warm–up period. Refer to Table 1–1 for tolerances applicable to an instrument that is operating outside this temperature range. All tolerances specified are for the instrument only and do not include test–equipment error.

Preparation For Checks

It is not necessary to remove the instrument cover to accomplish any subsection in the "Performance Check Procedure," since all checks are made using operator–accessible front– and rear–panel controls and connectors.

The most accurate display adjustments are made with a stable, well–focused, low–intensity display. Unless otherwise noted, adjust the INTENSITY, FOCUS, and Trigger LEVEL controls as needed to view the display.

Table A-1
Test Equipment Required

Item and Description	Minimum Specification	Use	Example of Test Equipment
1. Calibration Generator	Standard-amplitude signal levels: 5 mV to 50 V. Accuracy: ±0.3%. High-amplitude signal levels: 1 V to 60 V. Repetition rate: 1 kHz. Fast-rise signal level: 1 V. Repetition rate: 1 MHz. Rise time: 1 ns or less. Flatness: ±0.5%.	Signal source for gain and transient response checks and adjustments.	TEKTRONIX PG 506 Calibration Generator.[a]
2. Leveled Sine-Wave Generator	Frequency: 250 kHz to above 50 MHz. Output amplitude: variable from 10 mV to 5 V p-p. Output impedance: 50 Ω. Reference frequency: 50 kHz. Amplitude accuracy: constant within 3% of reference frequency as output frequency changes.	Vertical, horizontal, and triggering checks and adjustments. Display adjustments and Z-Axis check.	TEKTRONIX SG 503 Leveled Sine-Wave Generator.[a]
3. Time-Mark Generator	Marker outputs: 10 ns to 0.5 S. Marker accuracy: ±0.1%. Trigger output: 1 ms to 0.1 µs, time-coincident with markers.	Horizontal checks and adjustments. Display adjustment.	TEKTRONIX TG 501 Time-Mark Generator.[a]
4. Low-Frequency Sine-Wave Generator	Range: 10 Hz to 500 kHz. Output amplitude: 300 mV. Output impedance: 600 Ω. Reference frequency: constant within 0.3 dB of reference frequency as output frequency changes.	Low-Frequency trigger checks.	TEKTRONIX SG 502 Oscillator.[a]

Table A-1 (cont)

5. Pulse Generator	Output: high and low levels independently adjustable over a −5 V to +5 V range. Minimum amplitude: less than or equal to 0.5 V p-p. Maximum amplitude: greater than or equal to 5 V p-p. Amplitude accuracy: less than or equal to ±5% at 5 V p-p amplitude.	Signal source for Storage board external clock checks.	TEKTRONIX PG 502 250 MHz Pulse Generator.[a]
6. Screwdriver	Length: 3-inch shaft. Bit size: 3/32 inch.	Adjust variable resistors.	Xcelite R-3323.
7. Test Oscilloscope	Bandwidth: dc to 100 MHz. Minimum deflection factor: 5 mV/div. Accuracy: ±3%.	General troubleshooting.	TEKTRONIX 2235.
8. Digital Voltmeter (DMM)	Range: 0 to 140 V. DC voltage accuracy: 0.15%, 4-1/2 digit display.	Power supply checks and adjustments.	TEKTRONIX DM 501A Digital Multimeter.[a]
9. Coaxial Cable	Impedance: 50-Ω. Length: 42 inch. Connectors: BNC.	Signal interconnections.	Tektronix Part Number 012-0057-01.
10. Dual-Input Coupler	Connectors: BNC female-to-dual-BNC male.	Signal interconnections.	Tektronix Part Number 067-0525-01.
11. Termination	Impedance: 50-Ω. Connectors: BNC	Signal termination.	Tektronix Part Number 011-0049-01.
12. Termination	Impedance: 600-Ω. Connectors: BNC	Signal termination.	Tektronix Part Number 011-0092-00.
13. 10X Attenuator	Ratio: 10X. Impedance: 50-Ω. Connectors: BNC.	Vertical compensation and triggering checks.	Tektronix Part Number 011-0059-02.
14. Adapter	Connectors: BNC male-to-miniature-probe tip.	Signal interconnection.	Tektronix Part Number 013-0084-02.

Table A-1 (cont)

15. Low-Reactance Alignment Tool	Length: 1 inch shaft. Bit size: 3/32 inch.	Adjust variable capacitors.	J.F.D. Electronics Corp. Adjustment tool Number 5284.
16. GRABBER Disk		Test serial interface.	Tektronix Part Number 119-3566-01.
17. Interface Cable		Signal interconnection.	Tektronix Part Number 012-1197-00.
18. IBM Compatible PC	Serial interface.		

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

INDEX TO PERFORMANCE CHECK STEPS

Vertical

Horizontal

Trigger

External Z–Axis and Probe Adjust

Storage

Cursors and Readout

Serial Interface

VERTICAL

Equipment Required (See Table A-1):

Calibration Generator (Item 1)
Leveled Sine-Wave Generator (Item 2)
50-Ω BNC Coaxial Cable (Item 9)
Dual-Input Coupler (Item 10)
50-Ω BNC Termination (Item 11)
10X BNC Attenuator (Item 13)
BNC Male-to-Miniature-Probe Tip (Item 14)

INITIAL CONTROL SETTINGS

Vertical

POSITION (both)	Midrange
MODE	CH 1, NORM
VOLTS/DIV (both)	5 mV
VOLTS/DIV Variable (both)	CAL detent
Magnification	X1 (CAL knobs in)
AC-GND-DC	DC

Horizontal

POSITION (COARSE and FINE)	Midrange
MAG	X1
SEC/DIV	0.5 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 Deflection Accuracy and Variable Range

a. Connect a 20 mV standard-amplitude signal from the calibration generator via a 50-Ω BNC cable to the CH 1 OR X input connector.

b. CHECK—Deflection accuracy is within the limits given in Table A-2 for each CH 1 VOLTS/DIV switch setting and corresponding standard-amplitude signal. When at the 20 mV VOLTS/DIV switch setting, rotate the CH 1 VOLTS/DIV Variable control fully counter-clockwise and check that the display decreases to two divisions or less. Then return the CH 1 VOLTS/DIV Variable control to the CAL detent and continue with the 50 mV check.

c. Set the calibration generator to output 2 V.

d. Set the CH 1 vertical magnification to X10 (pull CAL knob out).

e. CHECK—X10 MAG deflection accuracy is within the limits given in Table A-2 for each VOLTS/DIV switch setting and corresponding standard amplitude signal in reverse order, starting at 5 V per division (0.5 V per division in X10 magnified).

f. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector. Set the Vertical MODE switch to CH 2.

g. Set the calibration generator to output 20 mV.

h. Repeat parts b through e using the Channel 2 controls.

2. Check Position Range

a. SET:

VOLTS/DIV (both)	10 mV
AC-GND-DC (both)	AC
SEC/DIV	0.2 ms

b. Set the calibration generator to output 0.1 V.

Table A–2
Deflection Accuracy Limits

VOLTS/DIV Switch Setting		Standard Amplitude Signal		Accuracy Limits (Divisions)	
X1	X10	X1	X10	X1	X10
5 mV	.5 mV	20 mV	2 mV	3.88 to 4.12	3.8 to 4.2
10 mV	1 mV	50 mV	5 mV	4.85 to 5.15	4.75 to 5.25
20 mV	2 mV	0.1 V	10 mV	4.85 to 5.15	4.75 to 5.25
50 mV	5 mV	0.2 V	20 mV	3.88 to 4.12	3.8 to 4.2
0.1 V	10 mV	0.5 V	50 mV	4.85 to 5.15	4.75 to 5.25
0.2 V	20 mV	1 V	0.1 V	4.85 to 5.15	4.75 to 5.25
0.5 V	50 mV	2 V	0.2 V	3.88 to 4.12	3.8 to 4.2
1 V	0.1 V	5 V	0.5 V	4.85 to 5.15	4.75 to 5.25
2 V	0.2 V	10 V	1 V	4.85 to 5.15	4.75 to 5.25
5 V	0.5 V	20 V	2 V	3.88 to 4.12	3.8 to 4.2

c. Adjust the CH 2 VOLTS/DIV Variable control to produce a 5.25-division display.

d. Set CH 2 VOLTS/DIV to 5 mV.

e. Set the calibration generator to produce a 0.2 V signal.

f. CHECK—The bottom and top of the trace may be positioned above and below the center horizontal graticule line by rotating the Channel 2 POSITION control fully clockwise and counter-clockwise respectively.

g. Move the cable from the CH 2 OR Y input connector to the CH 1 OR X input connector.

h. Set the Vertical MODE switch to CH 1.

i. Repeat parts b through e using the Channel 1 controls.

j. Return both VOLTS/DIV Variable knobs to their detent positions.

k. Disconnect the test equipment from the instrument.

3. Check High Frequency Compensation

a. SET:

AC–GND–DC (both)	DC
SEC/DIV	0.2 μs
Horizontal MAG	X1
Trigger SOURCE	VERT MODE

b. Connect the positive–going fast–rise square wave output via a 50–Ω BNC coaxial cable, a 10X BNC attenuator, and a 50–Ω BNC termination to the CH 1 OR X input connector.

c. Set the generator to produce a 1 MHz, five–division display.

d. Position the bottom of the display to the bottom horizontal graticule line using the CH 1 POSITION control and position the leading edge of a pulse on the center vertical graticule line.

e. CHECK—For aberrations at the top of the waveform of ±6% (0.3 division) or less.

f. Set CH 1 VOLTS/DIV to 10 mV.

g. Set the generator to produce a 1 MHz, five–division display.

h. CHECK—For aberrations ±4% (0.2 division) or less.

i. Repeat part g and h for each of the following CH 1 VOLTS/DIV switch settings: 20 mV through 0.2 V. Adjust the generator output and add or remove the 10X attenuator as necessary to maintain a five–division display at each VOLTS/DIV switch setting.

j. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector. Set the Vertical MODE switch to CH 2.

k. Repeat parts c through i for Channel 2.

l. Disconnect the test equipment from the instrument.

4. Check Bandwidth

a. SET:

VOLTS/DIV (both)	5 mV
Vertical MODE	CH 1
SEC/DIV	10 μs

b. Connect the leveled sine-wave generator output via a 50-ΩBNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input connector.

c. Set the generator to produce a 50 kHz, six-division display.

d. Increase the signal frequency until a 4.2-division display is obtained.

e. CHECK—That the frequency is greater than 50 MHz.

f. Repeat parts c through e for all VOLTS/DIV setting from 10 mV to 1 V.

NOTE

For the 1-V-per-division VOLTS/DIV settings, use a five-division display of the 50-kHz reference frequency; use 3.5 divisions peak-to-peak as the -3dB reference point of the bandwidth.

g. SET:

Channel 1 VOLTS/DIV	5 mV
Channel 1 Vertical Magnification	X10 (pull CH 1 CAL knob out)

h. Set the generator to produce a 50 kHz, six-division display.

i. Increase the signal frequency until a 4.2-division display is obtained.

j. CHECK—That the frequency is greater than 5 MHz.

k. Repeat parts h through j for all ranges from 10 mV to 0.2 V.

l. Set the CH 1 Vertical Magnification to X1 (push CAL knob in).

m. Set Vertical MODE to CH 2.

n. Repeat parts b through l for CH 2 using the CH 2 controls.

5. Check Channel Isolation

a. SET:

VOLTS/DIV (both)	0.5 V
AC-GND-DC (CH 1)	GND
SEC/DIV	0.05 µs

b. Set the generator to produce a 10 MHz, five-division display.

c. Set Vertical MODE to CH 1.

d. CHECK—That the display amplitude is less than 0.1 division.

e. Move the test-signal cable from the CH 2 OR Y input connector to the CH 1 OR X input connector.

f. SET:

Vertical MODE	CH 2
CH 2 AC-GND-DC	GND
CH 1 AC-GND-DC	DC

g. CHECK—That the display amplitude is less than 0.1 division.

h. Disconnect the test equipment from the instrument.

6. Check Common Mode Rejection Ratio

a. SET:

VOLTS/DIV (both)	10 mV
AC-GND-DC (both)	DC

b. Connect the leveled sine-wave generator output via a 50-Ω BNC coaxial cable, a 50-Ω BNC termination, and dual-input coupler to the CH 1 OR X and CH 2 OR Y input connectors.

c. Set the generator to produce a 20 MHz, five-division display.

d. SET:

Vertical MODE	BOTH, INVERT and ADD.

e. CHECK—That the ADD trace is 0.6 division or less.

f. Disconnect the test equipment from the instrument.

HORIZONTAL

Equipment Required (See Table A-1):

Calibration Generator (Item 1)
Leveled Sine-Wave Generator (Item 2)
Time-Mark Generator (Item 3)
Test Oscilloscope (Item 7)
50-Ω Coaxial Cable (Item 9)
50-Ω BNC Termination (Item 11)

INITIAL CONTROL SETTINGS

Vertical

POSITION (both)	Midrange
MODE	CH 1, NORM
VOLTS/DIV (both)	0.5 V
VOLTS/DIV Variable (both)	CAL detent
Magnification (both)	X1 (CAL knobs in)
AC-GND-DC (both)	DC

Horizontal

POSITION (COARSE and FINE)	Midrange
MAG	X1
SEC/DIV	0.05 μs
SEC/DIV Variable	CAL detent

Trigger

SLOPE	Positive (⌐)
LEVEL	Midrange
MODE	P-P AUTO
HOLDOFF	MIN
SOURCE	CH 1
COUPLING	AC

PROCEDURE STEPS

1. Check Timing Accuracy and Linearity

a. Connect 50 ns time markers from the time-mark generator via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input connector.

b. Adjust the TRIGGER LEVEL control for a stable, triggered display.

c. Use the Horizontal POSITION controls to align the second time marker with the second vertical graticule line.

d. CHECK—Timing accuracy is within 3% (0.24 division at the tenth vertical graticule line), and linearity is within 5% (0.10 division over any two of the center eight divisions).

NOTE

For checking the timing accuracy of the SEC/DIV switch settings from 50 ms to 0.5 s, watch the time marker tips only at the second and tenth vertical graticule lines while adjusting the Horizontal POSITION controls to line up the time makers.

e. Repeat parts b through d for the remaining SEC/DIV and time-mark generator setting combinations shown in Table A-3 under the "Normal" column.

NOTE

In X50 magnification in all "2" decade switch settings, the associated time marker settings give only five markers per ten divisions instead of the customary 10. When checking these ranges, position the markers on the second and ninth vertical graticule lines.

f. SET:

SEC/DIV	0.1 μs
Horizontal MAG	X10

Table A-3
Settings for Timing Accuracy Checks

SEC/DIV Switch Setting	Time-Mark Generator Setting		
	Normal	X10 Mag	X50 Mag
0.05 μs	50 ns	10 ns	
0.1 μs	0.1 μs	10 ns	
0.2 μs	0.2 μs	20 ns	
0.5 μs	0.5 μs	50 ns	10 ns
1 μs	1 μs	0.1 μs	20 ns
2 μs	2 μs	0.2 μs	0.1 μs
5 μs	5 μs	0.5 μs	0.1 μs
10 μs	10 μs	1 μs	0.2 μs
20 μs	20 μs	2 μs	1 μs
50 μs	50 μs	5 μs	1 μs
0.1 ms	0.1 ms	10 μs	2 μs
0.2 ms	0.2 ms	20 μs	10 μs
0.5 ms	0.5 ms	50 μs	10 μs
1 ms	1 ms	0.1 ms	20 μs
2 ms	2 ms	0.2 ms	0.1 ms
5 ms	5 ms	0.5 ms	0.1 ms
10 ms	10 ms	1 ms	0.2 ms
20 ms	20 ms	2 ms	1 ms
50 ms	50 ms	5 ms	1 ms
0.1 s	0.1 s	10 ms	2 ms
0.2 s	0.2 s	20 ms	10 ms
0.5 s	0.5 s	50 ms	10 ms

g. Select 10 ns time markers from the time-marker generator.

h. Use the Horizontal POSITION control to align the first time marker that is 50 ns beyond the start of the sweep with the second vertical graticule line.

i. CHECK—Timing accuracy is within 4% (0.32 division at the tenth vertical graticule line), and linearity is within 7% (0.14 division over any two of the center eight divisions). Exclude any portion of the sweep past the 50th magnified division.

j. Repeat parts h and i for the remaining SEC/DIV and time-mark generator setting combinations shown in Table A-3 under the "X10 Magnified" column.

k. SET:

SEC/DIV	0.5 μs
Horizontal MAG	X50

l. Select 10 ns time markers from the time-marker generator.

m. Use the Horizontal POSITION control to align the first time marker that is 100 ns beyond the start of the sweep with the second vertical graticule line.

n. CHECK—Timing accuracy is within 5% (0.40 division at the tenth vertical graticule line), and linearity is within 9% (0.18 division over any two of the center eight divisions). Exclude any portion of the sweep past the 100th magnified division.

o. Repeat parts m and n for the remaining SEC/DIV and time-mark generator setting combinations shown in Table A-3 under the "X50 Magnified" column.

2. Check Sweep Length

a. SET:

SEC/DIV	0.1 ms
Horizontal MAG	X1

b. Select 0.1 ms time markers from the time-mark generator.

c. Position the start of the sweep at the first vertical graticule line using the Horizontal POSITION control.

d. CHECK—That the sweep length is between than 10.2 and 12 divisions.

3. Check COARSE and FINE Horizontal Position Range

a. CHECK—That the start of the sweep can be positioned to the right of the center vertical graticule line by rotating the COARSE Horizontal POSITION control fully clockwise.

b. CHECK—That the tenth time marker can be positioned to the left of the center vertical graticule line by rotating the COARSE Horizontal POSITION control fully counterclockwise.

c. CHECK—That the FINE Horizontal POSITION control can move the trace more than 0.4 divisions.

4. Check SEC/DIV Variable Range

a. Select 0.5 ms time markers from the time-mark generator.

b. Set the SEC/DIV Variable control fully counterclockwise.

c. CHECK—That the spacing between Time markers is two divisions or less.

d. Return the SEC/DIV Variable to the CAL detent position.

e. Disconnect the test equipment from the instrument.

5. Check X Gain

a. SET:

VOLTS/DIV (both)	10 mV
SEC/DIV	X-Y (fully counter-clockwise)

b. Connect 50 mV standard amplitude signal from the calibration generator via a 50-Ω BNC coaxial cable to the CH 1 OR X input connector.

c. CHECK—The display is between 4.85 and 5.15 divisions.

d. Disconnect the test equipment from the instrument.

6. Check X Bandwidth

a. Set both channels VOLTS/DIV switches to 50 mV.

b. Connect the leveled sine-wave generator output via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input connector.

c. Set the generator to produce an eight-division horizontal display at an output frequency of 50 kHz.

d. Increase the generator output frequency until the X-Axis (horizontal) deflection amplitude is 5.7 divisions.

e. CHECK—That the generators frequency is 2 MHz or greater.

f. Disconnect the test equipment from the instrument.

TRIGGER

Equipment Required (See Table A–1):

Calibration Generator (Item 1)
Leveled Sine–Wave Generator (Item 2)
Low–Frequency Sine–Wave Generator (Item 4)
50–Ω BNC Coaxial Cable (Item 9)
Dual–Input Coupler (Item 10)
50–Ω BNC Termination (Item 11)
600–Ω BNC Termination (Item 12)

INITIAL CONTROL SETTINGS

Vertical

POSITION	Midrange
MODE	CH 1
CH 1 VOLTS/DIV	0.1 V
CH 2 VOLTS/DIV	1 V
VOLTS/DIV Variable (both)	CAL detent
Magnification (both)	X1 (CAL knobs in)
AC–GND–DC (both)	DC

Horizontal

POSITION (COARSE and FINE)	Midrange
MAG	X1
SEC/DIV	0.2 μs
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 Trigger Sensitivity

a. Connect the leveled sine-wave generator output via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input connector.

b. Set the generator to produce a 3.5-division display at an output frequency of 5 MHz.

c. Set channel 1 VOLTS/DIV switch to 1 V.

d. CHECK – Stable display can be obtained by adjusting the TRIGGER LEVEL control for each switch combination given in Table A-4 in both positive and negative slope. Ensure that the TRIG'D light comes on when triggered.

e. Move the test-signal cable from the CH 1 OR X input connector to the CH 2 OR Y input connector. Set the Vertical MODE switch to CH 2.

f. Repeat part d.

g. Set the generator to produce a 1-division display at an output frequency of 50 MHz.

h. Repeat parts d and e.

i. Disconnect the test equipment from the instrument.

Table A-4
Switch Combinations for Triggering Checks

TRIGGER Mode	TRIGGER SLOPE
NORM	POSITIVE (⌐)
NORM	NEGATIVE (¬)
P-P AUTO	POSITIVE (⌐)
P-P AUTO	NEGATIVE (¬)

j. SET:

CH 1 VOLTS/DIV	10 mV
Vertical MODE	CH 1
SEC/DIV	0.2 μs
Trigger MODE	P-P AUTO
Trigger SOURCE	EXT, EXT

k. 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 input connector and EXT INPUT OR Z input connectors.

l. Set the generator to produce a four-division (40 mV) vertical display at an output frequency of 5 MHz.

m. Repeat part d.

n. Set the CH1 VOLTS/DIV to 50 mV. Set the generator to produce a 5-division (150 mV) display at an output frequency of 50 MHz.

o. Repeat part d.

p. Disconnect the test equipment from the instrument.

2. Check LF P-P AUTO Trigger

a. SET:

CH 1 VOLTS/DIV	0.1 V
SEC/DIV	20 ms
Trigger MODE	P-P AUTO
Trigger SOURCE	CH 1
Trigger SLOPE	Positive (⎍)

b. Connect the low-frequency sine-wave generator output via a 50 Ω BNC coaxial cable and a 600 Ω BNC termination to the CH 1 OR X input connector.

c. Set the low-frequency generator output to produce a 20 Hz one-division display.

d. CHECK—For stable triggering in both positive and negative slopes. Ensure that the TRIG'D light comes on when triggered.

e. Disconnect the test equipment from the instrument.

3. Check LF Reject

a. SET:

HORIZ MODE	X1, 10 μs/DIV
VERTICAL MODE	CH 2, NORM
CH2 VOLTS/DIV	0.1 V, AC COUPLED
TRIGGER MODE	P-P AUTO
TRIGGER SOURCE	CH 2
TRIGGER SLOPE	Positive (⌐)
TRIGGER COUPLING	LF REJECT

b. Set Calibration generator for 10KHz squarewave.

c. Connect generator output to CH2 INPUT connector.

d. Adjust the generator output to display a 3-division waveform.

e. Set TRIGGER MODE to NORM.

f. Adjust TRIG LEVEL control fully clockwise.

g. Rotate TRIG LEVEL control counterclockwise until waveform just triggers.

h. Set CH2 VOLTS/DIV to 50mV and HORIZONTAL MODE to X10.

i. Position vertical transition to right-hand side of screen.

j. CHECK—That when switching the TRIGGER SLOPE switch from positive to negative, the vertical transition is advanced horizontally by 3.2 to 5.2 divisions. If this check fails, recheck the TRIG LEVEL control as described in part g.

4. Check HF Reject

a. Set TRIGGER SLOPE to positive, TRIGGER COUPLING to DC and TRIGGER MODE to NORM.

b. Adjust TRIGGER LEVEL for stable trigger.

c. Adjust HORIZONTAL POSITION control to set vertical transition after 10 divisions of sweep to the center vertical graticule line.

d. Set TRIGGER COUPLING to HF REJECT.

e. Adjust TRIGGER LEVEL control so that when switching the TRIGGER SLOPE switch between positive and negative, the vertical transition does not move horizontally by more than 0.2 division.

f. CHECK—That when switching the TRIGGER COUPLING switch between DC and HF REJECT, the vertical transition is advanced horizontally by 3.1 to 5.1 divisions.

5. Check External Trigger Range

a. SET:

CH 1 VOLTS/DIV	0.5 V
SEC/DIV	20 μs
Trigger COUPLING	AC
Trigger SLOPE	POSITIVE (⌐)

b. 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 both the CH 1 OR X and EXT INPUT connectors.

c. Set the leveled sine-wave generator to produce a 50 kHz, five-division display.

d. Position the waveform equally about the center horizontal graticule line.

e. SET:

Trigger MODE	NORM
Trigger SOURCE	EXT, EXT

f. CHECK—That the display is not triggered at either extreme of rotation of the Trigger LEVEL control.

g. Set the trigger COUPLING switch to DC.

h. CHECK—That the display is not triggered at either extreme of rotation of the Trigger LEVEL control.

i. Set the trigger SOURCE switch to EXT/10.

j. CHECK—That the display can be triggered about the midrange of the Trigger LEVEL control.

k. Set the trigger SLOPE switch to NEGATIVE (⌐\) and repeat part j.

l. Disconnect the test equipment from the instrument.

6. Check Trigger Readout

a. Set:

VERT MODE	CH1
CH1 VOLTS/DIV	0.1V, DC COUPLED
HORIZ MODE	X1
SEC/DIV	20 μS
TRIGGER MODE	P-P AUTO
TRIGGER SOURCE	CH1
TRIGGER COUPLING	DC
READOUT	"ON"

b. Connect the leveled sine-wave generator output via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH1 OR X input connector.

c. Set the generator to produce an 8-division vertical display at an output frequency of 50 kHz.

d. Adjust the CH1 POSITION control to center the trace about the center horizontal graticule line. Set TRIG MODE to NORM.

e. Adjust the TRIG LEVEL control so that the trace starts equally about the center horizontal graticule line when switching between ⌐/ and ⌐\ trig slopes.

f. Set the TRIGGER SLOPE switch to ⌐/ .

g. Adjust the CH1 POSITION control so that the start of the trace is aligned with the center horizontal graticule line.

h. CHECK—That the trigger readout is 0.00V ± 0.03V.

i. Adjust the TRIG LEVEL control so that the trace starts 1 division above the center horizontal graticule line.

j. CHECK—That the trigger readout is +0.10V ±0.03V.

k. CHECK—That when the trace starts 2 divisions above the center horizontal graticule line that the readout is +0.20V ±0.03V and for 3 divisions it is +0.30V ±0.03V.

l. CHECK—That when the trace starts 1 division below the center horizontal graticule line that the readout is −0.10V ±0.03V, for 2 divisions it is −0.20V ±0.03V and for 3 divisions it is −0.30V ±0.03V.

m. Adjust the CH1 POSITION control to center the trace about the center horizontal graticule line.

n. Adjust the TRIG LEVEL control so that the trace starts equally about the center horizontal graticule line when switching between ⌐ and ¬ trig slopes.

o. Set the TRIGGER SLOPE switch to ⌐.

p. Adjust the CH1 POSITION control so that the start of the trace is aligned with the center horizontal graticule line.

q. Repeat steps h through l.

7. Check Single Sweep Operation

a. SET:

CH 1 VOLTS/DIV	10 mV
SEC/DIV	0.5 ms
Trigger SOURCE	CH 1
Trigger COUPLING	AC
Trigger SLOPE	POSITIVE (⌐)

b. Connect 50 mV standard amplitude signal from the calibration generator via a 50-Ω BNC coaxial cable to the CH 1 OR X input connector.

c. Adjust the TRIGGER LEVEL control to obtain a stable display.

d. SET:

CH 1 AC-GND-DC	GND
Trigger MODE	SGL SWP

e. Press the SGL SWP RESET button. The READY light should light up and remain on.

f. Set the Channel 1 AC-GND-DC switch to DC.

NOTE

The INTENSITY control may require adjustment to observe the single-sweep trace.

g. CHECK—READY light goes out and a single sweep occurs.

h. Press in the SGL SWP button several times.

i. CHECK—Single-sweep trace occurs, and the READY light comes on briefly every time the SGL SWP RESET button is pressed.

j. Disconnect the test equipment from the instrument.

EXTERNAL Z-AXIS, PROBE ADJUST

Equipment Required (see Table A-1):

Leveled Sine-Wave Generator (Item 2)
Two 50-Ω BNC Coaxial Cables (Item 9)
Dual-Input Coupler (Item 10)
50-Ω BNC Termination (Item 11)
10X Probe (Provided with instrument)
Low-Reactance Alignment Tool (Item 15)

INITIAL CONTROL SETTINGS

Vertical

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

Horizontal

POSITION (COARSE and FINE)	Midrange
HORIZONTAL MAG	X1
SEC/DIV	20 μs
SEC/DIV Variable	CAL detent

Trigger

SLOPE	POSITIVE (⌐)
LEVEL	Midrange
MODE	P-P AUTO
HOLDOFF	MIN
SOURCE	EXT, EXT=Z
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 termination, and a dual-input coupler to the CH 1 OR X input connector and the EXT INPUT OR Z connector.

b. Set the generator to produce a 5 V, 50 kHz signal.

NOTE

The INTENSITY level may need adjustment to view the intensity modulation on the displayed waveform.

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 connector on the instrument front panel. If necessary, adjust the probe compensation for a flat-topped square-wave display.

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

d. Disconnect the probe from the instrument.

STORAGE

Equipment Required (See Table A-1):

Calibration Generator (Item 1)
Leveled Sine-Wave Generator (Item 2)
Time Mark Generator (Item 3)
Low-Frequency Sine-Wave Generator (Item 4)
50-Ω BNC Coaxial Cable (Item 9)
Dual-Input Coupler (Item 10)
50-Ω BNC Termination (Item 11)
Pulse Generator (Item 5)

INITIAL CONTROL SETTINGS

Vertical

POSITION (both)	Midrange
MODE	CH 1, NORM
VOLTS/DIV (both)	5 mV
VOLTS/DIV Variable (both)	CAL detent
Magnification	X1 (CAL knobs in)
AC-GND-DC	DC

Horizontal

POSITION (COARSE and FINE)	Midrange
SEC/DIV	0.5 ms
SEC/DIV Variable	CAL detent
MAG	X1

Trigger

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

Storage

STORE/NON-STORE	NON-STORE
PRE-TRIG 25%/75%	75%
ACQ SAVE/CONTINUE	CONTINUE
REFERENCE POSITION	Midrange

PROCEDURE STEPS

1. Check Storage VOLTS/DIV Accuracy

a. Connect a 20 mV standard-amplitude signal from the calibration generator via a 50-Ω BNC cable to the CH 1 OR X input connector.

b. CHECK—That there is a 4-division signal displayed on the screen.

c. SET:

STORE/NON-STORE	STORE
ACQ SAVE/CONTINUE	SAVE

d. CHECK—That the displayed signal is within the limits given in Table A-5 for each CH 1 VOLTS/DIV switch setting and corresponding standard-amplitude signal. At each level, select CONTINUE then SAVE to acquire and hold the next test waveform.

e. Set the calibration generator to output 20 mV.

f. Move the cable from the CH 1 or X input connector to the CH 2 OR Y input connector.

g. SET:

Vertical MODE	CH 2
STORE/NON-STORE	NON-STORE
ACQ SAVE/CONTINUE	CONTINUE

h. Repeats parts b through d for CH 2.

Table A–5
Storage Deflection Accuracy Limits

VOLTS/DIV Switch Setting	STANDARD Amplitude Signal	ACCURACY Limits (Divisions)
5 mV	20 mV	3.88 to 4.12
10 mV	50 mV	4.85 to 5.15
20 mV	0.1 V	4.85 to 5.15
50 mV	0.2 V	3.88 to 4.12
0.1 V	0.5 V	4.85 to 5.15
0.2 V	1 V	4.85 to 5.15
0.5 V	2 V	3.88 to 4.12
1 V	5 V	4.85 to 5.15
2 V	10 V	4.85 to 5.15
5 V	20 V	3.88 to 4.12

i. SET:

STORE/NON–STORE	NON–STORE
ACQ SAVE/CONTINUE	CONTINUE

2. Check Store Add Mode

a. SET:

SEC/DIV	0.2 ms
VOLTS/DIV (both)	20 mV
Vertical MODE	BOTH, ADD, NORM
STORE/NON–STORE	NON–STORE

b. Set the calibration generator to output 50 mV and connect it via a dual–input coupler to both CH 1 (X) and CH 2 (Y) inputs.

c. Position the display around the center horizontal graticule line.

d. CHECK—That the displayed signal is between 4.85 and 5.15 divisions in height.

e. SET

STORE/NON-STORE	STORE

f. CHECK—That the displayed signal is between 4.85 and 5.15 divisions in height.

g. Disconnect the test equipment from the instrument.

3. Check CH 1 Storage Balance

a. SET:

SEC/DIV	0.2 ms
Vertical MODE	CH 1, NORM
VOLTS/DIV (CH 1)	5 mV
AC-GND-DC (CH 1)	GND
Trigger SOURCE	EXT
STORE/NON-STORE	NON-STORE

b. Position the trace to the center horizontal graticule line using the CH 1 Position control.

c. Set STORE/NON-STORE to STORE.

d. CHECK—That the trace is positioned within 0.5 of a division of the center horizontal graticule line.

4. Check CH 2 Storage Balance

a. SET:

Vertical MODE	CH 2, NORM
VOLTS/DIV (CH 2)	5 mV
AC-GND-DC (CH 2)	GND
STORE/NON-STORE	NON-STORE

b. Using the CH 2 Position control, position the trace to the center horizontal graticule.

c. Set STORE/NON-STORE to STORE.

d. CHECK—That the trace is positioned within 0.5 of a division of the center horizontal graticule.

5. Check Add Storage Balance

a. SET:

Vertical MODE	BOTH, ADD
STORE/NON-STORE	NON-STORE

b. Position the trace to the center horizontal graticule line.

c. SET:

STORE/NON-STORE	STORE

d. CHECK—That the trace is positioned within 0.5 of a division of the center horizontal graticule line.

6. Check Vertical Bandwidth

a. SET:

Vertical MODE	CH 1, NORM, ALT
SEC/DIV	20 μs
Trigger SOURCE	VERT
Trigger COUPLING	AC
AC-GND-DC (both)	DC
STORE/NON-STORE	STORE

b. Connect a 50 kHz signal from the leveled sine-wave generator via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input.

c. CHECK—That the trace has a height of 6 divisions.

d. Increase the signal frequency until a 4.2-division display is obtained.

e. CHECK—That the frequency is greater than 10 MHz.

f. Repeat parts c through e for all VOLTS/DIV settings.

g. Set Vertical MODE to CH 2.

h. Reduce the signal generator output level to minimum and move the test signal to the CH 2 input.

i. Repeat parts c through e for CH 2 using the CH 2 controls.

7. Check Store Mode Channel Isolation

a. SET:

VOLTS/DIV (CH 2)	0.5 V
VOLTS/DIV (CH 1)	1 V
AC-GND-DC (CH 2)	GND

b. Connect a 50 MHz,5 V peak to peak signal from a leveled sine-wave generator via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input.

c. Increase the generator frequency to 10 MHz.

d. SET:

Vertical MODE	CH 2
CH 1 VOLTS/DIV	0.5 V

e. CHECK—That the displayed signal is less than 0.1 divisions in height.

f. Move the test signal to the CH 2 input.

g. SET:

Vertical MODE	CH 2
AC-GND-DC (CH 1)	GND
AC-GND-DC (CH 2)	DC

h. CHECK—That the displayed signal amplitude is less than 0.1 divisions.

i. Disconnect the test equipment from the instrument.

8. Check Common Mode Rejection Ratio

a. SET:

VOLTS/DIV (both)	5 mV
AC–GND–DC (CH 2)	DC

b. Connect a 50 kHz signal from the leveled sine-wave generator via a dual-input coupler to both the CH 1 (X) and CH 2 (Y) inputs.

c. Set the generator to give a 6-division display.

d. Set Vertical MODE to BOTH, INV, ADD.

e. Increase the signal frequency to 10 MHz.

f. CHECK—That the residual display is less than 0.6 divisions.

g. Disconnect the test equipment from the instrument.

9. Check Display and Save Ref

a. SET:

Vertical MODE	CH 1
AC–GND–DC (CH 1)	GND
Trigger SOURCE	CH 1
Trigger COUPLING	DC
PRE–TRIG	25%

b. Adjust the CH 1 Position control so that the trace is on the second from bottom horizontal graticule line.

c. Press SAVE REF.

d. CHECK—That the SAVE REF.trace appears and can be positioned more than 3.5 divisions above the reference trace using the Reference Position control.

e. Press the Display ON/OFF button.

f. CHECK—That the SAVE REF.trace disappears.

g. Press the Display ON/OFF button.

h. CHECK—That the SAVE REF.trace appears and that the Trigger Point (bright dot) is positioned at the same place on both traces.

i. SET:

PRE-TRIG	75%

j. CHECK—That the CH 1 display and Trigger Point change but that the REF display remains the same.

10. Check Save/Continue

a. Position the trace on the center horizontal graticule using the CH 1 Position control.

b. Press SAVE/CONTINUE.

c. CHECK—That the trace cannot be moved vertically using the Vertical Position control.

d. Press SAVE/CONTINUE.

e. CHECK—That the trace can be moved using the Vertical Position control.

11. Check Trigger Point

a. SET:

SEC/DIV	50 ms
PRE-TRIG	25%

b. CHECK—That the Trigger Point appears towards the beginning of the trace.

c. Set PRE-TRIG to 75%.

d. CHECK—That the Trigger Point appears towards the end of the trace.

e. Set SEC/DIV to 0.1 s.

f. CHECK—That the Trigger Point is not present.

g. Set Trigger MODE to Single Sweep.

h. CHECK—That the Trigger Point appears towards the end of the trace.

i. Set Trigger MODE to P-P AUTO and PRE-TRIG to 25%.

j. Set Trigger MODE to Single Sweep.

k. CHECK—That the Trigger Point appears towards the beginning of the trace.

12. Check Single Sweep

a. SET:

VOLTS/DIV (CH 1)	0.5 V
AC-GND-DC (CH 1)	DC
SEC/DIV	50 ms
Trigger MODE	NORM

b. Connect 0.1 s time markers from the time-mark generator via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input.

c. Adjust the Trigger Level control for stable trigger.

d. Set SEC/DIV to 0.1 s and Trigger MODE to Single Sweep.

e. CHECK—That the display continually scrolls to the left.

f. Press the RESET button.

g. CHECK—That the Trigger indicator lights immediately and then goes out. When the Trigger indicator has gone out the display should stop scrolling.

h. Press the RESET button.

i. CHECK—That the display clears and both the Trigger indicator and the Trigger Point do not light until the pre-trigger data is acquired.

j. Disconnect the test equipment from the instrument.

13. Check Roll Single Sweep Vert Chop-Alt Trigger

a. SET:

Vertical MODE	BOTH, NORM, ALT
VOLTS/DIV (both)	0.5 V
AC-GND-DC (both)	DC
SEC/DIV	50 ms
Trigger MODE	NORM
Trigger SOURCE	VERT

b. Connect 0.1 s time markers from the time-mark generator via a dual-input coupler to both the CH 1 (X) and the CH 2 (Y) inputs.

c. Adjust the Trigger Level control for stable trigger.

d. Position the CH 1 trace to the top of the display and CH 2 to the bottom.

e. Set SEC/DIV to 0.1 s and Trigger MODE to Single Sweep.

f. CHECK—That the display continually scrolls to the left.

g. Press RESET.

h. CHECK—That both channels trigger and remain on the screen.

i. CHECK—That every subsequent press of the RESET button updates CH 1 or CH 2 data alternately.

j. Press the RESET button until CH 2 is displayed on the screen.

k. Disconnect CH 1 input.

l. Press the RESET button.

m. CHECK—That the display continually scrolls to the left until CH 1 input is reconnected.

n. Disconnect CH 2 input.

o. Press the RESET button.

p. CHECK—That the display continually scrolls to the left until CH 2 input is reconnected.

q. Set Vertical MODE to CHOP.

r. Press the RESET button.

s. CHECK—That both channels are displayed and triggered.

t. Disconnect the test equipment from the instrument.

14. Check External Clock Record Mode

a. SET:

Vertical MODE	CH 1, NORM, ALT
SEC/DIV	EXT CLK
Trigger MODE	P-P AUTO
Trigger SOURCE	CH 1

b. Connect a 0-5 V 10 MHz square wave with an equal mark to space ratio from the pulse generator via a 50-Ω BNC coaxial cable to the EXT CLK input.

c. Connect 20 μs time markers from the time-mark generator via a 50-Ω BNC coaxial cable and a 50-Ω BNC terminator to the CH 1 OR X input.

d. Set SAVE/CONTINUE to SAVE.

e. CHECK—That the displayed signal has 2 markers per division.

f. Disconnect the test equipment from the instrument.

15. Check External Clock Roll Mode

a. Set SAVE/CONTINUE to CONTINUE.

b. Turn the Horizontal Variable control fully counterclockwise.

c. Connect a 0-5 V 4 kHz square wave with equal mark to space ratio from the pulse generator via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the EXT CLK input.

d. Connect 0.1 s time markers from the time-mark generator via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input.

e. Set SAVE/CONTINUE to SAVE.

f. CHECK—That the displayed signal has 1 marker per division.

g. Return the Horizontal Variable control to its detent position.

h. Disconnect the test equipment from the instrument.

CURSORS AND READOUT

Equipment Required (See Table A-1):

Time Mark Generator (Item 3)
50-Ω BNC Coaxial Cable (Item 9)
50-Ω BNC Termination (Item 11)

INITIAL CONTROL SETTINGS

Vertical

POSITION	Midrange
MODE	CH 2, NORM, ADD
VOLTS/DIV (both)	10 mV
VOLTS/DIV Variable (both)	CAL detent
Magnification	X1 (CAL knobs in)
AC-GND-DC	GND

Horizontal

POSITION (COARSE and FINE)	Midrange
SEC/DIV	0.05 µs
SEC/DIV Variable	CAL detent
MAG	X1

Trigger

SLOPE	Positive (⌐)
LEVEL	Midrange
MODE	SGL SWP
HOLDOFF	MIN
SOURCE	EXT
COUPLING	AC

Storage

STORE/NON-STORE	NON-STORE
PRE-TRIG 25%/75%	75%
ACQ SAVE/CONTINUE	CONTINUE
REFERENCE POSITION	Midrange

Cursors and Readout

READOUT/STORE INTENSITY	Midrange

PROCEDURE STEPS

1. Check Operation of Readout

a. Hold in the ΔV1/ΔV2 and ΔT/1/ΔT pushbuttons until the Tektronix logo appears on the crt screen.

b. Press the Cursor Position control four times,and check that a diagnostic table appears on the screen.

c. Hold the Cursor Position control in for approximately two seconds until the next menu appears on the crt screen. This menu indicates the last switch/control changed.

d. Set Vertical MODE to BOTH and check that the screen displays VMODE BOTH ADD.

e. Set Vertical MODE to ALT and check that the screen displays VMODE BOTH ALT.

f. Set Vertical MODE to CHOP and check that the screen displays VMODE BOTH CHOP.

g. Set Vertical MODE to CH 1 and check that the screen displays VMODE CH1.

h. Set Vertical MODE to CH 2 and check that the screen displays VMODE CH2.

i. Set Vertical MODE to INV and check that the screen displays VMODE INVERT.

j. Set Vertical MODE to NORM and check that the screen displays VMODE NORM.

k. Set AC-GND-DC (CH 1) to AC and check that the screen displays CH1 CPLNG AC.

l. Set AC-GND-DC (CH 1) to DC and check that the screen displays CH1 CPLNG DC.

m. Set AC-GND-DC (CH 2) to AC and check that the screen displays CH2 CPLNG AC.

n. Set AC-GND-DC (CH 2) to DC and check that the screen displays CH2 CPLNG DC.

o. Set CH 1 Variable to X10 and check that the screen displays CH1 X10.

p. Set CH 1 Variable to X1 and check that the screen displays CH1 X1.

q. Set CH 1 Variable to UNCAL and check that the screen displays CH1 UNCAL.

r. Set CH 1 Variable to CAL and check that the screen displays CH1 CAL.

s. Set CH 2 Variable to X10 and check that the screen displays CH2 X10.

t. Set CH 2 Variable to X1 and check that the screen displays CH2 X1.

u. Set CH 2 Variable to UNCAL and check that the screen displays CH2 UNCAL.

v. Set CH 2 Variable to CAL and check that the screen displays CH2 CAL.

w. Set VOLTS/DIV (CH 1) to 5 mV and check that the screen displays CH1 VOLTS 5mV.

x. Switch the CH 1 VOLTS/DIV control through its various settings checking that the crt screen displays the values shown in Table A-6.

y. Repeat items w and x for the CH 2 VOLTS/DIV switch.

z. Set the Horizontal MAG switch to X10 and check that the screen displays SEC MAG X10.

aa. Set the Horizontal MAG switch to X50 and check that the screen displays SEC MAG X50.

bb. Set the Horizontal MAG switch to X1 and check that the screen displays SEC MAG X1.

cc. Set the SEC/DIV switch to X-Y and check that the screen displays SEC/DIV X-Y.

Table A-6
VOLTS/DIV Switch Settings/Screen Displays

Switch Setting	Screen Display
10 mV (CH 1/2)	CH1/2 VOLTS 10mV
20 mV (CH 1/2)	CH1/2 VOLTS 20mV
50 mV (CH 1/2)	CH1/2 VOLTS 50mV
0.1 V (CH 1/2)	CH1/2 VOLTS 0.1V
0.2 V (CH 1/2)	CH1/2 VOLTS 0.2V
0.5 V (CH 1/2)	CH1/2 VOLTS 0.5V
1 V (CH 1/2)	CH1/2 VOLTS 1V
2 V (CH 1/2)	CH1/2 VOLTS 2V
5 V (CH 1/2)	CH1/2 VOLTS 5V

dd. Switch the SEC/DIV switch through its various settings and check that the screen displays agree with those given in Table A–7.

Table A–7
SEC/DIV Switch Settings/Screen Displays

SEC/DIV Switch Setting	Screen Display
0.5 s	SEC/DIV 0.5s
0.2 s	SEC/DIV 0.2s
0.1 s	SEC/DIV 0.1s
50 ms	SEC/DIV 50ms
20 ms	SEC/DIV 20ms
10 ms	SEC/DIV 10ms
5 ms	SEC/DIV 5ms
2 ms	SEC/DIV 2ms
1 ms	SEC/DIV 1ms
0.5 ms	SEC/DIV 0.5ms
0.2 ms	SEC/DIV 0.2ms
0.1 ms	SEC/DIV 0.1ms
50 µs	SEC/DIV 50µs
20 µs	SEC/DIV 20µs
10 µs	SEC/DIV 10µs
5 µs	SEC/DIV 5µs
2 µs	SEC/DIV 2µs
1 µs	SEC/DIV 1µs
0.5 µs	SEC/DIV 0.5µs
0.2 µs	SEC/DIV 0.2µs
0.1 µs	SEC/DIV 0.1µs
0.05 µs	SEC/DIV 0.05µs

ee. Set Trigger MODE, SOURCE, and COUPLING to the settings given in Table A–8 and check that the screen displays agree with those given.

Table A–8
Trigger MODE, SOURCE and COUPLING
Switch Settings/Screen Displays

Switch	Setting	Screen Display
MODE	P–P AUTO	TRIG MODE P–P AUTO
MODE	NORM	TRIG MODE NORM/SGL
MODE	TV FIELD	TRIG MODE TV–FIELD
MODE	SGL SWP	TRIG MODE NORM/SGL
SOURCE	CH 1	TRIG SRC CH1
SOURCE	VERT	TRIG SRC VERT
SOURCE	CH 2	TRIG SRC CH2
SOURCE	EXT	TRIG SRC EXT
COUPLING	DC	TRIG CPLNG DC
COUPLING	HF REJ	TRIG CPLNG HF–REJ
COUPLING	LF REJ	TRIG CPLNG LF–REJ
COUPLING	AC	TRIG CPLNG AC

ff. Press the Cursor ON/OFF push button several times and check that the screen display switches between CURSOR ON and CURSOR OFF.

gg. Press the TRACK/INDEP push button several times and check that the screen display switches between CURSOR TRACK and CURSOR INDEP.

hh. Press the ΔV1/ΔV2 push button and check that the screen displays ΔV.

ii. Press the ΔT/1/ΔT push button and check that the screen displays ΔT.

jj. Press the STORE/NON-STORE push button several times and check that the screen display switches between STORE and NON-STORE.

kk. Press the SAVE/CONTINUE push button several times and check that the screen display switches between ACQ SAVE and ACQ CONTINUE.

ll. Press the Cursor Position control followed by the ΔV1/ΔV2 push button to end the check.

2. Check Probe Encoding

a. SET:

VOLTS/DIV (both)	0.1V
VERTICAL MODE	CH1

b. Read the 0.1V on the Channel 1 VOLTS/DIV portion of the crt readout.

c. Connect the standard accessory 10X probe to the CH1 OR X connector.

d. CHECK—The Channel 1 VOLTS/DIV portion of the crt readout changes from 0.1V to 1V.

e. Set VERTICAL MODE to CH2.

f. Move the X10 probe from the CH1 OR X input connector to the CH2 OR Y input connector.

g. CHECK—The Channel 2 VOLTS/DIV portion of the crt readout changes from 0.1V to 1V.

h. Disconnect the X10 probe from the instrument.

3. Check Cursor Accuracy

a. SET:

Vertical MODE	CH 1, NORM
VOLTS/DIV (both)	5 mV
AC–GND–DC (both)	DC
SEC/DIV	1 ms
Trigger MODE	P–P AUTO
Trigger SOURCE	VERT MODE
Trigger COUPLING	DC
Cursors ON/OFF	ON
STORE/NON–STORE	NON–STORE

b. Press the ΔV1/ΔV2 push button.

c. Position the cursors, using the Cursor Position control, exactly two divisions above and below the center horizontal graticule line.

d. CHECK—That the ΔV1 readout is between 19.80 mV and 20.20 mV.

e. Press the ΔT/1/ΔT push button.

f. Position the cursors, using the Cursor Position control, so that they are aligned with the second and tenth vertical graticule line.

g. CHECK—That the ΔT readout is between 7.92 ms and 8.08 ms.

h. Set to STORE.

i. Repeat part e, f, and g using a range of 7.960 ms to 8.040 ms.

NOTE

If the instrument fails this check, the DAC CAL must be readjusted—see Section 5 "Adjustment Procedure".

j. SET:

VOLTS/DIV (CH 1)	0.5 V
STORE/NON–STORE	STORE

k. Connect 1 ms time markers from the time-mark generator via a 50-Ω BNC coaxial cable and a 50-Ω BNC termination to the CH 1 OR X input connector.

l. Position the cursors, using the Cursor Position control, so that they are aligned with the tips of the second and tenth time markers.

m. CHECK—That the ΔT readout is between 7.96 ms and 8.04 ms.

n. Disconnect the test equipment from the instrument.

SERIAL INTERFACE

Equipment Required (see Table A–1)

IBM compatible PC (Item 18)
GRABBER software (Item 16)
Interface Cable (Item 17)

1. Check Operation

a. Set

CH1 VOLTS/DIV	0.5V
CH1 COUPLING	DC
CH2 VOLTS/DIV	0.2V
CH2 COUPLING	DC
VERTICAL MODE	BOTH, NORM, ALT
HORIZONTAL MODE	X1
SEC/DIV	0.2ms
TRIGGER MODE	P–P AUTO
TRIGGER SOURCE	CH1
TRIGGER COUPLING	DC
STORE/NON–STORE	STORE
CURSORS	ON
ΔT/1/ΔT	ΔT

SERIAL INTERFACE DIP SWITCH SET TO:

1	2	3	4	5	6
ON	ON	OFF	OFF	ON	ON

b. Place the GRABBER floppy disk into drive A of the computer and then go to drive A:.

c. Connect the 9–way interface cable from COM1: of the computer to the serial interface socket on the right–hand side of the instrument.

d. Type "GRABBER COM1" followed by ENTER on the computer keyboard. A message will appear on the computer screen with the last line being "HIT ANY KEY TO CONTINUE".

e. Press any key on the computer keyboard.

f. Press the PRINT/PLOT button on the right-hand side of the instrument.

g. Wait until the computer displays a representation of the instrument's crt display (this could take up to 5 minutes).

h. CHECK—That the waveforms displayed on the crt and on the computer display are the same.

NOTE

If the traces or cursors are behind a graticule line, they will not be visible on the computer display or on a plot.

APPENDIX B

OPTION 07 INSTRUCTIONS

DESCRIPTION

The Tektronix Type 2200 Series Oscilloscopes fitted with Option 07 operate from either ac or dc power sources. Option 07 provides a dc-to-dc inverter circuit physically located within the power supply compartment of the instrument.

The inverter operates from a dc input voltage of 11.8 to 30 V. A dc voltage monitor circuit included on the inverter board continually checks the dc input level. If the voltage falls to approximately 11V, Option 07 disconnects the oscilloscope from the power source. This action limits the depth of the discharge that battery power sources are subjected to when supplying power to the oscilloscope. Option 07 is also protected from the application of reverse polarity dc voltage.

All instrument specifications and functions are maintained when operating from a dc power source except for the loss of line-trigger source selection.

ACCESSORIES

In addition to all the standard and optional accessories supplied with the standard oscilloscope, Option 07 is shipped with a dc power cord with intergral plug. Tektronix part number 161-0094-00, the color coding of the supplied cord is as follows:

RED.....POSITIVE
PURPLE.....NEGATIVE
GREEN/YELLOW.....CHASSIS

The1104A battery pack is an optional accessory available for use with Option 07.

OPERATION

AC Requirements

Operates from 115 or 230 V ac, within the limits specified on the instrument's back panel label.

DC Requirements

Operates from 11.8 to 30 V dc. Maximum elevation for either the positive or the negative conductor of the dc power cord is 42 V with respect to the chassis ground of the oscilloscope.

Operation with the 1104A Battery Pack

See the instruction sheet supplied with the1104A battery pack.

MAINTENANCE

Option 07 needs no routine maintenance.

SAFETY

Grounding the Product

This product is grounded through the grounding conductor of the dc power cord. To avoid electric shock, the ground conductor (green/yellow) of the dc power cord must be connected to ground. A protective ground connection is essential for safe operation.

Danger Arising from Loss of Ground

Upon loss of the protective ground connection, all accessible conductive parts - including those which may appear to be insulating - can render an electric shock.

SERVICING

WARNING

These servicing and calibration instructions are for use by qualified personnel only.

There is a fuse on the Option 07 circuit board. The fuse prevents excessive dc current into the instrument in the event of a faliure of either the instrument or the Option 07.

CALIBRATION AND PERFORMANCE CHECK

Option 07 has no adjustments, however, correct operation of the option may be verified.

Equipment Required

Variable dc voltage supply, capable of supplying 8 A. DC voltmeter with a measurement range of 50 V.

Procedure

NOTE

If the oscilloscope does not perform correctly in the testing procedure, it must be returned to a Tektronix service center for repair.

1. Set the dc supply to zero.

2. Connect the Option 07 instrument to the dc supply and turn on the power switch of the oscilloscope.

3. Using the voltmeter, monitor the applied voltage and increase the supply voltage. Observe that the oscilloscope switches on when the supply voltage reaches approximately 11.8 V dc at the input plug.

4. Check that the oscilloscope operates normally with a supply voltage up to 30 V dc.

5. Reduce the supply voltage and observe that the oscilloscope switches off at approximately 10.8 V dc at the input plug.

6. Turn off the oscilloscope.

7. Connect the ac mains power cord to a suitable ac power source and turn on the oscilloscope.

8. Check that the oscilloscope operates normally from the ac mains supply.

ELECTRICAL CHARACTERISTICS

Unless stated, all other electrical and mechanical characteristics remain unchanged from the standard instrument.

Characteristic	Information
DC input voltage	11.8 to 30 V
Battery protection - Shutdown voltage	10.5V approx. at dc socket*
Input current	6 A maximum (depends on host insturment).
Elevation	Maximum elevation of either the positive or the negative dc power conductor with respect to chassis ground is 42 V.
AC mains operation	Inverter automatically shuts down when the mains power is connected to the oscillo - scope - - and vice versa.

*Note:

Apparent shutdown voltage will be increased due to voltage drop incurred across dc input cable.