2430A DIGITAL OSCILLOSCOPE

OPERATORS

Please Check for CHANGE INFORMATION at the Rear of This Manual

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Tektronix®
COMMITTED TO EXCELLENCE

INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

Certificate of the Manufacturer/Importer

We hereby certify that the ______

2430A 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 ______

2430A OSCILLOSCOPE AND ALL INSTALLED OPTIONS

in Übereinstimmung mit den Bestimmungen der Amtsblatt-Verfügüng 1046/1984 funkentstört ist.

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

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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.

NOTICE to the user/operator:

The German Postal Service requires that this equipment, when used in a test setup, may only be operated if the requirements of Postal Regulation, Vfg. 1046/1984, Par. 2, Sect. 1.7.1 are complied with.

HINWEIS für den Benutzer/Betreiber:

Dies Gerät darf in Meßaufbauten nur betrieben werden, wenn die Voraussetzungen des Par. 2, Ziff. 1.7.1 der Vfg. 1046/1984 eingehalten werden.

Preface

The documentation for the 2430A consists of the following publications:

1 Operators Manual	070-6286-00
1 Users Reference	070-6339-00
1 Programmers Reference Guide	070-6338-00
1 Service Manual (Optional accessory)	070-6330-00

This operators manual is the authoritative reference of all operating information for this instrument. The only exception is system information regarding system interfacing and operating this instrument via the GPIB; the Programmers Reference Guide is the primary reference for GPIB operation.

This Operators Manual contains seven sections plus appendices. A brief description of each follows.

Section 1

This section introduces you to the instrument. It begins with a brief description of the instrument and continues with a brief explanation of how to prepare the instrument for initial start-up. Operating considerations necessary for preventing damage to the scope are also covered. Next, the user gets some "hands-on" experience with the instrument via a "Get Acquainted" procedure.

Section 2

This is a two-part section. Part one, "Operating Considerations", details the basic things to be aware of when making measurements. Part two of the section is an "Operator's Familiarization" procedure. This procedure requires you to make some measurements and demonstrate some features so that you can become familiar with how the controls and control menus are used to operate the scope. Use of the important SELF-CAL feature is also covered.

Section 3

Detailed procedures for using the scope to make measurements are given in this four-part section. The section aids you in developing your own methods for your measurement requirements.

The first part of the section, "General Applications," details the more familiar graticule measurements of signal amplitude and time period. Use of the Vertical and Horizontal Display Mode (including delay-time measurements) are also given in part one.

Part two, "Special Applications," describes use of the versatile cursors for making highly accurate measurements of voltage, time, and frequency. "Special Applications" includes an application for the combined A*B trigger source.

A third part, "Storage Applications," describes the various storage acquisition modes and their uses.

"Extended Features Applications," the final section, outlines usage of the AUTOsetup, AutoStep Sequencer, and MEASURE features.

Section 4

This section contains Operator's checks and adjustments procedures used to ensure the accuracy of measurements .

Section 5

This is the reference section for description of instrument features. The locations of the controls, connectors, and indicators are illustrated and their functions are described. At the rear of the section, the control menus are listed with details describing their use for reference by the user.

Section 6

This section contains tables of the electrical, environmental, and mechanical characteristics of the instrument. An introductory summary of the instrument's capabilities precedes the specification tables. A dimensional drawing of the instrument is included at the end of the section.

Section 7

Information about instrument options available are found in this section. Included is a list of the standard instrument accessories and a partial list of the recommended optional accessories. Operating instructions for the Video Option and the Word Recognizer Probe are included in Section 7.

Appendix A

The Extended Functions menus are described, and the operation of the internal calibration and diagnostics capabilities of the scope are detailed. A table at the rear of the appendix lists the Extended Diagnostic test codes and short names for the operator's information.

Appendix B

Supplemental reference tables and information are included in this appendix.

Appendix C

This appendix details considerations for using the MEASURE feature for automatically extracting parameter measurements from waveforms.

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3 Basic Applications (cont)

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Operators Safety Summary

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

Terms

In This Manual

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

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

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the 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 6-1.

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 connecting 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.

Use only a power cord that is in good condition.

For detailed information on power cords and connectors see Table 1-1.

Use the Proper Fuse

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

Do Not Operate in Explosive Atmospheres

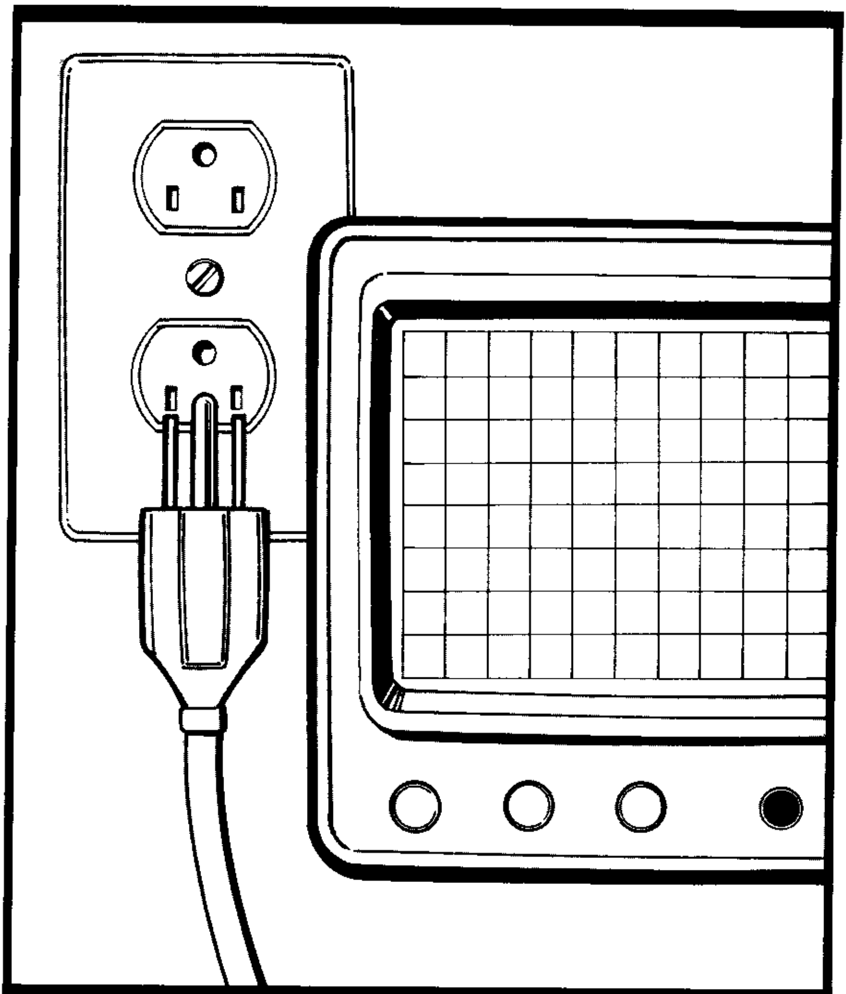
To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not 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

This section briefly describes the 2430A and tells how to prepare for and proceed with the initial start-up of the instrument. Safety information is included, as well as information necessary to prevent damage to the instrument. PLEASE READ.

Also included in this section is a "Get Acquainted" procedure designed to give operators some immediate "hands-on" experience with the instrument. It is suggested you go through this procedure first, in order to get acquainted with how the scope is controlled from its front panel. After completing the procedure, Section 2 will introduce some considerations for setups when making measurements as well as provide an additional, more extensive familiarization procedure. When you've covered this section, look through Section 3, "Applications". This section is full of examples that illustrate how to apply the instrument's features to make various measurements. Finally, "Controls, Connectors, and Indicators" (Section 5) serves as a reference for the function of the front panel and rear panel.

NOTE

Information regarding the use of this instrument in systems, via the GPIB interface at the instrument rear panel, is found in the Programmers Reference Guide included with this instrument.

Product Overview

This instrument is a 40-MHz real-time (maximum sample rate is 100 megasamples/sec for each channel), 150-MHz equivalent time, Digital Oscilloscope. It is capable of acquiring and digitizing waveforms connected to its inputs and can process the information in a variety of ways. The information can then be displayed or stored for later use.

The instrument has two vertical channels. Each is independently settable in a 1-2-5 multiple sequence, for deflection factor from 2 mV to 5 V/Division, with either 1-MΩ or 50-Ω input resistance. Coupling settings of DC, AC, or GND (ground) are available for the 1-MΩ resistance setting; DC and GND are available for the 50-Ω setting.

The trigger system provides for automatic triggering (AUTOLEVEL Trigger Mode) on most signals when using the A Horizontal mode. Alternate triggering modes, plus a variety of source selections and coupling modes, allow optimum triggering on a wide range of signals in both A and B Horizontal modes.

Two 20-division waveform records, A and B, are available, with display modes of A, B, or A intensified by B. The acquisition rate for both are settable using a 1-2-5 multiple sequence with a range of 5 s to 5 ns/Division. The B acquisition can be delayed from the A acquisition by using the Delay Time feature. A second delay, Δ Delay, can delay a second B acquisition beyond the time set for Delay Time.

Three acquisition modes are available with this instrument. NORMAL acquisition mode yields a "live" display, similar to that familiar to users of non-digital scopes. In this mode the display is continually updated as new waveform information is acquired and digitized. The AVERAGE mode processes successive acquisitions of a waveform using an averaging algorithm which averages corresponding data sample points between the acquisitions. The result is that uncorrelated noise is reduced from the display, resulting in an improved signal-to-noise ratio. Finally, ENVELOPE mode processes successive acquisitions, detecting minimum and maximum values between corresponding data points on the acquisitions. This mode provides a display of the max and min points (or the envelope) of the waveform.

Any of these three acquisition modes can be used with the REPET mode. The REPET mode forces the instrument to use equivalent-time (random) sampling of waveforms at acquisition rates faster than 500 ns/Division. When repetitive signals are acquired, REPET extends the bandwidth to 150 MHz.

Several features allow ease and versatility of operation when operating the scope. Front-panel complexity is reduced, since most front-panel buttons are used to call up menus and display them on screen. The user then turns on or off functions from the displayed menu. Up to 3 lines of readout are displayed at the top of the screen to inform the user of vertical, horizontal, triggering, and other settings. Cursors are available for directly measuring amplitude, time, frequency, and other waveform parameters, and the results are displayed on screen via a cursor readout. Information about almost any front-panel control can be displayed on screen using the HELP feature.

Operation ease is further enhanced by use of the AUTOSetup, MEASURE, and AUTOStep features. Pushing the AUTO button gives a workable front-panel setting for successive acquisitions. MEASURE can be used to display a "snapshot" of 20 parameters for a single acquisition or to continuously update and display up to 4 parameters for successive acquisitions. Finally, AUTOStep can store over 200 front-panel setups for recall and can be used in tandem with MEASURE to create setups that automatically make a waveform measurement.

The features touched on here are only part of those available with this instrument. The product description in Section 6 further details the features of this instrument.

Preparation For Use

Safety

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 a power source, read both this subsection and the Safety Summary.

CAUTION

This instrument may be damaged if operated with the LINE VOLTAGE SELECTOR switch set for the wrong applied ac input-source voltage or if the wrong line fuse is installed.

Line Voltage Selection

The scope operates from either a 115-V or 230-V nominal ac power- input source having a line frequency ranging from 48 Hz to 440 Hz. Before connecting the power cord to a power-input source, verify that the LINE VOLTAGE SELECTOR switch, located on the rear panel (see Figure 1-1), is set for the correct nominal ac input-source voltage. To convert the instrument for operation from one line-voltage range to the other, move the LINE VOLTAGE SELECTOR switch to the correct nominal ac source-voltage setting (see Table 1-1). The detachable power cord may have to be changed to match the particular power-source outlet.

Line Fuse

To verify the proper value of the instrument's power-input fuse, perform the following procedure.

1. Press the fuse-holder cap and release it with a slight counterclockwise rotation.
2. Pull the cap (with the attached fuse inside) out of the fuse holder.
3. Verify proper fuse value (see Table 1-1).
4. Install the proper fuse and reinstall the fuse-holder cap.

NOTE

A 4-A, 250-V, 5 x 20-mm Time-lag (T) fuse may be substituted for the factory-installed fuse. However, the two types of fuses are not directly interchangeable; each requires a different type of fuse cap.

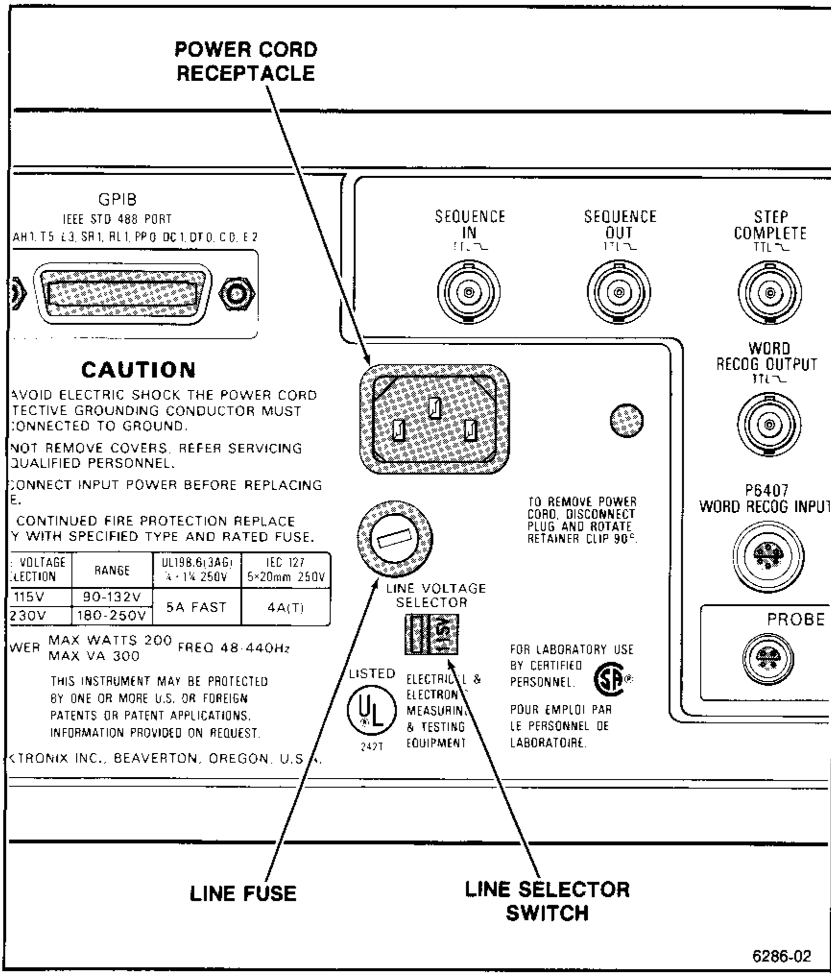
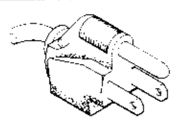
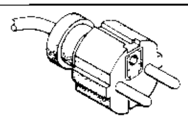
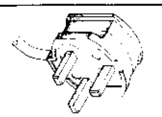
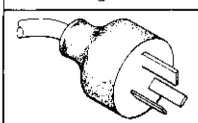
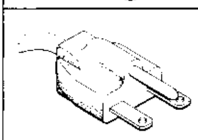
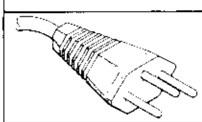


Figure 1-1. LINE VOLTAGE SELECTOR, fuse, and power cord receptacle.

Table 1-1
Voltage, Fuse,[a] and Power-Cord Data

Plug Config-uration	Category	Power Cord and Setting	Line Voltage Selector/ Voltage Range	Reference Standards[c]
	U.S. Domestic. Standard	U.S. 120V 15A	115V 90V to 132V	ANSI C73.11 NEMA 5-15-P IEC 83 UL 198.6
	Option A1	EURO 240V 10-16A	230V 180V to 250V	CEE(7), II, IV, VII IEC 83 IEC 127
	Option A2	UK[b] 240V 6A	230V 180V to 250V	BS 1363 IEC 83 IEC 127
	Option A3	Australian 240V 10A	230V 180V to 250V	AS C112 IEC 127
	Option A4	North American 240V 15A	230V 180V to 250V	ANSI C73.20 NEMA 6-15-P IEC 83 UL 198.6
	Option A5	Switzerland 220V 6A	230V to 250V 180	SEV IEC 127

[a]All options listed come with a factory-installed fuse with the following specifications: 5A, 250 V AGC/3AG Fast-blow (UL 198.6). The fuse holder used is AGC/3AG.

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

[c]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.

Power Cord

This instrument has a detachable three-wire power cord with a three-contact plug for connection to both the power source and protective ground. The power cord is secured to the rear panel by a cord-set securing clamp. The protective ground contact on the plug connects (through the power cord protective grounding conductor) to the accessible metal parts of the instrument. For electrical-shock protection, insert this plug into a power-source outlet that has a properly grounded protective-ground contact.

Instruments are shipped with the required power cord as ordered by the customer. Information on the available power cords is presented in Table 1-1, 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.

Instrument Cooling

To prevent instrument damage from overheated components, adequate internal airflow must be maintained. Before turning on the power, first verify that air-intake holes on the bottom and side of the cabinet and the fan exhaust holes are free of any obstruction to airflow. The scope has a thermal cutout that will activate if overheating occurs. The scope shuts down immediately with no attempt to save waveforms or front-panel conditions if a cutout happens. Power will be disabled to the scope until the thermal cutout cools down, at which time the power-on sequence is redone. The resulting loss of the last front-panel and waveform data will cause the power-on self test to fail and is indicated to the user by a failed CKSUM-NVRAM test (number 6000 in the main EXTENDED DIAGNOSTICS menu). The cause of the overheating must be corrected before attempting prolonged operation of the scope. Pressing the MENU OFF/EXTENDED FUNCTIONS button restores the scope to the normal operating mode.

Start-Up

This instrument automatically performs power-up tests each time the instrument is turned on. These tests provide the highest possible confidence level that the instrument is fully functional. If no faults are encountered, the instrument will enter the Scope mode in the either ACQUIRE or SAVE Storage mode, depending on the mode in effect when it was powered off.

If tests are failed, the 2430A displays the Extended Diagnostics menu. If the failure is in the range of 1000-5300 and the message "HARDWARE PROBLEM—SEE SERVICE MANUAL" is displayed with the menu, refer the instrument to qualified service personnel. If the failure is in 1000-5300 range, but "RUN SELF CAL WHEN WARMED UP" is displayed, the SELF CAL procedure should be executed from the EXTENDED FUNCTIONS menu (wait for the NOT WARMED UP message to disappear from the SELF CAL menu). If failures persist after the SELF CAL is run (the "HARDWARE PROBLEM—SEE SERVICE MANUAL" message will be displayed), refer the instrument to qualified service personnel.

Failure of a test in the range of 7000 to 9300 may not indicate a fatal scope fault. Several conditions can occur that will cause a non-fatal failure of the tests. The scope will display "RUN SELF CAL WHEN WARMED UP" to indicate a SELF CAL should be performed. If SELF CAL does not clear the failure ("HARDWARE PROBLEM—SEE SERVICE MANUAL" is displayed), the scope may still be usable for your immediate measurement purposes. For example, if the problem area is in CH 2, CH 1 may still be used with full confidence of making accurate measurements. Press the MENU OFF/EXTENDED FUNCTIONS button to exit EXTENDED DIAGNOSTICS and enter Scope mode.

NOTE

The SELF CAL procedure is detailed in Section 4 of this manual. Refer to Appendix A of this manual for information on the power-up tests and the procedures to follow in the event of a failed power-up test.

A fatal fault in the operating system will cause the scope to abort. No displays are possible, and the user is notified of an abort situation only by the flashing of the Trigger LED indicators (if that is possible). Cycling the power off then back on may clear the problem, but a failure of this magnitude usually requires the scope to be referred to a qualified service person for checkout and repairs. Persistent or reoccurring failures of the power-on or self-diagnostic tests should be brought to the attention of a qualified service person at the first opportunity. Consult your service department, your local Tektronix Service Center, or nearest Tektronix representative if further assistance is needed.

Power-Down

NOTE

POWER INTERRUPTION TO THE INSTRUMENT WHEN THE SELF-CALIBRATION ROUTINE IS EXECUTING INVALIDATES THE INSTRUMENT CALIBRATION CONSTANTS. Upon such an interruption, the instrument sets an internal flag denoting that SELF CAL was running at shutdown. When power is reestablished, the scope will display "RUN SELF CAL WHEN WARMED UP". When the "NOT WARMED UP" message disappears from the SELF CAL menu, the user MUST perform a SELF CAL to escape the EXT DIAG menu (the ↑ menu button MUST be used to access the SELF CAL menu—see Appendix A for more information). If failures persist after the SELF CAL is performed, refer the instrument to qualified service personnel.

For a normal power-off from the scope mode, an orderly power-down sequence retains the SAVE and SAVEREF waveforms, the current front-panel control settings, and any stored front-panel settings. If a power-off or transient power fluctuation occurs during SELF CAL, or EXTENDED CALIBRATION, or the instrument shuts-down at any time due to overheating, the normal power-down sequence is not executed. The result is loss of stored calibration constants or last front-panel control settings (or both) and a failure of the next power-on self-test (6000-6400 range). If front panel, sequencer, or stored waveform information was lost, the error will clear itself on the next power-down/power-up cycle. If calibration constants were lost the instrument will display information indicating if calibration is needed. If failures persist, refer the instrument to qualified service personnel.

If power is momentarily interrupted, starting the power-off sequence, but is reestablished before the sequence completes, the scope will redo the power-on procedure. If the scope is in the middle of a waveform acquisition when power interruption occurs, the waveform data will not be saved, and the invalid waveform data display will be seen when power-on has completed. Press ACQUIRE to restart the acquisition and obtain valid waveform data.

Repackaging For Shipment

It is recommended that the original carton and packing material be saved in the event it is necessary for the instrument to be reshipped using a commercial transport carrier. If the original materials are unfit or not available, then repackage the instrument using the following procedure.

1. Use a corrugated cardboard shipping carton having a test strength of at least 275 pounds and with an inside dimension at least six inches greater than the instrument dimensions.
2. If the instrument is being shipped to a Tektronix Service Center, enclose the following information: the owner's address, name and phone number of a contact person, type and serial number of the instrument, reason for returning, and a complete description of the service required.
3. Completely wrap the instrument with polyethylene sheeting or equivalent to protect the outside finish and prevent entry of harmful substances into the instrument.
4. Cushion instrument on all sides using three inches of padding material or urethane foam, tightly packed between the carton and the instrument.
5. Seal the shipping carton with an industrial stapler or strapping tape.
6. Mark the address of the Tektronix Service Center and also your own return address on the shipping carton in two prominent locations.

"Getting Acquainted" Procedure

A. Let's hook up and get a usable display...

CAUTION

Read "Operators Safety Summary" and "Preparation for Use" (in this section) before performing this procedure.

1. Connect the scope to a suitable power source and POWER it ON. Wait for the scope to finish running its power on self check. Push the front-panel button labeled "PRGM" (under the SEC/DIV control). Now push the button (one of five buttons in the bezel under the CRT) under the label "INIT PANEL".
2. Install one of the two probes included with the scope to the CH 1 input BNC; install the second probe to CH 2. Connect both probes to the CALIBRATOR output and hook the probe's ground leads to scope ground (the banana plug jack under the CALIBRATOR output can provide the ground if a suitable plug is inserted).
3. The scope has the ability to automatically set itself up for a usable display— Press the button labeled "AUTO" under the A and B SEC/DIV knob.

Note that the instrument flashes the message "AUTOSET WORKING: PLEASE WAIT" on-screen as it searches for information about the signal(s) its acquiring. In a few seconds, front-panel settings are effected that deliver a display for CH 1. Some of the front-panel settings effected are displayed on-screen. The top line of information indicates the following:

a. the CH 1 VOLTS/DIV setting;

b. the SEC/DIV mode and setting;

c. the level on the waveform the scope is triggered on; and

d. the signal source used for the trigger (VERT source).

The scope displays up to two more lines (directly below the top line) as needed to indicate other front-panel settings (CH 2 VOLTS/DIV setting, B SEC/DIV setting, etc.).

NOTE

AUTOset is a useful and versatile feature. Demonstrating its complete capabilities requires an external signal generator and is, therefore, beyond the scope of this introductory procedure. We will examine AUTOset more closely in Sections 2 and 3.

B. Let's learn about the vertical controls and instrument control menus...

1. Press the front-panel button labeled VERTICAL MODE. Note that the two lines of text at the bottom of the CRT display are replaced with two different lines. What you have just done is call up a new instrument menu. Many front-panel buttons call up menus which display mode choices available for user selection.
2. Push the button under the menu labeled "CH1". (This button is the left-most button of five buttons comprising the menu buttons in the bezel under the menu.)

Note that pressing the button removes the underline from the CH 1 menu label and turns off (removes) the display for CH 1 from the screen. Pushing the button again returns the underline to the label and the CH 1 display to the screen. This action is typical of the scope's menu operation; i. e., the buttons operate in a push/push fashion with the menu selection displayed underlined when the functions or modes corresponding to the buttons are on and with no underline when the functions are off.

3. Turn CH 1 back on and turn CH 2 on. Note the readout for the CH 2 VOLTS/DIV setting appears as the left-most entry of line 2 of the readout (directly under that for CH 1). Set the CH 1 VOLTS/DIV control to 1 V (2 positions counterclockwise).
4. Push the menu button labeled "ADD" (the readout for the ADD mode display appears on readout line 3). ADD mode displays the CH 1 and CH 2 signals added algebraically.
5. Turn on the MULT vertical mode. Note that the menu label for ADD is now no longer underlined while the MULT label is. There are some features in the instrument that cannot be used with others. The ADD and MULT vertical modes are mutually exclusive; therefore, turning one on cancels the other (the ADD waveform and VOLT/DIV setting were replaced by the MULT waveform and setting).

MULT is used to multiply two waveforms together and is useful as a measure of power. See "MULT Mode Applications" in Section 3, "Applications", for a discussion and an illustration of this function's use.

6. Turn off CH 2 and MULT. Press the button under YT¦XY. The instrument now leaves the YT mode (where acquired waveforms are plotted on the X axis against Time on the Y-axis) and enters the XY mode (where the CH 1 waveform is plotted on the X-axis against CH 2 on the Y-axis).

Notice that the ADD and MULT selections are removed from the menu. These vertical modes are not allowed when XY is the display mode. The scope is "smart" enough to remove the labels for modes or functions when a selected mode bars their use.

NOTE

This action is different from that in step 5. The instrument did not remove ADD from the menu when MULT was turned on, since ADD could be turned back on from the menu.

When you switched the instrument to XY mode from YT, the underline moved from YT to XY in the menu. This type of mode selection is different from the type you have used so far to turn on CH 1, CH 2, ADD, etc. When two modes are mutually exclusive, but one or the other must be on, the modes appear as one label over a single button with the mode presently in effect underlined. Pushing the button "toggles" the underline between the two modes, turning the underlined mode on and the other mode off.

7. Push the YT¦XY menu button to toggle the display mode back to YT. Note that, although you switched off CH 2 in step 6, CH 2 is now on (the CH 2 label is underlined and CH 2 is displayed). The scope turned on CH 2 when XY mode was selected in step 9, since the instrument "knew" that CH 2 must be on for an XY mode display. Go ahead and turn CH 2 back off.

8. Push the front-panel button under the CH 1 VOLT/DIV knob labeled "COUPLING/INVERT". Note that the coupling is set to DC. Push the COUPLING/INVERT button again. Note that the underline moves to the right to GND (ground setting). Push the button twice more. The underline "wraps around", turning AC coupling on first and then returning to DC coupling (leave coupling set to DC).

This "wrap around" feature for switching between different mode settings is a shortcut method used for several instrument modes. For many menus, the first push of the front-panel button selects the menu, while subsequent pushes select through two or more menu choices in sequence for turn on. Some examples are COUPLING/INVERT, BANDWIDTH, TRIGGER POSITION, TRIGGER COUPLING, and TRIGGER MODE.

9. PUSH the front-panel button labeled BANDWIDTH. Notice that you can bandwidth limit the vertical system of this scope to 20 MHz, 50 MHz, or FULL (150 MHz).

10. Rotate the SEC/DIV control clockwise to increase the A acquisition rate one setting (the A SEC/DIV readout in the top line of the readout changes). Note that designations for USB and USR change. These values are for USable Bandwidth and USable Rise time. Since the bandwidth and rise time of the instrument depends on the acquisition rate, the scope indicates what they are for the different SEC/DIV settings.

11. Switch SMOOTH ON!OFF to ON in the displayed menu. Notice the corners of the square wave roll off. This is because SMOOTH ON causes a moving 5 sample point digital filter to be applied to the waveform. SMOOTH is useful for eliminating noise from non-repetitive waveforms that cannot be acquired in AVERAGE mode. Switch the scope back to SMOOTH OFF.

Before we leave "vertical controls" let's look at the way the vertical positioning controls work...

12. Use the CH 1 VERTICAL POSITION control to adjust the display vertically on screen. Notice you can turn the control clockwise and counterclockwise far enough to position the waveform about 2 divisions up and down before you encounter the end stops on the control. Now gently rotate the control past the end of the stop. The waveform will now move outside of the two division area up or down on screen. Rotating the control harder past the stop increases the rate the waveform moves up or down the screen. The maximum rate the waveform can be moved is reached at the second stop (a "hard" stop).

    Types of controls like the VERTICAL POSITION controls are called "position-rate" controls. In the "position" region inside the first stops, they act like most rotating controls; i.e., they adjust the controlled function an amount directly proportional to the amount the control is moved and at a rate directly proportional to the rate the control is turned. In the "rate" regions, between the "soft" and "hard" stops, they adjust the function much quicker with the rate directly proportional to distance the control is rotated past the soft stop. In a sense, these controls are "smart" controls. They assume that small movements of the control means fine adjustments are desired while large movements mean large adjustments are desired and adjust their operation accordingly. The VERTICAL and HORIZONTAL POSITION controls, as well as the CURSOR/DELAY FUNCTION control, are all examples of rate-position controls.

13. Center the waveform vertically on-screen.

C. Let's check out the HORIZONTAL controls and menus...

1. Push the AUTO front-panel button. After AUTOset executes, set the SEC/DIV setting to 1 ms as required.
2. The resulting CH 1 display should be centered on screen with a small "T" riding on the square wave at center screen (the "T" indicates the trigger point on the waveform). If the "T" it is not present perform steps a to e. Otherwise, go to step 3.
   a. Push the MENU OFF/EXTENDED FUNCTIONS front-panel button twice to remove the menu displayed and to substitute the Extended Functions menu.
   b. Push the menu button labeled SYSTEM (menu will change).
   c. Push the menu button labeled MISC (menu will change).
   d. Set TRIG T ON|OFF to ON.
   e. Push the MENU OFF/EXTENDED FUNCTIONS front-panel button to return to normal operation.
3. Use the HORIZONTAL POSITION control to move the T, first to the extreme right side of the screen, then to the extreme left.

Note there are 10 horizontal divisions displayed on both sides of the T. This is because the instrument displays its 1024 sample point waveform record over 20 divisions (it's like having a 2X magnifier on all the time). Reposition the "T" to center screen.

4. Push the front-panel button labeled "A INTEN" in the horizontal controls section. Note this button does not call up a new menu. This is one of five (the others are A and B HORIZONTAL MODE, SLOPE and A/B TRIG) buttons that does not always call up or turn off a menu when pushed.

Pushing A INTEN enables the B SEC/DIV switch. You may have noticed the entire waveform displayed became more intensified when A INTEN was switched on. This is because the entire A display is overlapped by an intensified zone, the duration of which is controlled by the B SEC/DIV setting (displayed on-screen below the A SEC/DIV readout when A INTEN or B is on).

5. Turn the SEC/DIV control clockwise three positions until the B SEC/DIV setting reads 100 μs on screen. Note that the intensified zone shrank until it now only covers about 1 cycle of the waveform around the small "T". Since the B acquisition rate is now 10X faster than the A setting, the intensified zone now only overlaps about 2 horizontal divisions of the A display (2 divs/20 divs = 1/10).
6. Push the front-panel button labeled HORIZONTAL MODE B to display the waveform at the acquisition rate setting for B. Note the A display is now replaced by a 20-division, B display of what was the 2-division intensified zone. We have, in effect, magnified the 2-division intensified zone by 10 (we can further magnify it by changing the B SEC/DIV setting to increase the B acquisition rate).
7. We can also pick the area on the A display we wish to magnify. Return the HORIZONTAL MODE to A INTEN. Push the front-panel button labeled DELAY TIME. A new menu is now displayed, containing the delay time setting. Rotate the front-panel CURSOR/DELAY control clockwise (this control is located between the CURSOR and DELAY front panel sections). The intensified zone now moves to the right of the "T" along the waveform. Switch back to B horizontal mode. Now when you rotate the control the waveform moves on screen, since you are magnifying a different part of the A waveform.

There are two zones delayable by time available for use with the instrument, as well as a delay by events function. These features are further explained in Section 2. Applications are given in in Section 3 under "Delay Time Measurements and Applications".

8. Return the HORIZONTAL MODE setting to A.

One thing to remember when using the horizontal controls is that any time the B SEC/DIV readout is on screen (i.e., the HORIZONTAL MODE is A INTEN or B), the SEC/DIV control adjusts the B acquisition rate.

D. Using the Trigger controls...

Use of trigger controls is rather straightforward with the selections for TRIGGER COUPLING, SOURCE, POSITION, and MODE selectable by menu (the method used is like that described for the vertical menu controls). You can read about these trigger controls in Section 2. For right now, let's just cover a few aspects of the trigger controls:

1. Push the front-panel button labeled "MODE" in the TRIGGER controls section. Rotate the control labeled "TRIGGER LEVEL" to untrigger the display and note the unstable display on screen.

2. Turn AUTO LEVEL mode on (push the menu button). Note that the display automatically becomes triggered. Now rotate the level control as done in step 1.

Notice that the scope momentarily detriggers and then retriggers when you attempt to adjust the A trigger level outside of the signal level (peak-to-peak) range. The AUTO LEVEL feature establishes a new trigger level when signal levels change (or the user attempts to adjust the level outside the signal range). This feature is handy when making many consecutive measurements since you don't have to stop to adjust the trigger level.

3. Push the front-panel button labeled A/B TRIG. Note that the menu changes to the B TRIGGER MODE menu and that the B trigger level and source are displayed in the second line of the readout. The TRIGGER LEVEL control now adjusts the B-Trigger level to trigger B acquisitions for the B TRIG AFTER delay mode (see "B-Trigger Modes" in Section 5 for more information).
4. Push the front-panel button labeled TRIGGER COUPLING. Note that the B-Trigger coupling menu is displayed.
5. Push the front-panel button labeled A/B TRIG. Note that the A Trigger COUPLING menu is now displayed.

As inferred in steps 4 and 5, the trigger system selection, A or B, determines which system's menus are selected when TRIGGER COUPLING, MODE, SOURCE, or POSITION are pushed. Using the A/B TRIG button to switch between the triggering systems also switches between the A and B menus for those functions.

E. Let's learn about the storage controls...

1. Push the front-panel button labeled STORAGE ACQUIRE.
2. Repeatedly push the menu button labeled ENVELOPE. Note the count displayed above the "ENVELOPE" label is increased with each push. Continue to push the button until CONT (continuous) appears.

The count above the label for ENVELOPE and AVeraGe modes defines the number of triggered acquisitions for a single envelope or average sequence. (See "SINGLE SEQ" under "A-Trigger Mode" in Section 5 for a discussion of the difference between an acquisition and an acquisition sequence.)

3. Use the CH 1 Position control to move the display vertically slightly (about a division up or down). Notice that when the signal is moved vertically as a result of the position offset added, a "filled" area is created between the previous amplitude and the new amplitude level. This "envelope" waveform represents the minimum and maximum levels the waveform has assumed since the acquisition was initiated.

Although the offset "enveloped" in step 3 was caused by you when you positioned the display, changes in minimum and maximum amplitude levels of signals you input are captured the same way.

4. Push STORAGE ACQUIRE again. Note the envelope is erased and the acquisition sequence restarted. Pushing STORAGE ACQUIRE always restarts the acquisition for ALL acquisition modes.

There are many mode changes that can cause envelope or average sequences to restart. Some of these are changes to the settings for VOLTS/DIV, SEC/DIV, VERTICAL and HORIZONTAL MODE, etc. Some exceptions (they don't cause the restart) are changes to the VERTICAL and HORIZONTAL POSITION settings, changes to the VERTICAL VARIABLE setting, and the TRIGGER LEVEL, use of CURSORS, etc.

5. Disconnect the CH 1 probe's ground lead from scope ground to create a noisy signal.

6. Change the menu selection from ENVELOPE to AVG (Average). Continue to push the AVG button several more times. Notice that any noise on the waveform is greatly reduced as you increase the number of acquisitions you specify for an acquisition sequence. Also, notice the count "rolls around" to the minimum count of 2 after the maximum of 256 is encountered (same roll-around action occurs after CONTinuous for ENVELOPE).

7. Set the ACQUIRE MODE to NORMAL to return to the "live" mode we used during the other subsections of this procedure. Reconnect the probe ground disconnected in step 5.

8. Push the front-panel button labeled "SAVE". The instrument now enters the save mode, where all displays are "frozen" (the instrument quits acquiring). Notice that although the display is saved, you can use the CH 1 VERTICAL POSITION and the HORIZONTAL POSITION controls to position the saved waveform on screen.

The saved waveform can be stored for later reference—try this:

a. Push the button labeled CH1 in the SAVEREF SOURCE menu (menu changes).

b. Push any of the buttons labeled REF[1-4] for the SAVEREF DESTINATION menu.

c. Move the saved waveform to the top half of the screen and push ACQUIRE to resume acquiring the CH 1 waveform.

d. Push the front-panel button labeled "DISPLAY REF" and push the menu button that corresponds to the REF used for step b.

Essentially, you saved the waveform in step 8 and selected the CH 1 waveform (it was the only one displayed) for storing in step 8a. Step 8b selected the REF memory the waveform was to be stored in. Step 8c moved the saved-on-screen waveform out of the way so the waveform stored in the REF memory could be seen when displayed.

There are many other details about acquisition and storage modes/features. Read about these details in "Operators Familiarization" in the next section and "Storage Applications" in Section 3.

F. Let's make some measurements...

1. Push the AUTO front-panel button to AUTOset the scope. Set the A SEC/DIV to 1 ms as required.
2. Push the button labeled "FUNCTION" in the CURSOR section of the front panel. Select VOLTS from the CURSOR FUNCTION menu that's displayed.

Note that two horizontal cursors are displayed. These are called the vertical cursors because they move vertically.

3. Rotate the CURSOR/FUNCTION control. Note that the segmented cursor moves up and down screen with that control. Align that cursor to the top of the square wave displayed.
4. Push the front panel button labeled "SELECT". Note that the cursor that was solid becomes segmented and can now be moved by the CURSOR/FUNCTION control (we use this button to "select" cursors for adjustment). Align this cursor to the bottom of the square wave.
5. Read the peak-to-peak amplitude of the square wave from the cursor readout (upper-right quadrant of the screen). It should read approximately 400 mV, since that is the amplitude of the calibrator output into 1 MΩ.
6. Increase the A SEC/DIV setting to 500 μs.
7. Change the menu function selected from VOLTS to TIME. Note the cursors are now parallel to the vertical graticule lines instead of the horizontal lines. These cursors are called horizontal cursors because they move horizontally.
8. Rotate the CURSOR/FUNCTION control and notice which cursor moves. Although both of these cursors are segmented, you will notice that the one with the most "dots" moves. Align this cursor to the rising edge of one cycle of the square wave.
9. Push SELECT and move the other cursor to the rising edge of the square wave that immediately precedes or follows the one used in step 8.
10. Read the time period (approximately 2.000 ms) of the bracketed square wave from the cursor readout.
11. Change the menu function selected from TIME to 1/TIME. Read the frequency (approximately 500 kHz) from the readout.

These last few measurements illustrate only a fraction of those possible using the cursors in their various functions, units, and in conjunction with different display modes. "Special Applications" in Section 3 of this manual will show you how to use the cursors to make a variety of measurements.

G. A word about HELP.

1. This scope can display on-screen information about the functions and operations of its front panel controls. Push the STATUS/HELP button under the CRT.

2. Only one menu selection is available with the STATUS/HELP menu; push the menu button labeled HELP.

You have just invoked the HELP mode for the instrument. In this mode, all front-panel controls (except POWER and the menu buttons) cause the instrument to display information about that control when actuated. Don't push any front panel buttons just yet. We'll try out HELP in a moment.

3. Right now, introductory information is displayed on-screen. As the information says, you exit HELP by pushing the EXIT button and you proceed through the information screens by pushing MORE. Push MORE now.

4. Use the MORE menu button to proceed through the remaining two screens of introductory information (go ahead and read the information as it's displayed). When MORE is no longer displayed in the menu, follow the instructions at the bottom of the screen.

5. Assuming you went ahead and pushed a button or turned a knob, you saw information about the control you actuated appear on screen. If more than one screenful of information is required to explain the control, MORE also appears in the menu for use as previously explained.

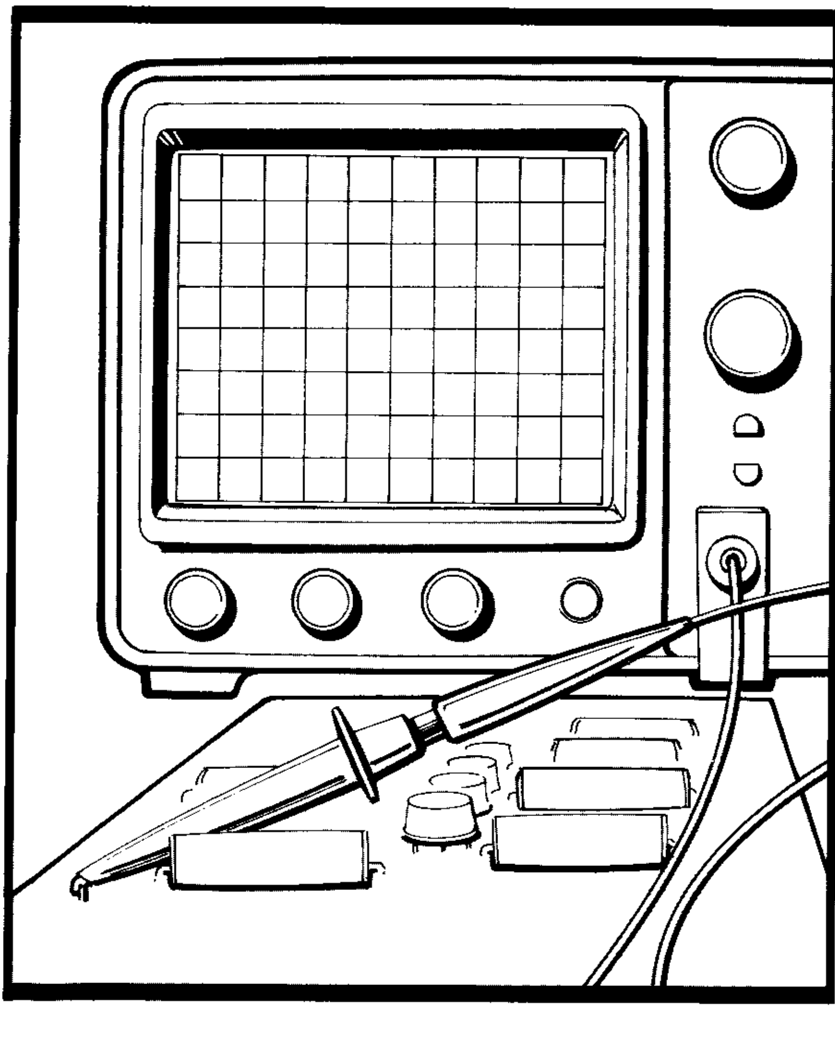
6. Push any other front-panel controls (again, except POWER) to see an explanation of their function and operation. When you've read about as many of the controls as you want to right now, go ahead and push the menu button labeled EXIT to return to scope mode. But remember, HELP can be used any time information on a control is desired (except when running internal calibration and/or diagnostic routines). Just press EXIT when finished and you will return to your original setup in effect before HELP was invoked.

This procedure, as indicated previously, does not detail all of the many features and their possible applications; rather, it is intended to introduce some of those features/applications and whet your appetite for more. Read through the information and perform the procedure in Section 2. Some of the material reviews that covered in our "Get Acquainted" procedure (but with additional expansion) while some will be new. In any case, the material presented should increase your understanding of the instrument features available and suggest uses for those features.

After Section 2, examine the Applications in Section 3 to see how to apply this instrument to your own applications. We also recommend you consult the Table of Contents for Section 3 when you have an application you need to address, to see if it is covered there.

SECTION 2

Operation



Operation

This section is composed of two subsections. The first contains basic operating information and techniques that should be considered before attempting to make measurements with your instrument. The second subsection consists of operators familiarization procedures designed to get a first-time user quickly introduced to all the operating controls and most menu selections.

Operating Considerations

Graticule

The graticule is internally marked on the faceplate of the CRT to eliminate parallax-viewing error and to enable accurate measurements. The graticule is marked with eight vertical and ten horizontal major divisions. Major divisions are further divided into five subdivisions of 0.2 division each, marked along the center vertical and horizontal graticule lines (see Figure 2-1). Percentage marks for rise-time and fall-time measurements are located on the left side of the graticule. The vertical deflection factors and horizontal timing are calibrated to the graticule so that accurate measurements may be made directly from the CRT.

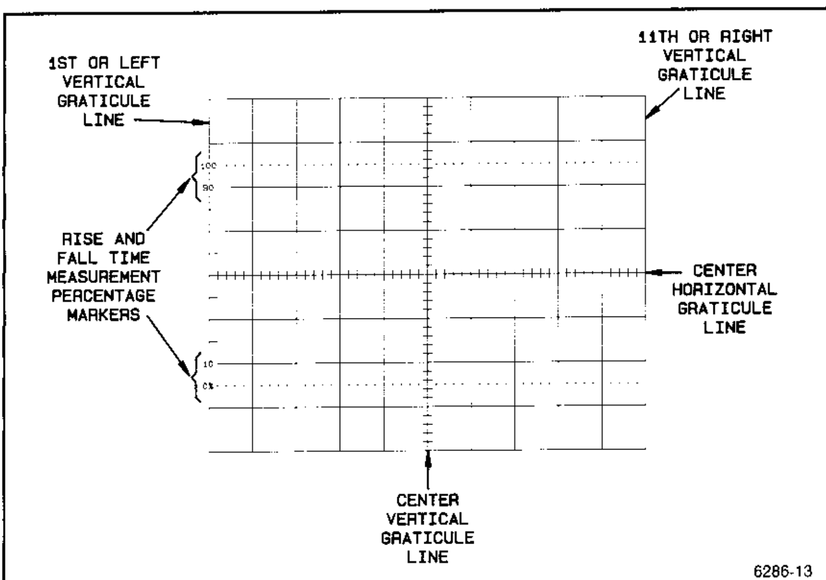


Figure 2-1. Graticule measurement markings.

Time and Voltage Measurements

This instrument provides several methods for making both time and voltage measurements. The various methods produce different degrees of accuracy and require different amounts of time and care in obtaining the measurement value. Using the graticule markings for measuring voltage or time produces the quickest evaluation, but the results are the least accurate. Improved accuracy with this method is gained only by using a great deal of care and time in positioning the waveform on the graticule and counting the graticule divisions. Direct graticule measurements should be used only where precision is of less importance than speed.

Time and voltage measurements made on the displayed waveforms using the CURSOR functions produce highly accurate, precise results. Setup time to make a particular measurement is fast, and the measurement result is readout on the CRT. Using the cursors avoids errors due to display gain and CRT trace non-linearity and eliminates the inconvenience of counting and interpolating graticule markings.

Cursor measurements are also very flexible in that they can be set up to measure either the difference between cursor positions or the difference between the cursor position and an absolute reference point (ground for voltage measurements and the Record Trigger Point for time measurements). Two coupled cursor modes tie each VOLT cursor to a corresponding TIME cursor allowing slew rate to be measured (SLOPE mode) and voltage measurements to be made at chosen time points on the waveform (V@T mode). The 1/TIME cursor mode is available for making frequency measurements. The units of measurement are also selectable to serve a wide range of measurement applications.

Time difference measurements that require the highest degree of accuracy and/or involving delays beyond the on-screen limits of the TIME cursors are made using the DELAY by TIME and ΔTIME modes of the B Delayed trace. B Delayed time measurements take the most time to set up, but they avoid the introduction of errors due to possible cursor misalignment at the measurement point on the waveforms.

Details of all the available cursor functions and units are provided in Section 5 "Controls, Connectors, and Indicators." Use of the various cursor and B Delay modes for making measurements is described in Section 3, "Basic Applications."

Acquiring Data

Acquisition of both the CH 1 and CH 2 input signals is made simultaneously at all times whether the signal is being displayed or not. This feature permits the user to call up the undisplayed channel signal after entering SAVE Mode. Either channel signal may be independently inverted during acquisition.

Waveforms may be acquired in NORMAL, ENVELOPE, or AVG (average) Storage Mode. NORMAL produces a live trace similar to that seen on a conventional oscilloscope. Signals acquired using ENVELOPE mode readily display any variations of the waveshape as minimum and maximum data point values for each sample interval are displayed. AVG Storage Mode acquisitions present a very clean display with uncorrelated noise accompanying a signal being averaged out. The number of acquired waveforms to be incorporated into the ENVELOPE or AVG display is selectable by the user.

REPET Mode may be used with either NORMAL or AVG Storage Mode to extend the usable storage bandwidth to 150 MHz when viewing repetitive signals. REPET is also available for SINGLE SEQ operation, where the actual number of acquisitions occurring for a single sequence is the number required to meet the USB (Useful Storage Bandwidth) for the SEC/DIV setting used and adequately "fill in" the waveform for good display. When REPET is not used, the Useful Storage Bandwidth is 40 MHz, and digital interpolation is used to provide the waveform data points between samples taken at the maximum sampling rate (for SEC/DIV settings of 200 ns and faster).

A SAVE-ON-Δ feature enables the scope to compare the incoming signal against a reference envelope waveform. If the signal falls outside the reference envelope, the scope switches to the SAVE Mode to preserve the out-of-limit waveform for analysis. There are two applications in "Storage Applications" (Section 3) that illustrate methods of using this feature, both from the front panel and the GPIB.

Acquired waveforms are also saved when the user presses the front-panel button labeled SAVE. The scope immediately preserves the current CH 1 and CH 2 waveforms and ADD/MULT functions (displayed or not). All cursor functions are usable for making measurements on the saved waveform displays, and the SAVE waveforms may be horizontally and vertically positioned and expanded. Expansion of SAVE waveforms is nondestructive; it is done as a display function only, so the original waveform may be returned by merely de-expanding the display. Once saved, the waveforms may be transferred to a SAVEREF memory where they may be preserved for extended periods of time. Saved waveforms can be called up at anytime to analyze them or to use them as reference waveforms for comparison to the live waveforms being acquired.

Grounding

The most reliable signal measurements are made when the scope and the unit under test are connected by a common reference (ground lead) in addition to the single lead or probe. The ground lead of the probe provides the best grounding method for signal interconnection and ensures 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 jack on the front panel using a banana-tip connector.

Signal Connections

Probes

Generally, probes offer the most convenient means of connecting an input signal to the instrument and are shielded to prevent pickup of electromagnetic interference. The standard 10X probes supplied with this instrument offer a high input impedance that minimizes circuit loading. This allows the circuit under test to operate with a minimum of change from the normal, unloaded condition. Also, the subminiature body of these probes has been designed for ease of use when probing circuitry containing close lead spacing.

The probe itself and the probe accessories should be handled carefully at all times to prevent damage. Striking a hard surface or dropping the probe body can cause damage to both the body and the probe tip. Use care to prevent the cable from being crushed or kinked, and do not place excessive strain on the cable by pulling it.

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 long signal or ground leads may form a series-resonant circuit. This resonant circuit affects system bandwidth and can oscillate (ring) if driven by a signal containing significant frequency components at or near its resonant frequency. Ringing can then appear on the scope display and distort the true signal waveform. Always keep both the ground lead and the probe signal-input connections as short as possible to maintain the best waveform fidelity.

Misadjustment of probe compensation is a common source of measurement error. Because of variations in oscilloscope input characteristics, probe compensation should be checked and adjusted, if necessary, whenever a probe is moved from one oscilloscope to another or between channels of a multichannel oscilloscope. The probe compensation adjustment procedure is found in "Checks and Adjustments," in Section 4 of this manual and in the instructions supplied with the probe.

AUTOMATIC SCALE FACTOR SWITCHING. The VOLTS/DIV scale factors, displayed on the CRT, can be automatically switched by either GPIB-initiated control changes or by any change in the probe attenuation factor. Table B-1 in Appendix B of this manual shows the range of the VOLTS/DIV switch for all available Tektronix coded probes. The "expanded" portion of the table is obtained using firmware data-expansion routines for SAVE and averaged waveforms.

Coaxial Cables

Cables used to connect signals to the input connectors may have considerable effect on 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 must be terminated at both ends in their characteristic impedance to prevent signal reflections within the cable. The built-in 50-Ω termination for the input of the scope should be used for interconnection of 50-Ω system signals to the scope. If this is not possible, then use suitable impedance-matching devices.

Input Precharging

When the input coupling is set to GND, the input signal is connected to ground through the input-coupling capacitor in series with a 1-MΩ resistor to form a precharging network. This network allows the input-coupling capacitor to charge to the average DC voltage level of the signal applied to the probe. This prevents large voltage transients that may be generated from being applied to the amplifier input when the input coupling is switched from GND to AC. This precharging network also protects external circuits to the extent that it reduces the current levels drawn from the external circuitry during capacitor charging.

External Triggering

The A and the B trigger signals can be independently obtained from a variety of sources. Samples of the CH 1, CH 2, and ADD waveforms are available as trigger sources. Sometimes a different trigger source is needed instead of the one that corresponds to the channel the signal of interest is displayed in. In this case, either an unused vertical channel or either of two external trigger input channels can be used to input the signal. The vertical channels can be used to condition a wide range of signals to produce triggers over the full vertical deflection range from millivolts to thousands of volts in amplitude. The external trigger input channels have a limited choice of attenuation factors (either divided by 1 or by 5 without the use of external attenuation).

Operators Familiarization Procedures

Introduction

The Tektronix 2430A is an easy-to-use Digital Oscilloscope that provides you with an accurate and flexible waveform measurement and analysis tool. A combination of front-panel controls and menu-driven selections provides fast and convenient setup of the instrument operating modes. Menu selections allow access to the many waveform acquisition and processing functions while maintaining an uncluttered front-panel.

Selected menu functions, front-panel control settings, and measurement results are displayed in the CRT readout. In the menu displays, the selected operating mode or processing function is indicated by an underscored menu selection. The absence of an underscore beneath a choice in the menu display indicates that the selection is off.

Readout Display

The CRT readout display is your guide to how the instrument controls are set up. No physical markings are on the rotating switches and control knobs to indicate the control setting. A key to the location and type of readout information displayed is illustrated in Figure 2-2.

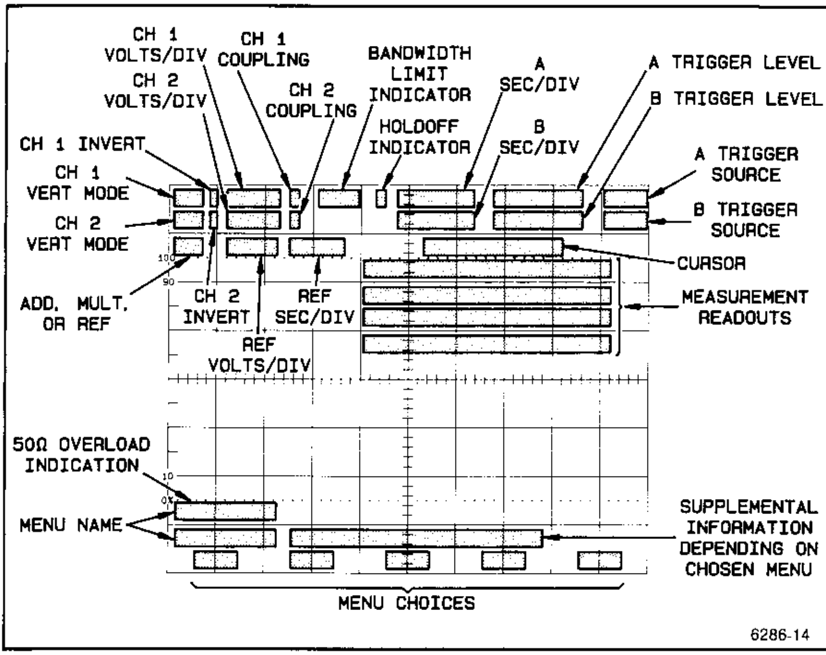


Figure 2-2. 2430A Readout display locations.

Front-Panel Controls

The front-panel controls are divided into two types:

Those directly affecting system operation as the control is activated, (i.e., VOLTS/DIV, SEC/DIV, HORIZONTAL and VERTICAL POSITION, and the specific menu selection buttons); and

Those that call up a menu with the specific entry choices that actually make an instrument function change (i.e., VERTICAL MODE, CURSOR selections, and most of the TRIGGER operation selections).

Menu control buttons work in several different ways as dictated by the type of function they are controlling. In certain instances they merely toggle a function on and off; in others, they are used to make additional selections once the main function selected by that menu button has been made. For some functions, the menu selections are self-canceling such as when two menu choices are mutually exclusive.

For ease of operation, many of the choices in a displayed control menu may be rotated through by simply pressing the front-panel button that called up the menu. An example of the last type is the COUPLING control menu. While the COUPLING control menu is displayed, the choices of AC, DC, and GND may be rotated through simply by repeatedly pressing the COUPLING/INVERT button of the active menu (either CH 1 or CH 2). As the procedure steps are performed, the ways in which the menu control buttons work are pointed out.

Familiarization Procedures

The following procedures acquaint you with the system menus and front-panel function buttons. Performing the step-by-step instructions and simple exercises of these procedures enhances your ability to use the instrument. As you use the controls and see how they affect the instrument, your understanding of their operation will be visually reinforced. Once acquainted with how the menus control the operating system and how quickly initial set-ups are made, developing efficient techniques for making specific measurements should be easy.

The detailed operation of each control and connector is described in "Controls, Connectors, and Indicators," in Section 5 of this manual. Included at the end of that section is a complete list of the control menus for user reference.

Getting a Display

1. With the scope connected to an appropriate power source, push the POWER button IN (green indicator is seen in the button). The scope does a power-on self test each time it is turned on. After a few seconds, the self test will be completed and the instrument will be ready for operation.

NOTE

If instrument fails power-up self test, see "Start Up" under "Preparation For Use" in Section 1. If the scope powers up in SAVE mode (not acquiring) a message is displayed instructing you to push STORAGE ACQUIRE.

Depending on the front-panel settings in effect when the instrument was powered off (the same settings are reestablished when the instrument is turned back on), there may or may not be a visible display on screen after the SELF-TEST is finished. If the CRT readout intensity has not been turned completely down, you should see some type of readout display. If a display source (VERTICAL MODE) is turned on and the DISPLAY intensity is not turned down, some waveform displays or traces are on screen. Regardless of whether or not there are visible displays on screen perform the following two steps:

2. Push STATUS/SELECT to set the READOUT INTENSITY to 65%. This level yields viewable readout and menu displays.

3. Push PRGM to display that menu, and push the menu button labeled INIT PANEL. This sets the front-panel to known default settings and yields an on-screen display of the CH 1 display source.

Remember this two-step procedure (steps 2 and 3) for use in obtaining visible displays.

NOTE

While INIT PANEL changes most front-panel controls to predefined states, certain controls are not allowed to be changed, (such as those accessed via the EXTENDED FUNCTIONS menus.) See Table B-15 in Appendix B for a list of the setup states initiated.

INIT PANEL can be used to quickly return the instrument to known operating conditions without searching the STATUS display or the menu selections to determine each front-panel control state (useful when front-panel controls are left in seldom used settings).

If you desire to re-adjust the intensity levels established by pushing STATUS and INIT, perform steps 4-7; otherwise, go to the next procedure, "Front-Panel Setup".

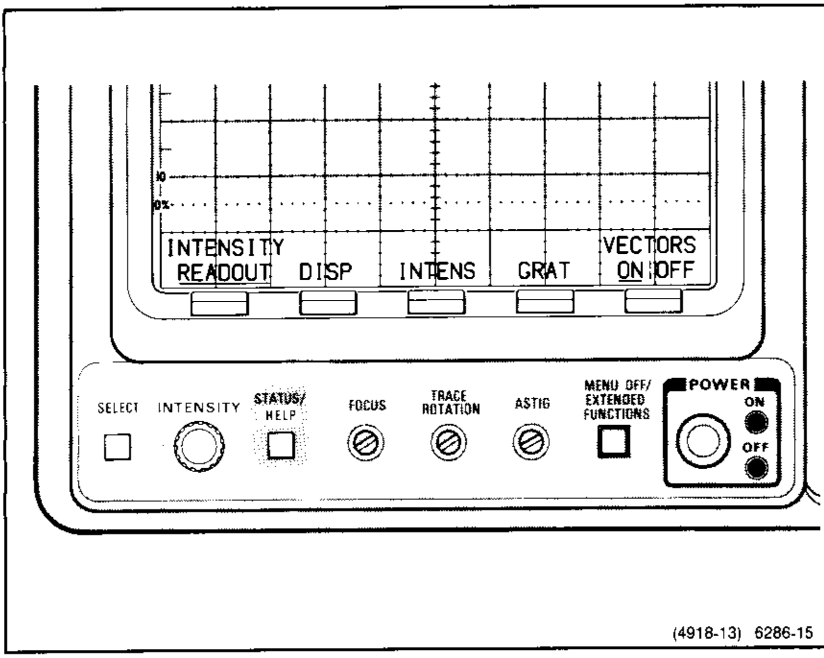


Figure 2-3. SELECT Menu and Menu Control buttons.

4. Press the SELECT button to display the INTENSITY control menu. Figure 2-3 illustrates the SELECT Menu entries and the position of the Menu Control buttons.

5. Press the READOUT menu button and use the INTENSITY control knob to set the readout intensity to a viewable level without excessive brightness. (Clockwise rotation of knob increases intensity.) The INTENSITY control is a continuous- rotation pot with no end stops to designate physical maximum or minimum rotation. You decide by observation when maximum or minimum intensity is achieved.

6. Now select GRATicule and adjust the illumination to the minimum (off) level. GRAT controls the edge lighting of the scribed CRT graticule markings for dimly lighted work areas and oscilloscope photography. The INTENS menu selection is used when adjustment of the contrast between the normal trace and the intensified zone in A INTEN displays is required. No adjustment of INTENS is required at this time.

7. Press DISP menu entry button and use the INTENSITY control to adjust the waveform trace to a viewable level.

Front-Panel Setup

Assuming steps 1-3 of the previous procedure were performed, you are now ready to set up the remaining front-panel controls to obtain a basic operating mode. Set the front-panel controls and make the menu selections for a basic setup as follows:

1. Push TRIGGER MODE and set the mode to AUTO in the Mode menu displayed.

2. Now set up (or verify; some settings may not need changing) the front-panel shown in the following list. The methods needed to set up the listed functions should be familiar from the procedure in Section 1. In general, the bold-face headings indicate the front-panel area the listed controls are found in, while the left and right columns indicate each control and its setting, respectively. Actuating the control may or may not result in a menu display. When using menus, remember that you underline menu label (push the button beneath it) to turn functions on and remove the underline to turn them off.

VERTICAL CONTROLS

MODE	CH 1 and CH 2—ON (underlined) ADD and MULT—OFF YT:XY—YT (toggling choice)
CH 1 and CH 2 VOLTS/DIV	20 mV
CH 1 and CH 2 COUPLING/INVERT	COUPLING—AC INVERT—OFF
CH 1 POSITION	Set trace to 1.5 divisions above graticule center.
CH 2 POSITION	Set trace to 1.5 divisions below graticule center.
BANDWIDTH	20 MHz
SMOOTH ON:OFF	OFF
CH 1 and CH 2 VARIABLE	CAL

HORIZONTAL CONTROLS

MODE	A
A SEC/DIV	500 μs

TRIGGER CONTROLS

B TRIGGER (Press A/B TRIG for B Trigger menu displays.)

TRIG POSITION	½
CPLG	AC
SOURCE	VERT (CH 1 is used)
MODE	RUNS AFTER—ON EXT CLK—OFF
SLOPE	+ (plus)

A TRIGGER (Press A/B TRIG for A Trigger menu

SLOPE	+ (plus)
MODE	AUTO (already set from step 1)
SOURCE	VERT (CH 1 is displayed)
CPLG	AC
TRIG POSITION	½

CURSORS CONTROLS

FUNCTION	All OFF (none underlined)

DELAY CONTROLS

DELAY EVENTS	OFF
Δ DELAY TIME	OFF

STORAGE CONTROLS

DISPLAY REF	All Off (none underlined)
ACQUIRE	NORMAL—ON REPET and SAVE ON Δ—OFF

3. Perform the following steps to set up the SYSTEM menu.

   a. Push the front-panel button labeled MENU OFF/EXTENDED FUNCTION (located immediately left of the POWER switch). Push the button once more.

   b. Select SYSTEM from the menu displayed to switch to the SYSTEM menu. Set PREFLT ON¦OFF to ON for that menu.

   c. Push MISC to switch to that menu and set BELL ON¦OFF to ON and TRIG T ON¦OFF to ON.

   d. Push the front-panel button labeled MENU OFF/EXTENDED FUNCTION to exit the EXTENDED FUNCTIONS menus.

4. Center the Trigger Position Indicator (a small "T" riding on the CH 1 and CH 2 baseline traces) horizontally on the graticule using the HORIZONTAL POSITION control.

5. Connect one of the standard accessory 10X probes to the CH 1 Vertical Input BNC connector; connect the other probe to CH 2. (The CH 1 and CH 2 VOLTS/DIV readouts should now read 200 mV.)

6. Connect the probe tips of both probes to the CALIBRATOR output connectors and the ground lead to scope ground. A two-division peak-to-peak display of the CALIBRATOR output signal should now be seen in both channels. The display may or may not be stable depending on the setting of the A Trigger LEVELcontrol.

7. Use the following procedure to set the A Trigger LEVEL.

   a. Press the TRIGGER MODE button.

   b. Press the A/B TRIG button to obtain the A TRIGGER MODE control menu if the B TRIGGER MODE menu is displayed.

   c. Select AUTO LEVEL Trigger Mode. Now the trigger level automatically follows trigger signal changes to maintain stable triggering. If you adjust the TRIGGER LEVEL control to set the level beyond the peak-to-peak limits of the trigger signal, the scope automatically resets the level to regain a stable trigger.

You now have a basic front-panel display setup for viewing signals applied to the CH 1 and CH 2 inputs. In the "Get Acquainted" procedure in Section 1, you saw how AUTOsetup was used to perform much the same function, i.e., to get the front-panel setup for a usable display. With AUTOsetup, the instrument executes many of the steps you performed up to this point in the procedure automatically, illustrating the the power and convenience of this feature. We'll examine AUTOsetup more closely later in this procedure.

Storing Front-Panel Setups

The AutoStep Sequencer function can be used to store single front-panel settings under a label. Let's save the setup you have created for later use...

1. Press the PRGM front-panel button to display the SEQUENCE menu.

2. Press the SAVE menu button. This calls up a sub-menu for labeling your front-panel setup with a 1-6 character name so it can be recalled later.

3. Use the arrows under ROLL-CHARS to create a label (use FP1, for front-panel 1) for the front-panel setup as outlined here in steps a-d:

   a. Select the first character for your label. Press the ↓ to step forward through the alphabet first and then through the digits 0-9. The ↑ steps from 9-0 and from z-a. (There is a "blank space" character between the digit 9 and letter a.)

   b. When you have displayed the letter or digit for the first character of the label, push CURSOR <> to move to the next character. Repeat step a to select the letter or digit for the next character of your label.

   c. Repeat step b to include up to 6 characters in your label. You can return to any character by continually pushing the cursor button, since it reverses the selection order after the first and sixth character is selected.

4. Push menu button labeled SAVE when your label is complete to assign it to the front-panel settings.

NOTE

You can create labels with as few as one character and can leave any character position (1-6) blank. Simply push SAVE when the label has the number of characters you want, in the positions you want them.

5. When SAVE is pushed, the scope displays a message indicating your chosen label and telling you to set up the controls. You could now change the controls as desired. Since the controls were already set up earlier in this procedure, just push the front-panel button PRGM to display the ACTIONS menu.

6. The ACTIONS menu allows you to specify different functions to be executed when the front panel is recalled. Since we only want to store our front-panel settings here, just push the menu button SAVE SEQ to store the front-panel settings. To recall any front panel stored, push PRGM and select RECALL from the SEQUENCE menu. Next, use the SELECT SEQ arrows in the RECALL menu to underline the label for the front-panel desired. Pressing RECALL implements the selected setup.

Performing SELF-CALibration

The SELF-CAL feature assures you that the most accurate measurements possible are being made. Self Calibration should be performed after instrument warmup, whenever the ambient temperature changes by more than ±5°C, and immediately prior to making a series of measurements when the highest level of accuracy is required.

NOTE

For about ten minutes after power-on (whether the instrument is warm or not), the message "NOT WARMED UP" is displayed in the CAL/DIAG menu. This message warns you that the temperature of the scope may not be stabilized. The message can be ignored and the SELF CAL procedure initiated at any time, but optimum calibration results are obtained after the temperature is stabilized and the message is removed.

Let's go ahead and do a SELF-CAL of the scope . . .

1. Push the MENU OFF/EXTENDED FUNCTIONS button twice (the first time to turn off the menus, the second time to turn on the EXTENDED FUNCTIONS menu).

2. Press the CAL/DIAG menu button to display the Calibration/Diagnostic menu.

3. Press the SELF CAL menu button to start the calibration; the message "RUNNING" should appear in the menu display. After a few seconds the self calibration is completed ("RUNNING" message leaves the display) and a PASS message should be above the SELF CAL label. The scope is then ready to return to its operating state.

NOTE

If the self calibration fails, the self-diagnostic mode is entered. In this event, push MENU OFF/EXTENDED FUNCTIONS twice and repeat step 2 to rerun the self calibration. If errors persist, the scope should be referred to a qualified service person. Any fatal test errors should also have caused a failure of the power-on self test when the scope was first turned on. See Appendix A for more information on the Self Test and Self Calibration features.

Depending on the test failed, the scope may function adequately for the measurements you need to make. Press the MENU OFF/EXTENDED FUNCTIONS button to exit the error display, and check the scope operation to determine if it will function for your purposes. In any event, the instrument should be referred to a qualified service person at the first opportunity.

4. Press MENU OFF/EXTENDED FUNCTIONS to turn off the calibration/diagnostics menu, then push ACQUIRE to start the waveform acquisitions again. Note the scope is returned to the setup you created prior to executing SELF CAL. This is a characteristic of SELF CAL operation.

By the way, you won't need CH 2 displayed for the next part of the procedure. Go ahead and turn it off using the VERTICAL mode menu and center the CH 1 display vertically on screen.

Using the SEC/DIV Control and a Horizontal Graticule Measurement

1. Turn the SEC/DIV switch slowly clockwise through the settings to 500 ns, then counterclockwise back to 500 μs. See how the A SEC/DIV readout changes and note the effects on the CALIBRATOR waveform.

Notice the CALIBRATOR output frequency changes with SEC/DIV switch settings every 3 settings between a maximum and a minimum output frequency. See Table B-2 in Appendix B for the CALIBRATOR output frequency for each SEC/DIVsetting.

2. Now check the period of the CALIBRATOR signal by determining the time of one complete cycle using the following procedure.

a. Use the Horizontal POSITION control to align the beginning of a cycle (the negative-to-positive rising edge) with any convenient vertical graticule line, and determine the number of horizontal divisions needed for one complete cycle of the CALIBRATOR signal. The center horizontal graticule line is graduated in 0.2 division increments to aid in interpolating between the large division markings.

b. Multiply the number of divisions (and/or decimal fraction parts of a division) counted by the SEC/DIV readout to calculate the CALIBRATOR signal period. Frequency is calculated by taking the reciprocal of the period. Since you set the SEC/DIV back to 500 μs in step 1, the period should approximately equal 2 ms and the frequency 500 Hz.

Using CH1 Controls and a Vertical Graticule Measurement

1. Set CH 1 VOLTS/DIV control clockwise to 50 mV, then switch slowly through settings counterclockwise to 1 V. Note the effect on the VOLTS/DIV readout and the waveform amplitude.

NOTE

Between 500 mV and 1 V per division, the attenuator switch activates with a clicking sound.

2. Set the CH1 VOLTS/DIV control to 100 mV for a four-division peak-to-peak display.

3. Use the graticule division markings and the VOLTS/DIV setting to determine the peak-to-peak voltage of the CALIBRATOR signal in the following manner:

a. Align a peak of the display with any convenient horizontal graticule marking to determine the peak-to-peak amplitude in divisions. The center vertical graticule line is graduated in 0.2 division increments to assist you in determining fractional parts of the major divisions.

b. Determine the peak-to-peak amplitude of the CALIBRATOR signal by multiplying the number of divisions (and/or decimal fraction part of a division) by the VOLTS/DIV readout (should be 400 mV).

4. Press CH 1 COUPLING/INVERT button to display the CH 1 COUPLING menu. Additional pushes of the button will rotate the input COUPLING selections first to DC, then GND, then back to AC. Watch the vertical position of CH 1 change as you switch between AC and DC. Also note the symbols displayed with the VOLTS/DIV readout changes with each COUPLING selection.

COUPLING may also be chosen (as well as the 50-Ω termination and INVERT features) by use of the individual menu buttons located beneath each selection.

NOTE

AC COUPLING and 50-Ω input termination are mutually exclusive; selecting one will deselect the other.

5. Select 50-Ω input termination for Channel 1. Observe that the COUPLING switches from AC to DC and the Ω symbol is displayed following the CH 1 VOLTS/DIV readout. (The signal display amplitude will drop to zero in 50-Ω termination as the CALIBRATOR signal is dropped across the 10X high impedance probe.)

6. Again select AC and observe that the 50-Ω termination is turned off.

7. Press the CH 1 VARIABLE button to display the VARIABLE menu. Press and hold the "↓" menu button until the displayed peak-to-peak amplitude decreases to about 1 division. Also note the symbol preceding the VOLTS/DIV readout indicates when the CH 1 display is uncalibrated.

8. Press and hold the "↑" menu button to increase the display amplitude back to about 1.5 divisions peak-to-peak.

9. Return to the calibrated VOLTS/DIV settings by pushing the CAL menu button.

Using SAVE and DISPLAY REF Storage Modes

SAVE mode is normally entered in one of three ways: pushing the SAVE Storage Mode button, as a result of a SAVE ON Δ, and at the end of a SINGLE SEQ acquisition.

SAVE Mode freezes any waveform acquisition in process and holds the waveform displayed for saving as a reference, making any type of measurements needed, or outputting via the GPIB. SAVE mode may be entered using a command via the GPIB.

Displayed along with the SAVE waveform is a count of the number of acquisitions made in the current process before SAVE was entered and a real-time clock display. The time in HRS (hours) is the scope run-time since the last cold start. (The two least-significant digits, right of the colon, indicate minutes).

Upon entering the SAVE Storage Mode, the SAVEREF SOURCE control menu is displayed. The menu permits the selection of any displayed VERTICAL MODE signal as the source of the reference signal to be stored. Once a source is selected, the SAVEREF DESTINATION menu is displayed to allow selection of which of the four reference memories is to store the selected source.

Besides storing selected VERTICAL MODE signals, the SAVEREF SOURCE menu can be used to copy a stored reference waveform to another memory location. If REF is selected for the source, a menu is displayed to allow one of the four available reference waveforms to be selected. Once the REF is selected as a source, the SAVEREF DESTINATION menu appears as before for selection of the REF destination into which the REF source is to be copied.

The SAVEREF SOURCE menu provides a third option for selecting REF sources and destinations. The STACK REF selection treats the reference memories as a push-up stack. REF1 is the bottom stack location and REF3 is the top. The first push of STACK REF stores a single-channel display first into REF1, then repeated pushes moves it to REF2, then REF3, and finally off the stack. Previously stored waveforms are pushed ahead toward the tip of the stack with each push. When more than one waveform is being displayed, a predefined storage plan is used to place selected waveforms in certain reference memory locations. Basically, if CH 1, CH 2, and either ADD or MULT are displayed, pushing STACK REF will store CH 1 in REF1, CH 2 in REF2, and the ADD or MULT function in REF3. See Table B-13 in Appendix B for the detailed STACK REF storage arrangement.

1. You should have a display of CH 1 centered on screen from the previous procedure.

2. Press the SAVE Storage Mode button. This freezes the waveform acquisition and displays the SAVEREF SOURCE menu.

3. In the SAVEREF SOURCE menu, push CH 1. The Channel 1 signal is now selected as the source of the reference waveform to be stored, and the SAVEREF DESTINATION menu is displayed to select the SAVEREF memory location to store it.

4. Press the REF1 menu button. The Channel 1 signal is now stored in reference memory 1, and the SAVEREF SOURCE menu returns for further source selections if wanted.

5. Now select REF as the source choice. A display of the four reference choices is displayed for choosing which reference memory you want to be the source.

6. Select REF1 as the source, and, in the SAVEREF DESTINATION menu that then appears, push REF3 as the storage location. You have now copied the REF1 waveform in the REF3 reference memory.

7. To display the stored references, push the DISPLAY REF Storage Mode button. A menu is displayed for choosing the reference waveform for display. A reference memory without a waveform stored in it will be labeled "EMPTY". (If a REF memory contains an invalid waveform, that invalid waveform may be displayed; however, the "EMPTY" label tells you that it is invalid.)

8. Press REF1 and REF3 to display those reference waveforms superimposed. Use the VERTICAL MODE menu to remove the CH 1 SAVE waveform from the display, then push DISPLAY REF again to return that menu to the display.

NOTE

The fact that both waveforms are displayed can be inferred by noting that both REF1 and REF3 must be turned off before the waveform disappears from the display. Also, although REF waveforms cannot be positioned vertically, they can be horizontally positioned independently and in unison, as we will see.

9. Press the HORIZ POS REF menu button and set REF POS IND¦LOCK to LOCK (if not already on). Rotate the horizontal position control to simultaneously move all REF waveforms (whether displayed or not) with SAVED or "live" VERT MODE waveforms.

10. Push IND (independent) in the menu to unlock the positioning. Now push REF3P. Now rotate the HORIZONTAL POSITION control and note that it now positions the REF3 waveform independently of other waveforms.

NOTE

REF waveforms can be horizontally positioned only when the HORIZ POS REF menu is displayed. One REF is always underlined (selected), and only one can be selected at any one time. (If IND/LOCK is set to LOCK, it doesn't matter which REF is selected since the REF waveforms are positioned in unison with each other and the VERT mode waveforms, whether displayed or not.) The HORIZONTAL POSITION menu must be displayed for the HORIZONTAL POSITION control to position a reference waveform independently or in unison.

11. Select REF1P to be positioned horizontally, and position that reference waveform using the HORIZONTAL POSITION control.

Although we could use the DISPLAY REF menu and the ACQUIRE front-panel button to turn off the REF waveforms and return to "live" acquisition mode, let's use the stored front-panel we saved in earlier in this section...

12. Recall the stored dual-channel front panel by doing the following:

   a. Push PRGM and select RECALL from the SEQUENCE menu.

   b. Use the SELECT SEQ arrows in the RECALL menu to underline the label (FP1 is assumed) you created for the dual-channel setup.

Press RECALL to implement the selected setup.

Using Dual-Channel Displays

1. Press VERTICAL MODE and select ADD (three displays should now be present (CH 1, CH 2, and ADD). Observe that the CH 1 and CH 2 SAVE signals are digitally added together; it is not necessary to acquire a signal in ADD VERTICAL MODE to obtain the ADD display.

2. Turn off the CH 1 and CH 2 displays. Check that the ADD display is four divisions in amplitude.

3. Use the CH 1 and CH 2 Vertical POSITION controls to observe that both controls position the ADD trace.

4. Press CH 1 COUPLING/INVERT panel button and turn CH 1 INVERT ON. Observe that the ADD display is reduced to approximately a baseline trace (CH 2 signal minus the CH 1 signal).

5. Press CH 2 COUPLING/INVERT panel button and turn CH 2 INVERT ON. Observe the ADD trace amplitude returns to four divisions (inverted CH 1 signal plus the inverted CH 2 signal).

6. Turn on the CH 1 and CH 2 displays.

7. Press the SAVE button, then push the STACK REF in the menu displayed. STACK REF treats the SAVEREF memories as a stack and automatically saves the CH 1 signal in REF 1, the CH 2 signal in REF 2, and the ADD waveform in REF 3.

8. Select VERT MODE and turn the ADD Vertical Mode OFF.

9. Switch the display to XY Mode and observe the display of CH 1 versus CH 2. The CH 1 signal is supplying the X-axis (horizontal) deflection and CH 2 is supplying the Y-axis (vertical) deflection in an XY display. Therefore, the CH 1 Vertical POSITION control is used to move the display horizontally and the CH 2 Vertical POSITION control is used to move the display vertically. The Horizontal POSITION control does not position the XY display, but it does control which 512 data points of the 1024 data point record are being displayed.

10. Return the display mode to YT and turn CH 2 off.

Review of ENVELOPE and AVG (Average) ACQUIRE Modes

If you performed the introductory procedure in Section 1, this next exercise is a review. Skip ahead to "Using SINGLE SEQ Trigger Mode" as desired.

1. Press the ACQUIRE panel button. Next, push the ENVELOPE menu button until the number displayed above the ENVELOPE menu label is set at 1. This sets the number of waveform acquisitions included in the ENVELOPE display to only one acquisition before it resets to start a new ENVELOPE sequence.

2. Press and release the ENVELOPE menu button to step through the range of the number of waveforms that may be included, one step at a time to continuous (CONT), then stop. In CONT, the instrument is saving the minimum and maximum values over each sampling interval without a reset occurring.

3. Rotate the CH 1 VERTICAL POSITION control knob left and right (waveform up and down) and see how the display grows vertically, approximating the effect of amplitude changes and dc level shifts in the incoming signal.

4. Now push the ACQUIRE panel button again to erase the continuous ENVELOPE display and restart the acquisitions for a new ENVELOPE sequence.

5. Select BANDWIDTH and change the menu setting to FULL. Push ACQUIRE to return to that menu.

6. Select AVERAGE Storage mode and vertically reposition the trace to center screen. Press and release the AVG menu button until the number over the AVG (Average) menu label is set to 2. Notice the effect of a maximum average weighting factor of two on the displayed waveform.

7. Now push the AVG entry button to increment through the range from 2 to 256, one step at a time. Notice at each step that the displayed waveform becomes cleaner as the number of waveforms averaged increases. This is an illustration of the improvement in signal-to-noise ratio of the displayed waveform using AVG acquisition mode. See Table B-3 in Appendix B for the expected improvement ratio as the number of averages increases. Return the number of Averages setting to 16.

8. Rotate the CH 1 VERTICAL POSITION control a small amount and observe that the accumulation of waveforms into the averaged waveform display restarts (as seen by the increased noise in the display).

NOTE

Any front-panel control change that affects the waveform data being acquired restarts the AVG acquisition. Pressing the ACQUIRE button also restarts the acquisition.

Using SINGLE SEQ Trigger Mode

With the Single SEQuence mode, you can select an acquisition process that, when completed, does not restart until you direct it to. As the SINGLE SEQ acquisition completes, the scope switches to the SAVE Storage Mode to freeze the waveform display. That waveform may then be saved for reference, transmitted to a data collection device, or analyzed as required before you start another acquisition. Let's use AVERAGE mode to explore this feature (ENVELOPE mode could also be used)...

1. Set the ACQUIRE Mode to AVERAGE 64.

2. Set the A TRIGGER MODE to SINGLE SEQ.

3. Watch the Trigger Status Indicators (TRIG'D, READY, and ARM). When they stop flashing (or the TRIG'D indicator light goes out, depending on the SEC/DIV setting) and the SAVE mode is entered, the single-sequence acquisition of 64 averages is complete.

4. Press ACQUIRE to restart the SINGLE SEQ, and again watch the Trigger Status Indicators flash (or TRIG'D light remains on solidly) until the single sequence has completed.

You could STORE this saved waveform, if needed as a reference in SAVEREF memory, using the process you learned previously in the demonstration about SAVE and DISPLAY REF modes.

Using The Cursors

Volts Cursors

Leave the display as set up from the SINGLE SEQ demonstration to start this part of the procedure (you will make the measurements on the SAVEd CH 1 waveform).

Remember how in Section 1 we measured the amplitude of the calibrator using the CURSOR FUNCTIONs? Let's review that procedure and also look at some other uses and modes for the CURSORs...

1. Press the CURSOR FUNCTIONS to display that menu and push VOLTS to make voltage measurements.

2. Press the CURSOR UNITS button to call up the UNITS menu and select VOLTS for units. Set the Δ¦ABS menu choice to Δ.

Delta mode (Δ) provides two cursors for voltage difference measurements. ABS cursor mode provides a single cursor, referenced to the ground position indicator.

3. Move CURSOR/DELAY knob clockwise and counterclockwise. Observe how the "active" (dashed line) cursor is positioned. Set the active cursor to the top of the CALIBRATOR signal waveform.

4. Press the SELECT button and see that the second cursor becomes the active one. Position it to the bottom of the waveform display. The cursor readout now indicates the CALIBRATOR amplitude.

Now let's look at some ABS (absolute) measurements...

5. Switch Δ¦ABS to the ABS cursor mode. Only one cursor will be displayed.

6. Position the VOLTS cursor to the ground indicator (a small "+" at the left edge of the screen), and observe that the readout is 0 volts when exactly aligned with ground. Cursor measurements in ABS mode are taken relative to ground level.

7. Set the VOLTS cursor to the positive peak of the waveform to see that the readout is the positive (above ground) and equal to about ½ the total amplitude of the square wave. Position the cursor to the negative peak. Notice the readout is now NEGATIVE (below ground) with about the same amplitude value (as you would expect with a ac-coupled, square-wave CALIBRATOR signal).

8. Switch back to delta mode cursors and align both cursors to the top and bottom of the waveform as in steps 3 and 4.

This instrument lets you store the difference between the cursors as a reference and use it to make ratiometric (comparison) measurements between subsequent voltages measured with the cursors and that stored as the reference. Let's see how it's done...

9. Press the NEW REF menu button. You have just saved the present VOLTS cursor difference (approximately 400 mV) as the reference level for making percentage and dB measurements.

As long as you leave VOLTS selected as the units, the readout only indicates the present voltage difference between the cursors. When % (percent) or dB (decibels) is selected, the measurement function becomes ratiometric.

10. Select % units. The VOLTS cursor readout should now read 100%.

11. Move the active cursor to the vertical center of the waveform.

Notice the readout changes to about 50%, indicating the cursors are measuring about ½ of the total amplitude of the CALIBRATOR signal which was stored as a NEW REF. If you position the cursor so it's separated by more than 4 divisions from the other cursor, the readout exceeds 100% since the amplitude is greater than that stored for NEW REF. See "Cursor Measurements" in Section 3 for more information on making ratiometric measurements.

V@T Cursors

These coupled cursors provide voltage readout with VOLTS cursors that are confined to within the peak-to-peak amplitude points of the waveform. Each VOLT cursor (one for ABS, two for Δ) tracks the amplitude at the point on the waveform to which its coupled time cursor is positioned. Therefore, the amplitude measurements performed by these coupled cursors is limited to the waveform amplitude, since you cannot move time cursors horizontally off the waveform. As with the VOLTS FUNCTION, the alternate units of measurement are % and dB.

1. Set the CURSOR UNITS to VOLTS in the Δ cursor mode. Push CURSOR FUNCTION and select the V@T cursors.

2. Rotate the CURSOR/DELAY control to move the active cursor pair over several cycles of the waveform. Did you notice that the active (segmented) vertical cursor moves to the amplitude level corresponding to the placement of the active horizontal cursor? Also, notice that the active vertical cursor does not leave the waveform.

3. Position the active cursor pair to place the TIME cursor at the peak amplitude of a positive peak of the CALIBRATOR signal.

4. Press SELECT and position the second TIME cursor at the peak amplitude of the negative peak.

5. Read the peak-to-peak voltage of the waveform.

6. Press UNITS to display that menu. Push the NEW REF button, set the CURSOR UNITS to ABS mode, and select % units for the measurement.

7. Read the percentage of the peak amplitude from the ground marker as compared with respect to the 100% level set in Step 6.

8. Position the TIME marker to the opposite peak of the signal and read the percentage. With AC input coupling, the percentage difference is a measure of the nonsymmetry of the CALIBRATOR square wave. (The difference is typically small.)

SLOPE Cursors

SLOPE cursors are identical to V@T cursors in action. The readout is given in VOLTS/SEC to indicate slew rate or slope (rate of voltage change with time). An alternate unit of measurement for SLOPE cursors is percentage, used when comparing against a reference slope. SLOPE measurements require that delta cursors are on at all times; therefore, the Δ¦ABS label is omitted from the SLOPE UNITS menu.

The CALIBRATOR signal is a poor signal source with which to display SLOPE measurement unless the SAVE horizontal expansion is used. That is because the CALIBRATOR signal frequency changes as the SEC/DIV switch is set to different settings. The following procedure simulates an increased rise time signal for demonstrating the SLOPE cursors.

1. Select the SLOPE FUNCTION and set the UNITS to SLOPE.

2. Use the Horizontal POSITION control to place the Trigger Point Indicator ("T"), and the rising edge of the CALIBRATOR signal, on the center vertical graticule line.

3. Use the SELECT button and the Cursor Position knob to place both time markers of the SLOPE cursors on the trigger point.

4. The scope should still be in SAVE from the previous procedure. Advance the SEC/DIV switch to 5 μs. This expands the display by a factor of 100 times and produces a display with noticeable rise time.

5. Position the SLOPE cursors to bracket a linear portion of the leading edge and check the SLOPE readout.

6. Change the position of the SLOPE cursors to bracket a portion of the waveform with a different slope and observe how the readout varies.

7. Switch the SEC/DIV setting back to 500 μs.

NOTE

The user must determine the sign of the slope from observing the waveform.

TIME Cursors

TIME cursors provide rapid measurement of signal period, pulse width, or time difference. The alternate units of percent (%) provide for comparing between the measurement being made and a reference time in percentage of difference. Units of DEGREES are used for phase difference measurements between a reference signal and the comparison signal.

1. Press the CURSOR FUNCTION button and select TIME cursors.

2. Press the CURSOR UNITS button and select SEC for the time readout units.

3. Position the active cursor (the cursor with the most dots) to one of the rising edges of the displayed CALIBRATOR square-wave signal.

4. Press SELECT to activate the alternate cursor and position it to the next rising edge (either left or right, as convenient).

NOTE

The waveform record is 1024 data points long; the display is 500 data points long. Since cursors may be positioned anyplace within the record length, the TIME cursors may be used to scroll through the complete record merely by positioning the active cursor from one end to the other.

5. Read the time of one period of the CALIBRATOR signal.

6. Press NEW REF to set the reference value to the period of the CALIBRATOR signal.

7. Now select the % units for the TIME cursor readout. Observe that the readout is 100%.

8. Measure the percentage of the first half cycle of the CALIBRATOR period compared to the whole period. Then measure the second half cycle. Are both half cycles of the CALIBRATOR square wave equal? (There is usually a small difference because the CALIBRATOR signal is not perfectly symmetrical.)

9. Position the TIME cursors for 100% at the original measurement points and select DEGREES units for the TIME cursors readout. Observe that the readout switches to 360° (one complete period = 360°) when the cursors are correctly aligned.

10. Position the active cursor to the falling edge at the center of the CALIBRATOR signal period. Observe that the readout is approximately 180°.

11. Select SEC units for the TIME cursors and switch to ABS cursor mode.

12. Position the displayed cursor (only one in absolute mode) to the Trigger Point Indicator. Use the TIME cursor to scroll the display if the Trigger Point Indicator is not presently displayed near center screen vertically.

13. Position the cursor to the left and to the right of the Trigger Point Indicator (time measured is relative to that trigger point). Notice that the time readout is negative when the TIME cursor is positioned before (left of), and positive when positioned after (right of), the Trigger Point.

1/TIME Cursors

These cursors conveniently measure a signal's frequency by automatically performing the 1/TIME calculation when Hz is the chosen UNITS of measurement. Percentage units quickly determine how much higher or lower (in percent) the frequency of a signal is when compared to a reference frequency. When units of degrees are chosen, the comparison measurement functions exactly as with TIME cursors for making phase measurements.

1. Press SAVE/RECALL SETUP and recall front-panel setup FP1.

2. Select 1/TIME cursors from the CURSOR FUNCTION menu.

Notice the target menu is displayed for CH 1 and CH 2 targets. When more than one display source is on-screen, this menu is displayed (for all cursor types) to allow you to specify which display source the cursors are to be attached to. The cursors then take into account the settings (VOLTS/DIV, etc.) of the specified source when reading out measurements.

Since the measurement is 1/TIME, the target selected doesn't matter here (both CH 1 and CH 2 are acquired and displayed at the same SEC/DIV setting).

3. Push CURSOR UNITS and set to Hz.

4. Position the 1/TIME cursors to bracket one full period of the CALIBRATOR square wave and read the frequency of the signal (should be very near 500 Hz).

5. Press NEW REF to obtain a comparison time and set the UNITS to % (readout should be 100%).

6. Set the SEC/DIV switch to 5 ms, push the ACQUIRE button and, if necessary, reposition the CURSORS after SAVE is entered to define one full period of the displayed CALIBRATOR square wave.

7. Observe that the percentage readout is 10%, indicating that the CALIBRATOR signal frequency is now 10% of the reference frequency.

8. Switch UNITS to Hz and read the frequency (500 Hz $\times$ 10% = 50 Hz).

DELAY Features

DELAY by TIME

The Delay-by-Time function is used with the A INTEN and B Horizontal modes. A INTEN mode is used to locate areas of interest within the A waveform record for closer examination using B Horizontal mode. Using Δ TIME delay mode, precise timing measurements can be made between two points on a single channel (for pulse width and rise-time measurements) or between single points on different channels (for propagation-delay measurements).

Delay time may be set to many times the B SEC/DIV setting (2641.4 times to be precise). This means that B Delay acquisitions are not confined to within the time set by the A time base, and that the intensified zone will not be present on the A waveform record if the delay is set to more time than the total A record length. We start the procedure with setup conditions that set the delay time for a visible intensified zone on the A waveform record.

1. Recall the front-panel setup FP1.

2. Press the DELAY by TIME button and hold the Cursor/Delay control knob fully counterclockwise to set the delay time to its minimum setting.

3. Select A INTEN Horizontal mode and set the B SEC/DIV setting to 50 μs.

4. Press the Intensity SELECT button and switch between DISP and INTENS to adjust the levels for a visible intensified zone on the trace.

5. Press the DELAY by TIME button again to return the delay time readout to the CRT.

6. Hold the Horizontal POSITION control knob counterclockwise to position the end of the waveform record to center screen.

7. Hold the Cursor/Delay control knob clockwise to increase the delay-time setting. Observe that the intensified zone will position off the A trace when the delay time exceeds the time between the A trigger point and the end of the A record.

NOTE

If the intensified zone is not present on the A trace in A INTEN Horizontal Mode, check that the delay time does not exceed the time from the A trigger point to the end of the A record.

8. Reduce the delay time to minimum to bring the intensified zone on the display.

9. Recenter the A trigger point marker on the center vertical graticule line and select B Horizontal MODE.

10. Observe the B waveform record acquired at 50 μs/div.

11. Rotate the Cursor/Delay control knob to observe the effect on the position of the delayed waveform.

12. The delay time readout is the amount of elapsed delay from the A record trigger to the B record trigger. Decrease the delay time to minimum.

13. Turn Δ TIME delay mode on and select A INTEN Horizontal Mode again.

14. Press the TIME button to underline the Δ DELAY TIME menu label and set the delay time to minimum, if not already there.

15. Set the B SEC/DIV switch to 10 μs.

16. Now increase the Δ DELAY TIME to position the second intensified zone on the rising edge of the next cycle of CALIBRATOR signal to the right of the A record trigger point "T" (about 2 ms).

17. Switch to B Horizontal MODE, and use the Cursor/Delay control knob to precisely align the two leading edges (there will be a little trigger jitter). You have now precisely measured the period of the CALIBRATOR square wave (indicated by the Δ DELAY TIME readout).

18. Turn Δ TIME off. The DELAY TIME readout is the time elapsed from the A record trigger to the B record trigger.

19. Hold the Cursor/Delay control knob clockwise until the maximum delay time is reached (26.214 ms). At 10 μs per division, this is the maximum delay time, and, if ΔTIME were on, it would be the maximum total delay of DELAY TIME plus Δ DELAY TIME.

20. Switch the B SEC/DIV setting to 5 μs. Observe that the DELAY TIME readout is reduced to the maximum delay time possible for 5 μs per division.

NOTE

When dealing with long delays at a particular B SEC/DIV setting, switching to the next faster B SEC/DIV setting will cause the DELAY TIME setting to be limited to the maximum for that SEC/DIV setting. The delayed waveform will be relocated in time, and you must reset the DELAY TIME to the desired value when switching back to the slower SEC/DIV setting. Also, if Δ DELAY is on and the sum of the DELAY TIME plus the Δ DELAY TIME reaches the maximum limit, any further increase in the DELAY TIME setting causes the Δ DELAY TIME setting to decrease down to zero if the DELAY TIME is increased to the maximum limit.

DELAY by EVENTS

With this delay feature you can delay the A record trigger by a selected number of B trigger events. Since the B trigger circuitry is the source of the events, proper B triggering conditions must be set (LEVEL, SOURCE, CPLG, etc.).

1. Recall front-panel setup FP1. The initial setup conditions saved for the B trigger are: CPLG—AC; SOURCE—CH 1; MODE—RUNS AFTER. Verify the trigger conditions by pushing the TRIG STATUS button.

2. Press A/B TRIG to display the B Trigger Level readout and set the LEVEL for 0 mV. A level of 0 V with AC trigger coupling sets the level in the middle of the trigger signal and assures that triggering occurs.

3. Set the A SEC/DIV switch to 50 μs. This yields a high enough CALIBRATOR signal frequency so that you don't have to wait so long for all the events to have occurred when the EVENTS COUNT is high.

4. Press the DELAY by EVENTS button and turn EVENTS ON.

5. Use the Cursor/Delay control knob to set the EVENTS COUNT to 1, if not already there. The count will wrap around the end counts from minimum to maximum or maximum to minimum if the control knob is held in the rate region for a moment after the end count has been reached.

Notice the rate at which the display is continuously updating. You are going to gradually increase the EVENTS COUNT and watch the effect on the update rate.

6. Increase the EVENTS COUNT number up about 1000 counts. Notice that the update rate is slowed slightly.

7. Increase the count to about 10,000 counts. Now the display takes several seconds to update (notice also that the Trigger Ready Indicator can be seen slowly flashing, indicating the length of time between A acquisitions). A new waveform is acquired only after the set number of B trigger events has been counted.

8. Increase the EVENTS COUNT to maximum (65536), and then hold the control hard clockwise for a few seconds to wrap the count around back to 1.

9. Adjust the B Trigger LEVEL to a point where the waveform stops updating (outside the ±200 mV range).

10. Press STATUS/HELP and observe that the trigger message reads "TRIG WAIT: EVENTS" and that the EVENTS COUNT = 1. These messages tell you that no events are occurring. Probable causes are: wrong trigger level, wrong source, or wrong coupling.

11. Reset the B trigger level to start acquiring again (set to 0 V) and push STATUS/HELP twice to rewrite the status display.

12. Note that the trigger message has changed to "COMPLETING ACQUISITION."

Extended Features

The following features allow you to operate the instrument in modes not usually available with conventional oscilloscopes. The AUTOsetup feature is demonstrated first, followed by two automatic measurement features. Finally, the AutoStep Sequencer is demonstrated.

Remember how AUTOsetup was used in "Get Acquainted" to quickly get you a usable display of the CALIBRATOR output? It turns out that the calibrator isn't the best signal to use to explore AUTOsetup and the other Extended Features (calibrator period and amplitude vary with the SEC/DIV setting). To explore the Extended Features, you need to obtain the following equipment:

Table 2-1
Equipment Required

Item	Requirements	Recommended
1. Calibration Generator	Capable of outputting a square wave signal with an amplitude between 20 mv and 20 V. It should also have a period of 1 ms and a rise time longer than 50 ns, but less than 70 μs.	TEKTRONIX PG506 Calibration Generator[a]
2. Coaxial Cable Connectors: BNC	Impedance: 50 Ω. Length: About 40 inches.	Tektronix Part No. 012-0057-00
3. Dual-Input Coupler	Connects: BNC female to dual-BNC male.	Tektronix Part No. 067-0525-01

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

Using AUTOsetup

1. Recall the front-panel setting FP1. Select VERTICAL MODE and turn off CH 2.

2. Connect the Standard Output of the Calibration Generator to CH 1 and CH 2 inputs through a 50-Ω cable and a dual-input coupler.

3. Set the generator's output to .5 V (the generator's frequency should be 1 kHz).

4. Push the front-panel button labeled AUTO to do an AUTOsetup on the input waveform for CH 1.

The scope displays the message "AUTOsetup WORKING: PLEASE WAIT" as it acquires information about the CH 1 waveform. Once it has characterized the waveform sufficiently to allow vertical and horizontal scaling, the waveform is sized to yield a usable display on-screen.

When AUTOsetup is executed, it uses the mode selected in the AUTOsetup menu. When you did an AUTOsetup in step 4, the mode selected was VIEW, which is designed to yield a display of 3 to 5 cycles over 10 divisions (gives a good overall display). You might wonder at what time you selected VIEW mode. VIEW was selected when you reestablished the front-panel setup in step 1. Let's go ahead and try some other modes...

5. Push the front-panel button labeled "PERIOD". Note that the menu entry RES HI¦LO appears. Push the AUTO button.

The scope does an AUTOsetup that sizes the waveform so that about 1 cycle of the waveform is displayed on screen, triggered on the positive TRIGGER SLOPE (PERIOD and VIEW always trigger on the positive edge of the waveform; change the TRIGGER SLOPE switch as required). The waveform is vertically scaled so that the waveform fits in about the center 5 divisions on screen.

The RES HI¦LO entry you noted determines how the scope sizes the waveforms when executed in the parameter-oriented modes (all modes except VIEW). This instrument has a 20-division horizontal record length. When resolution is set to low, the parameter associated with the mode (in this case, PERIOD) is sized for best display over the 10 divisions on screen.

6. Switch RES HI¦LO to HI and do another AUTOsetup.

Notice that the period of the waveform is now spread over more divisions and is not (or barely is) contained within the 10 divisions on screen. For RES HI settings, the parameter associated with the mode is contained within the 20-division record length. Horizontal position may be required to view the entire parameter. By spreading the parameter over more divisions, more sample points are obtained for the parameter, yielding better resolution of the waveform (RES stands for RESolution).

The other modes are PULSE and EDGE. The vertical and horizontal scaling is similar for these modes. Briefly, the PULSE mode causes the scope to do an AUTOsetup which yields a positive or negative pulse (the pulse is defined as that part of the rectangular waveform's cycle having the LEAST time duration) for display. EDGE mode yields a display of the rising or falling edge of the waveform depending on the EDGE mode setting. The horizontal resolution for both PULSE and EDGE mode is determined by the RES HI¦LO setting the same as for PULSE. These modes are covered in detail in Sections 3 and 5. Let's look at PULSE...

7. Set PULSE mode on and execute another AUTOsetup.

Notice that the positive section of the waveform is treated as a positive pulse and horizontally scaled to fit in about 20 horizontal divisions for the HI RES setting.

8. Switch RES back to LO and reexecute AUTOsetup. Notice the reduced horizontal scale (SEC/DIV setting is slower).

9. Set the AUTOsetup mode to period.

10. Push the VERTICAL MODE front-panel button. Turn CH 2 on.

11. Execute an AUTOsetup.

AUTOsetup can also set itself up for various VERTICAL MODES. In this case, the waveforms in both CH 2 and CH 1 were sized to about 3 divisions and displayed on screen overlapped at the vertical center of the screen (adjust vertical positioning slightly to see both waveforms).

12. Set the AUTOsetup mode to VIEW and do another AUTOsetup.

Notice that this time the waveforms are scaled for about 2 divisions with the CH 1 waveform centered vertically around the graticule 2 divisions above graticule center and the CH 2 waveform centered around the graticule line 2 divisions below graticule center. Since in view mode it's assumed you want to see and compare waveform amplitudes, the waveforms are positioned offset vertically on screen. If PULSE, PERIOD, or EDGE are selected, it's assumed that you are more interested in comparing time differences between waveforms. Therefore, the channels are displayed overlapped.

Before leaving AUTOsetup, it's important to stress that various front-panel settings for VERTICAL MODE, TRIGGER SOURCE, and AUTOsetup all influence how it operates. In general, VIEW mode can be used to get a usable display any time a signal triggerable in AUTOLEVEL trigger mode is available as a trigger source in the CH1 or CH2 display source selected in the VERTICAL MODE menu. The sources the scope uses to trigger and size the displays vary with the front-panel conditions you set up. Read the description for control number 47 "AUTO" in Section 5 and the applications for AUTO in Section 3. Once finished, you should be ready to use this convenient feature in all its modes.

Using MEASURE

1. Recall FP1, the procedure stored earlier in this section. Turn CH 2 off.

2. Push AUTO to do an AUTOsetup on the CH 1 waveform. Since AUTOsetup executed in VIEW mode, you should have several cycles of the square wave displayed on screen.

3. Push MEASURE (next to AUTO) to display that menu. Press SNAPSHOT for the displayed menu.

You have just executed the snapshot mode for the MEASURE feature. It allows you to see at a glance many of the characteristics of the waveform for a single acquisition.

Realize that the accuracy of these measurements depends on the front-panel conditions setup. For instance, since we used AUTOsetup in the VIEW mode, several cycles of the waveform are displayed on screen. This means that few sample points were obtained for the high-frequency components of the waveform. Those measurements relating to high-frequency components, such as RISE and FALL (rise- and fall-time) and OVRS and UNDS (under- and overshoot), should be discounted for this setup. However, since we obtained complete cycles of the waveform, we can trust those measurements related to amplitude and frequency, such as P-P (peak-to-peak voltage), TOP and BASE (voltage at the Top and Bottom levels of the waveform, respectively), FREQ (frequency), etc.

In general, the screen tells you whether a particular parameter is valid or not. If you can't see the front-corner aberrations or you note that the rise time comprises little of the 20-division acquisition, you should set up the scope to display those parameters adequately. Let's do that now for the front edge of the waveform...

4. Do an AUTOsetup to display its menu. When AUTOsetup finishes executing, set the mode to EDGE and RES to HI. Now do the AUTOsetup for EDGE mode. Notice that in the resulting display the front corner is spread over several divisions.

5. Do another snapshot of the waveform. See step 3 if you don't remember how it is executed.

Since the leading edge of the waveform is spread over several divisions, it now makes sense to use the measurements related to the front corner.

Note that some of the parameters have a string of "?" marks displayed instead of the parameter value. When the instrument cannot extract the parameter, it indicates so by displaying the string. In this case, we used the EDGE mode to display the front corner of the waveform and an entire cycle of the square wave was not acquired. Therefore, those parameters pertaining to the period of the square wave were not extracted.

6. Change the generator output to 1 V and push the menu button labeled AGAIN. Notice that the screen is updated with a new snapshot (note the new values for TOP and BASE) of the single acquisition of the waveform.

7. Select the VERTICAL MODE menu and turn CH 2 on (leave CH 1 on also).

8. Do an AUTOsetup to display that menu. Change the menu to VIEW and reexecute AUTOsetup.

9. Select the MEASURE menu. Set WINDOW OFF in the menu.

10. Push the menu button labeled MEAS TYPE.

The parameter matrix you've displayed allows you to select the parameters you wish to extract from the waveform. (Selecting any of the parameters automatically turns DISPLAY ON in the preceding menu.) Any parameters (up to four total) you select can be displayed on screen and continuously updated for successive acquisitions. Let's select some parameters...

11. One parameter in the matrix is underlined (DISTAL). Push the button labeled ON in the menu. Note that the matrix menu is replaced by a target menu for selecting the waveform for which you want to see the parameter displayed. The target menu is always displayed after you select a parameter or execute a snapshot measurement if more than one display source is on screen.

12. Select CH 2 from the target menu. Since DISPLAY automatically turns ON in the main measure menu, the scope displays the parameter name and value on screen, along with the chosen display source. (It displays a default display source until you choose one.) Note that the parameter menu is also returned for further parameter selection.

Look at the parameter name you turned on in the parameter matrix. It's still underlined, but now there are two asterisks displayed, one on each side of the parameter name. The asterisks indicate which parameters are on so you can see when they are turned on regardless whether DISPLAY is ON or OFF in the main MEASURE menu.

13. The arrow-labeled buttons allow you to select any parameter in the matrix for display. Pushing the arrow moves the underline in the direction indicated.

14. Use the arrow-labeled buttons to move the underline to PERIOD in the matrix. Note that, as the underline moves away from the parameter you turned on, the parameter is no longer underlined; the underline selects the parameter, and the asterisks tell you when it's on.

15. When PERIOD is underlined, turn it on and select CH 1 as the target. The CH 1 period should be displayed.

16. Push ON to turn the PERIOD on again. Note that the target menu is displayed and a second CH 1 PERIOD readout appears on screen. Go ahead and select CH 2 as the target.

17. Turn DISTAL off in the matrix and turn PK-PK (peak-to-peak voltage) on. Select CH 1 as the target for PK-PK.

18. Increase the SEC/DIV setting 4 positions. Note that when the acquisition rate allows less than a complete period of a waveform, the message "NEED 3 EDGES" (3 transitions are needed to define a waveform cycle) replaces the parameter value in the readout. In general, the scope displays an error message if it can't extract the specified parameter.

19. Return the SEC/DIV setting to its original setting. Now vertically position the top of the CH 1 waveform up several divisions off-screen. Note that, as the waveform exceeds the 10.24-division vertical-acquisition window, the message "CLIP" appears at left on screen. In general, the scope displays a warning message when it CAN extract a parameter, but detects a condition that makes the result questionable. A complete list of both error and warning messages is found in Appendix C of this manual.

20. Turn CH 2 off and center CH 1 vertically on screen.

21. Push MEASURE and set WINDOW on in that menu.

22. Push CURSOR FUNCTION and turn the TIME cursors on.

23. Use the CURSOR/DELAY control to move the active cursor toward the inactive one. Note that when the cursors no longer bracket at least one full cycle of the waveform, the message "NEED 3 EDGES" is displayed for the PERIOD measurements. Note also that the PK-PK voltage changes to approximately 0 Volts, when the active cursor is on the same amplitude peak as the inactive (superimpose the active on the inactive cursor).

When you switched WINDOW on in the MEASURE menu, you tied the measurements to the position of the TIME cursors. That's why, even though several cycles of the waveform are displayed on screen, you got the error message. There were not several cycles displayed BETWEEN THE TWO CURSORS when the message appeared.

24. Push MEASURE and select SETUP from the main MEASURE menu.

25. Set MARK ON¦OFF to ON for the SETUP menu.

26. Move the active cursor so that both cursors bracket more than one waveform cycle.

Notice that two "X"'s appeared on screen. These are the markers you turned on (step 25), and they indicate at what points on the waveform time-related measurements are being made.

27. Note the METHOD selections in the SETUP menu. These selections relate to the way the scope extracts waveforms.

28. Push LEVEL. This menu lets you define measurement reference levels on waveforms.

Let's learn more about the METHOD and LEVEL features by using HELP...

29. Push the STATUS/HELP button near the INTENSITY control. Select HELP from the menu displayed.

30. Push MEASURE.

The screen now displays a synopsis of MEASURE and its associated modes. The first two screens review some of the material you have already covered. (Why not read it as a review?) Use the menu key labeled MORE to step through the screens of information; METHOD and SETUP information is on screens 3 and 4. Push EXIT to return to scope mode when finished.

The MEASURE feature is discussed in Section 5, "Controls, Connectors, and Indicators", and applications are found in Section 3. Also, Appendix C lists definitions of each parameter and the methods used for extracting those parameters, in addition to other MEASURE-related information.

Using PRGM (AutoStep)

In this procedure, you have already used the AutoStep to store front panels for later recall. While recalling front panels in this way is useful, the AutoStep can be used for more powerful applications. Let's see how...

1. Connect the STD AMPLITUDE OUTPUT of the generator to CH 1 through a 50-Ω coaxial cable. Set the generator output for a 5-V, 1-kHz square wave.

We are going to assume that this waveform needs to be characterized for rise and fall times, top and base levels, and total amplitude peak-to-peak. What's more, we'll use our imagination and assume that this waveform is present on several instruments, so we need to make these measurements once for each instrument.

2. Recall the front panel you stored earlier. We will use it as a basis for our sequence steps.

3. Push the button PRGM and select SAVE from the SEQUENCE menu. Give the sequence a label (like TEST1) using the menu displayed.

4. When you have assigned the sequence a label, push the menu button SAVE to store the name and proceed with creating the sequence.

From the message on screen, you can see that here is where we set up the front panel for step 1. Since we only want to make sure the instrument is operating properly and is set up to make the most accurate measurements possible, let's not change any front-panel settings (we will AUTOsetup later in step 2), but just proceed to the ACTIONS menu.

5. Push PRGM to move to the ACTIONS menu for step 1.

You have now displayed the ACTIONS menu for the first step of your sequence. Notice that the display indicates the flow of events by labeling the beginning and end of the step and the events that occur between them (the ACTIONS menu is a kind of time line for the substeps that occur for each step). Actions followed by <N> (off) are not executed when the step is recalled; actions followed by <Y> (on) are executed. Those events not marked either Y or N are not settable actions; rather, they are indicators of the order in which certain events occur (such as when LOAD PANEL occurs) relative to the settable actions.

Find the line under the Y or N following one of the actions. The arrow-labeled menu buttons are used to move that underline up and down in the ACTIONS menu to select the action desired.

6. Use the arrows in the menu to underline the SELF-CAL action and push Y¦N to toggle that action on (Y). Repeat for the SELF-TEST and PROTECT action (PROTECT keeps the sequence from being accidently deleted). All other actions should be turned off.

7. Press NEXT STEP to exit the ACTIONS menu and store our first step.

The first step is now complete. When the sequence is recalled, the scope delivers the front panel you recalled prior to labeling this sequence (in procedure-step 2), since you made no changes to the front panel when you created the step. Prior to recalling (loading) the front panel, it executes the SELF-CAL and SELF-TEST routines, since you selected those actions for step 1.

8. The menu for setting up step 2 is now displayed. Change the VERTICAL MODE setting to display CH 1 only, and change the COUPLING for CH 1 to DC. These menu changes will cause the scope to AUTOsetup on the DC-coupled square wave in CH 1, when you later include AUTOsetup as an action for this step.

9. Execute AUTOsetup. You're doing an AUTOsetup here to verify that the AUTOsetup menu is set to VIEW mode. (If the mode is not set to VIEW, set it to VIEW.) When AUTOsetup finishes executing, push MEASURE to display that menu.

10. Select MEAS TYPE from the menu and turn on the parameter TOP, BASE, and PK-PK (Peak-to-Peak) using the method outlined under the MEASURE procedure in this section (see steps 11 to 17 under "MEASURE" as required).

11. This completes the front-panel setup for step 2. Push PRGM to proceed to the ACTIONS menu.

Note that the ACTIONS menu is left as you set it up for step 1. This feature allows you to just push NEXT STEP if you do not wish to change those actions. In this case, however, you do not need to SELF-CALibrate or SELF-TEST the scope again. Also, now that you have set the scope up to measure the Top and Base levels of the waveform in step 2, you probably need to PAUSE so the user of your sequence can record the measurements, take photographs of the display, etc. This is also where we turn on the AUTOsetup action so it executes during the step in the mode verified in step 9.

12. Set the SELF-CAL, SELF-TEST, and PROTECT actions off (N); set PAUSE and AUTOsetup on (Y). SET BELL on, also, to signal the user of your sequence when the measurements are ready to be recorded.

13. Set the REPEAT action on (we will see why later when we execute the procedure). Push NEXT step when finished.

14. Execute AUTOsetup to display that menu. Change the mode to EDGE (_/‾) and RES HI¦LO to HI.

15. Turn TOP and BASE parameters off and the RISE parameter on in the MEAS TYPE menu.

44. PAUSE should be the only action on. Push NEXT STEP.

45. Position the CH 1 trace to the graticule line 1 division below graticule center. Push PRGM to advance to step 3 actions.

46. PAUSE should be the only action on. Push NEXT STEP.

47. Position the CH 1 trace to the graticule line 3 divisions below graticule center. Push PRGM to advance to step 4 actions.

48. PAUSE should be the only action on. Save the sequence by pushing SAVE SEQ.

Let's look at the sequence...

49. Select RECALL from the main SEQUENCE menu and select and recall the sequence you just saved. Step 1 should now be displayed.

50. Use PRGM to step through the sequence, noting that the vertical position relates to the step number (most positive, step 1; 2nd-most positive, step 2, etc.). When you reach step 4 (the main SEQUENCE menu is displayed), push EDIT to switch to that menu.

Let's use this new sequence to explore modes of editing sequences...

51. Select ED 1 from the list of sequences, then push EDIT.

The front-panel for step 1 of our sequence is loaded on screen (note the vertical position of the trace) as the on-screen message indicates. You can make changes to this setup at this time.

52. Since no changes are really needed here, just push PRGM to proceed to the actions associated with step 1.

53. Leave PAUSE on and turn BELL on.

You have now edited both the front-panel setup for and the actions associated with step 1. Either or both edits could have been skipped by proceeding through without making any changes (as was done for the first edit). If no other steps were to be edited, you would push SAVE SEQ to quit the edit session and save the revised sequence. In this case, however...

54. Push NEXT step to save the revised step and continue editing.

You are now at step 2. Let's not edit this step now.

55. Push the up-arrow button in the menu.

Note the step number in the message changes back to 1. This is how you can select steps to edit. When the front-panel is loaded and this menu is displayed, you use the arrow-labeled buttons to select any step in the sequence you desire to edit.

56. Go ahead and select step 4 for editing. Notice that each step is loaded in sequence for editing as you proceed through steps 1-4.

57. You are not going to really edit step 4, but add a step instead. Push ADD.

58. Center the trace vertically on screen. Select VERTICAL MODE and set YT¦XY to XY. Push PRGM (don't change the actions), and then push NEXT STEP.

The new step is now added (becomes step 5). The scope doesn't proceed to step 6 because there are no more steps. Instead, a warning message is displayed to indicate that no more steps to edit exist.

If there had been additional steps (say we went to step 2 and pushed ADD), steps 3-4 would be "pushed down" in the sequence as a stack and the new step 3 would be added (ADD puts the new step after the step selected). All the "pushed-down" steps that follow would be incremented by one.

You move steps from one point to another in the sequence by deleting them to a buffer and adding them back in at the point desired.

59. Press DELETE TO BUFFER to delete the step just added. Use the arrow-labeled buttons to move to step 1.

60. Push ADD. When the menu changes, push LOAD BUFFER. Step 5 has been moved to step 2 and steps 2-4 become steps 3-5. Go ahead and use the arrow buttons to proceed through (load the front panels of) each step to see the changes in the sequence.

You might be thinking, "What if I need to add a step BEFORE step 1?" That also can be done. You move to step 1 and add the step as before. Since you did that in procedure steps 59 and 60, that part is already accomplished.

61. Select step 1 and push DELETE TO BUFFER.

62. Push ADD and, when the menu changes, push LOAD BUFFER.

When you deleted step 1, step 2 moved to step 1. When you added the deleted step 1, it was added after the new step 1.

Copying steps is very similar to moving them...

63. Return to step 1 and DELETE TO BUFFER step 1. Our sequence should now have the original 4 steps (with minor edits) in the same order as at the start of this edit session.

64. Select step 3 and push DELETE TO BUFFER.

65. Select step 2 and push ADD, and, when the menu changes, push LOAD BUFFER. Step 3 is now restored.

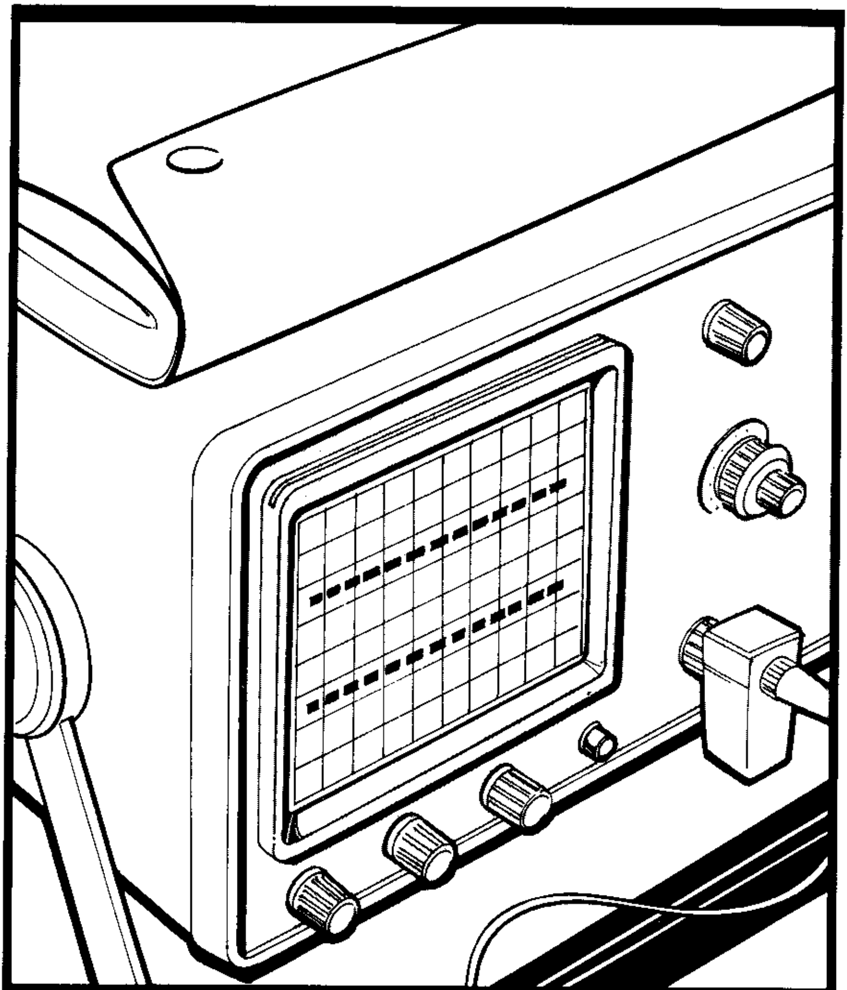
66. Push EXIT and Select the step 4 (it's assumed you want to put the copied step AFTER step 4). Push ADD and push LOAD BUFFER to finish copying step 3 to step 5.

In procedure step 64 you deleted step 3 to the buffer and, in the following step, you moved to step 2 and added it back in at the same location from which it was deleted. Then, in procedure step 66, you moved to step 4 and added the buffer at that location. If you use the arrow buttons (push EXIT) to step through the sequence, you can see that you've copied step 3 and put it after step 4.

This ends the Operators Familiarization procedures. A majority of the controls has been exercised, though not every possible mode. No attempt was made to cover each possible trigger coupling condition or the use of the SET WORD and OUTPUT features. The "Controls, Connectors, and Indicators" information in Section 5 of this manual gives more details on the way in which each control functions, and the "Applications" procedures in Section 3 give more detail about making actual measurements. For those users whose instrument has the Video Option installed, a short familiarization procedure on its use is given in Section 7 of this manual.

SECTION 3

Applications



Basic Applications

The Tektronix 2430A Digital Oscilloscope is an accurate and flexible measurement system. When familiar with the controls, indicators, operating considerations and capabilities of the instrument, you can easily develop your own method for making any particular measurement. This section demonstrates and discusses some applications for the various measurement features this oscilloscope offers. You can build on this information (along with information from other sections) when forming your own methods and applications.

This section is divided into four subsections. "General Applications" covers the more familiar, graticule measurements of signal amplitude and time period. Vertical and horizontal display modes are also detailed. "Storage Applications" describes the various acquisition modes and their applications, as well as how those acquisitions can be stored and displayed. The "Special Applications" subsection deals with methods for making measurements using the highly accurate and versatile cursors. Finally, "Extended Features" looks at applications for the AUTOsetup, MEASURE, and AutoStep features.

The procedures for the various applications assume your familiarity with obtaining front panel setups. Some control settings may require menu setups not fully described. In general, each procedure outlined assumes the Front Panel control settings in effect after an INIT PANEL is performed. All control and menu operations are explained in Section 5 of this manual, "Controls, Connectors, and Indicators." The "Getting Acquainted" procedure in Section 1 and "Operators Familiarization" in Section 2 of this manual provide some additional assistance in becoming familiar with the operation of the scope for the first-time user.

General Applications

This oscilloscope has two channels (CH 1 and CH 2) available for signal input and display. The two channels can be displayed alone or together. They can be added or multiplied algebraically and the results displayed alone or with other display sources. The following applications illustrate the method for graticule measurements as well as some uses for the ADD and MULT VERTICAL MODES.

Voltage Measurements

Peak-to-Peak Voltage

Use the following procedure to make peak-to-peak measurements on signals:

1. Input the signal into CH 1 or CH 2 and trigger the display. Adjust the VOLTS/DIV and SEC/DIV controls so the display is within the graticule area.

2. Vertically position the waveform so that its negative peaks are aligned to a horizontal graticule line (see Figure 6-1).

3. Count the number of divisions from the negative peaks to the positive peaks of the waveform.

4. Calculate the peak-to-peak voltage using the following formula:

$$\text{Volts (p-p)} = \text{Number of Divisions} \times \text{VOLTS/DIV Setting}$$

Example calculation for the waveform pictured in Figure 3-1:

$$\text{Volts (p-p)} = 4.8 \text{ div.} \times 500 \text{ mV/div} = 2.4 \text{ V}$$

NOTE

The probe attenuation factor does not need to be taken into account when computing voltage amplitudes. The VOLTS/DIV readout on screen reflects the VOLTS/DIV setting and the probe attenuation factor.

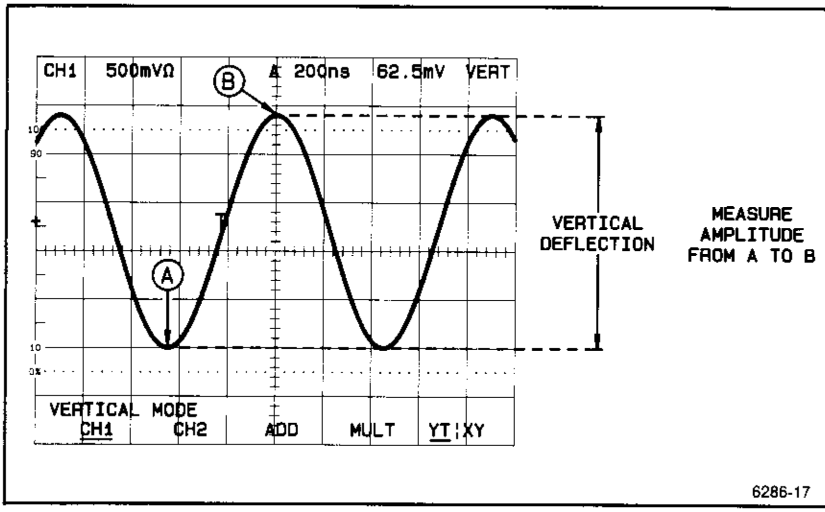


Figure 3-1. Sine wave Peak-to-peak voltage.

Instantaneous DC Voltage Level

Use the following procedure to make DC level measurements on signals:

1. Input the signal into CH 1 or CH 2 and trigger the display. Adjust the SEC/DIV control to display a few cycles of the waveform.

2. Adjust the appropriate VOLTS/DIV control for a setting that displays the waveform AND the Ground Reference Indicator on screen. The Ground Reference Symbol is a small "+" at the left edge of the screen.

NOTE

Do not adjust the VOLTS/DIV (Step 2) or the VERTICAL POSITION (Step 3) controls to display the ground reference symbol at the upper and lower graticule extremes. The symbol will be limited to the graticule area and will not give a true indication of the ground reference if that reference is outside the graticule.

3. Vertically position the "+" indicator to a horizontal graticule line. Keep the waveform (or at least the point to be measured) on screen. See Figure 3-2.

4. Count the number of divisions the measurement point is above or below the "+".

5. Calculate the DC level voltage using the following formula:

Volts (DC Level) = Number of Divisions × VOLTS/DIV Setting

Multiply the result by a -1 if the measurement point was below the "+" for Step 4, otherwise the result is positive (assuming the channel used has not been inverted).

Example calculation for the DC Level at Point B of Figure 3-2:

Volts (DC Level) $= 1.8$ div $\times$ 10 mV/div $\times (-1) = -18$ mV

ADD Mode Measurements

ADD VERTICAL MODE can be used to add or subtract two waveforms. With the two waveforms displayed, one in CH 1, the other in CH 2, the ADD mode waveform is the algebraic sum of the two waveforms. Note that the ADD VERTICAL MODE (as well as MULT) can only use CH 1 and CH 2 as signal sources for adding or subtracting. Use the following procedure to add or subtract two waveforms:

1. Input one signal into CH 1, the other into CH 2, and trigger the display. Adjust the SEC/DIV control to display a few cycles of the waveform.

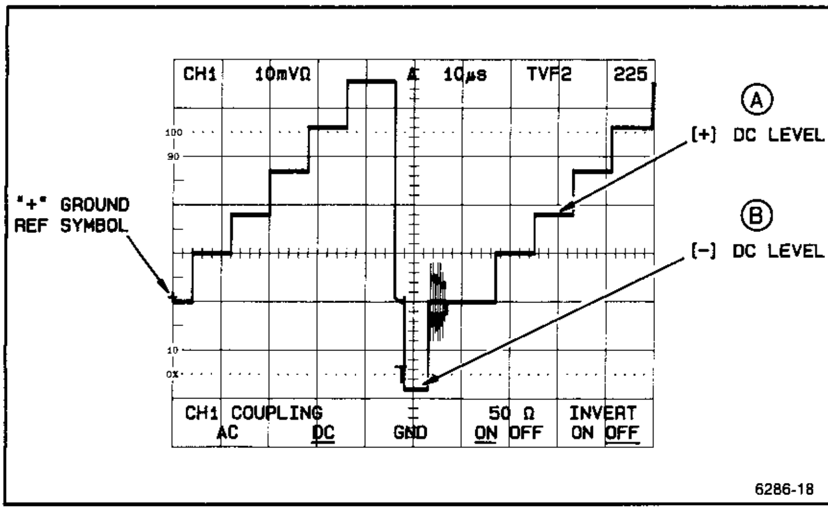


Figure 3-2. Instantaneous DC voltage levels on a waveform.

2. Set CH 1 or CH 2 to INVERT ON if subtraction of one waveform from the other is desired.

3. Set the CH 1 and CH 2 VOLTS/DIV controls to display about 3 divisions of signal amplitude in each channel. Both channels should be set to the same amplitude.

NOTE

If either signal is much greater than three divisions, the added waveform may extend vertically outside the graticule area. In that case, increase both VOLTS/DIV controls to the setting that results in 3 divisions or less for each channel (keep CH 1 and CH 2 settings equal).

4. Set the VERTICAL MODE to ADD (CH 1 and CH 2 may be turned off for easier viewing of the added waveform). Use the VERTICAL POSITION controls to position the waveform for measuring.

NOTE

The position of the ground reference (baseline trace) for the ADD mode waveform is based on the algebraic sum of the positions of the CH 1 and CH 2 ground reference traces.

Positions above the center graticule line are positive values; positions below the line are negative. As an example, if reference for CH 1 is one division above graticule center and the reference for CH 2 is 3 divisions below, the ADD mode ground reference will be two divisions below graticule center ($+1$ div $+$ $[-3]$ div $=$ -2 div).

5. Use the general methods outlined in the previous two procedures to measure the peak-to-peak or DC Level for the added waveform as required. The VOLTS/DIV setting for the ADD mode is indicated by the ADD readout.

Noise Reduction and Unwanted Signal Cancellation

The ability to add or subtract waveforms allows the following two useful applications. First, differential signals, such as the outputs of a paraphase amplifier, can be measured differentially to eliminate any common mode noise. Follow the basic procedure for adding two signals. Invert one of the channels to display the difference between the two signals (when added), while rejecting any common mode noise. If the exact amplitude of the added waveform is not critical, adjust the VARIABLE gain of one of the channels for best noise reduction. Figure 3-3 illustrates this method of noise reduction.

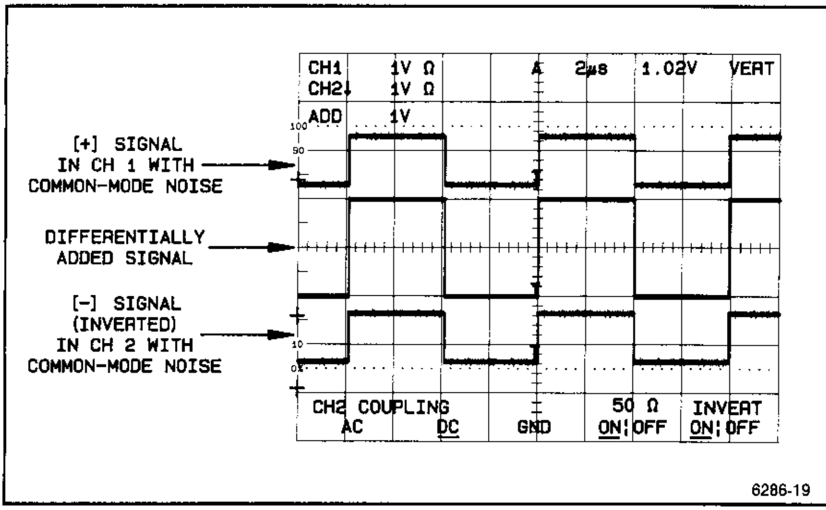


Figure 3-3. Cancellation of common-mode noise for differential signals.

The second application referred to is unwanted signal cancellation. In this case, the desired signal (to be measured) is riding on a large signal, as when a large ac hum is present (see Figure 3-4). Here, a source of the unwanted signal is applied to the alternate channel (note that this signal must not contain the desired signal), and the "composite" signal to the other. Use the basic procedure for adding two signals. The invert mode can be used to invert the polarity of the undesired signal and the VOLTS/DIV control and VARIABLE adjusted as required.

Use the following procedure to cancel an unwanted component from a signal:

1. Input the signal with the unwanted component to CH 1. Adjust the SEC/DIV control to display a few cycles of the waveform.

2. Input a source of the unwanted component to CH 2. Set INVERT ON for CH 2.

NOTE

The phase of the source used for CH 2 should match that of the unwanted component in CH 1, if maximum elimination is to be obtained.

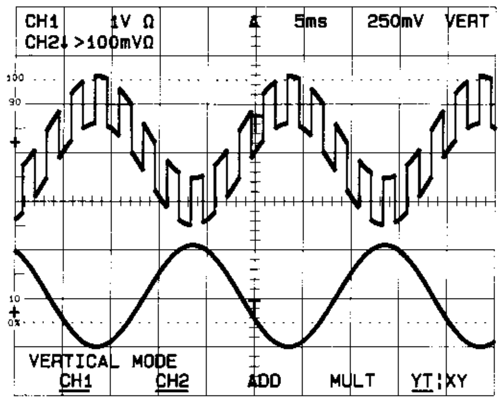
3. Set the CH 1 VOLTS/DIV control to display about four divisions of signal amplitude.

4. Set the CH 2 VOLTS/DIV control so that the amplitude of the CH 2 signal is approximately equal to that of the unwanted component in the CH 1 display.

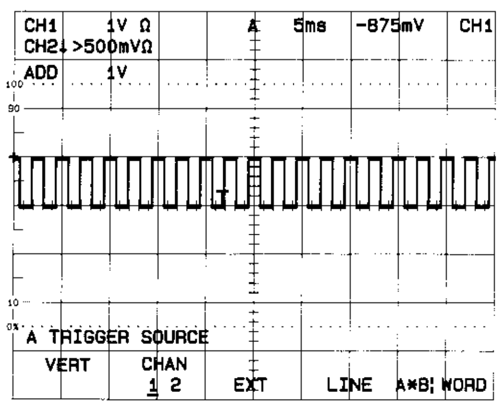
5. Use the CH 2 VARIABLE to match the CH 2 signal amplitude to the amplitude of the unwanted component in the CH 1 signal.

6. Set the VERTICAL MODE to ADD (CH 1 and CH 2 may be turned off for easier viewing of the added waveform). Adjust the CH 2 VARIABLE, using the CH 2 VAR control menu, for maximum elimination of the unwanted signal component from the CH 1 display.

7. Use the general methods outlined in the previous procedures to measure the peak-to-peak or DC Level for the added waveform as required. The VOLTS/DIV setting for the ADD mode is indicated by the readout.



a. CH 1 signal with 60 Hz component and the CH 2 signal from line source.



b. Resultant ADD mode signal with 60 Hz component removed.

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Figure 3-4. (a and b). Cancellation of an unwanted component in a signal.

Note that in the last procedure the signal applied to the CH 2 input was inverted for the sole purpose of canceling that signal component from the ADD mode waveform. In other words, we do not intend to measure the amplitude which the CH 2 signal contributes to the ADD mode signal, but we wish to use the CH 2 signal to eliminate the unwanted noise riding on the CH 1 signal. For such cases, the unwanted signal should always be applied via the CH 2 input, because when the CH 2 VOLTS/DIV and VARIABLE controls are adjusted for best elimination of the unwanted signal, the CH 1 VOLTS/DIV readout and VOLTS cursor measurements remain calibrated. In this way, a signal from perhaps the 200 mV winding of a transformer can be scaled up to eliminate a 2 V hum component from a signal (see Figure 3-4).

When scaling CH 2 for eliminating a signal component from CH 1 (or any time the CH 2 VOLTS/DIV setting differs from that of CH 1), note that the ADD Volts/Div readout will be the same as the CH 1 readout. This feature allows the correct scale factor (that agreeing with CH 1) to be used when canceling unwanted signal components. When the ADD mode is NOT used for that application, the ADD readout will NOT be correct. In such cases, the VOLTS/DIV controls should be set to the same scale factor and the variables set to CAL (calibrated) for accurate adding or subtracting of waveforms.

NOTE

If VOLTS, V/T, or SLOPE cursors are attached to ADD mode, they too will match CH 1's volts/div readout. Cursor use is covered later in this section.

MULT Mode Measurements

MULT VERTICAL MODE can be used to multiply two waveforms. With the two waveforms displayed, one in CH 1, the other in CH 2, the MULT mode waveform is the algebraic product of the two waveforms. Note that the signal sources to be multiplied must be applied to CH 1 and CH 2 as when using ADD mode.

In order to display the product of two waveforms at the same time that the two component waveforms are displayed, the MULT function scales the display to the screen and supplies an appropriate V^2/Div scale factor (displayed next to the MUL designation on screen). This scale factor for the MULT VERTICAL MODE is determined according to the following formula:

$$\text{Volts}^2\text{/Div (MULT)} = 5.12 \times \text{V/Div (CH 1)} \times \text{V/Div (CH 2)}$$

For a 2-V setting of both the CH 1 and CH 2 VOLTS/DIV controls, the MULT mode scale factor is:

$$5.12 \times 2 \text{ V/Div} \times 2 \text{ V/Div} = 20.48 \text{ V}^2\text{/Div}$$

NOTE

When using MULT VERTICAL MODE, it is usually desirable to adjust the CH 1 and CH 2 VOLTS/DIV controls for a three-to-five division display for each channel. With the MULT display scaled as mentioned above, these settings will normally provide the best MULT display for viewing and measurement.

When interpreting MULT mode displays, it is important to note that CH 1 and CH 2 waveforms with values below the ground reference level (of the channel in which they are displayed) are treated as negative quantities. Therefore, with a 2-V peak-to-peak sine wave signal applied to both CH 1 and CH 2, the MULT function would display a 1-V^2 peak-to-peak sine wave with the positive peak at +1 V^2 and the negative peak at 0 V^2. The frequency of the MULT waveform is twice that of the CH 1 and CH 2 waveforms (because, in this example, when the negative values of the two waveforms are multiplied together, a positive product is obtained and two positive cycles of the multiplied waveform are produced for every complete cycle of the CH 1 and CH 2 waveforms).

MULT VERTICAL MODE finds a major application in making power measurements. With a voltage displayed in one channel and a current waveform in the other channel, the two waveforms can be multiplied to yield an instantaneous power waveform. Use of a current probe and a current probe amplifier are necessary for this application.

Use the following procedure when using the MULT VERTICAL MODE for making power measurements:

1. Ensure that the CH 1 and CH 2 VARIABLE controls are in their CAL state.

2. Select VERTICAL MODE and set CH 1 and CH 2 on.

3. Set the CH 1 VOLTS/DIV control to the setting required by the current amplifier to calibrate the scope in amperes per division. Consult the operator's instructions for the current probe/amplifier combination used to determine the VOLTS/DIV setting as well as any output termination required.

4. Connect the current-to-voltage converted output to the CH 1 input connector, using a coaxial cable and the proper termination.

5. Connect the current probe/amplifier combination to the circuit under test (consult operator's instructions for the probe/amplifier combination).

6. Connect the voltage waveform corresponding to the current being measured to the CH 2 input connector.

7. Set the CH 2 VOLTS/DIV control for an on-screen display. Adjust the SEC/DIV control to display several cycles of the waveforms.

8. Set the VERTICAL MODE menu to MULT. Adjust the CH 1 and CH 2 POSITION controls for convenient viewing of the MULT display. CH 1 and CH 2 VERTICAL MODES can be turned off (for easier viewing) as desired.

9. Compute the multiplier for the MULT scale factor displayed on screen:

$$\begin{array}{c}\text{Scale Factor Multiplier}\\ \text{(Power Waveforms)}\end{array} = \frac{\text{Current Amplifier Scale Factor}}{\text{CH 1 Volts/Div}}$$

EXAMPLE: The current-to-voltage converted output is connected to the CH 1 input and a 1 mA/div scale factor is obtained. The CH 1 VOLTS/DIV control is set for a 10 mV/div scale factor. Assuming the corresponding voltage waveform is input into CH 2, the resulting MULT waveform scale factor multiplier is:

$$\begin{array}{c}\text{Scale Factor Multiplier}\\ \text{(Power Waveforms)}\end{array} = \frac{1\text{ mA/div}}{10\text{ mV/div}} = 0.1\text{ Amp/Volt}$$

10. Compute the scale factor by multiplying the displayed MULT scale factor by the Scale Factor Multiplier. For the above example (a CH 2 VOLTS/DIV setting of 2 volts/div is assumed):

$$\begin{array}{c}\text{Scale Factor}\\ \text{(Power Waveforms)}\end{array} = 0.1\text{ A/V} \times 10.2\text{ mV}^2\text{/div } 10.2\text{ mW/div}$$

NOTE

The cursors can be used to measure the MULT mode waveform (see "Cursor Measurements" in this section). With the cursors attached to the MULT waveform display, multiply the cursor measurement values seen in the readout by the Scale Factor Multiplier obtained in Step 9 to obtain the actual values for power waveform display.

11. Count the number of vertical divisions for the MULT waveform and multiply by the scale factor obtained in Step 10. The result is the peak-to-peak power for the circuit under test. The RMS, peak, or mean values can be computed by applying the appropriate formulas.

TIME AND FREQUENCY Measurements—Non-Delayed.

To measure time duration between two points on a waveform while using the graticule, it is only necessary to display the points on screen, count the number of horizontal divisions between the points, and apply the formula:

$$\text{Time Duration} = \text{Horizontal Div Counted} \times \text{SEC/DIV Setting}$$

If the time duration measured is for a single cycle of a periodic waveform, the frequency can be determined by the formula:

$$\text{Frequency} = \frac{1}{\text{Time Duration}}$$

The following application gives a specific example of measuring time; specifically, the rise time of a square wave.

1. Display and trigger (on the positive, "+" slope) the square wave to be measured in CH 1 or CH 2. Set the input coupling to DC.

2. Set the VOLTS/DIV control to display about 5 divisions. Use the VARIABLE function to adjust the display for exactly five divisions.

3. Adjust the vertical positioning so that the bottom of the square wave is aligned to the 0% reference line and the top of the square wave is aligned to the 100% reference line.

4. Set the SEC/DIV control to display the leading edge of the square wave over as many horizontal divisions as possible, while remaining within the graticule area.

5. Horizontally position the square wave so that the 10% point on the waveform intersects a vertical graticule line near the left side of the screen (see point A of Figure 3-5).

6. Count the number of horizontal divisions (include fractional div) between the 10% and 90% amplitude levels (points A and B of Figure 3-5) on the waveform. Use the following general formula for time duration measurements to determine the rise time:

Time Duration = Horizontal Div Counted × SEC/DIV Setting

EXAMPLE: Figure 3-5 gives the SEC/DIV control setting as 5 μs for the A time base. Counting the number of divisions between the 10% and 90% graticule lines (marked as A and B in diagram) yields 2.2 divisions. Substituting into the formula:

Rise time = Time Duration = 2.2 div × 5 μs/div = 11 μs

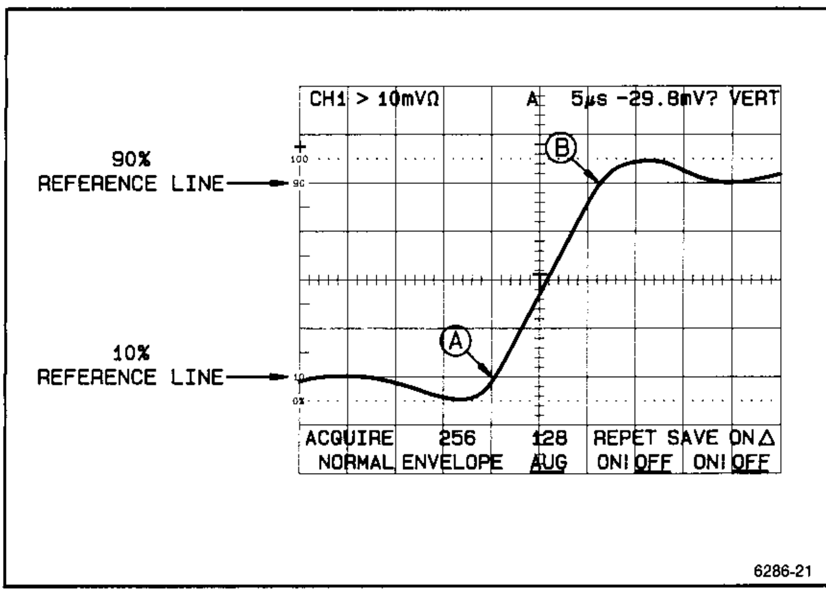


Figure 3-5. Rise time of a square wave (time duration).

Delay Time Measurements and Applications

The B Acquisition system, coupled with DELAY TIME and Δ DELAY TIME, provides several features. First, when the B TRIG MODE is set to RUNS AFTER (Delay), the B Acquisition system can be used to "magnify" selected events displayed at the A acquisition rate (selected using A INTEN MODE). Second, the DELAY by TIME feature can be set to provide a delay between the acquiring of data by the A acquisition System and the B acquisition system. Third, the TRIG AFTER (Delay) mode allows time delays to be specified between A acquisitions and the enabling of the B trigger system to recognize trigger events. These features are examined below.

DELAY TIME Mode As A Magnifier

The A INTEN selection for HORIZONTAL MODE provides a means to identify the portion of the A trace to be magnified when switching to B HORIZONTAL MODE. The Cursor/Delay control knob is used to position the intensified zone to the desired position on the A trace display (within the A waveform record length), after which the HORIZONTAL MODE is switched to B. The result is a display of the area of interest at the B acquisition rate. Switching the B SEC/DIV setting to a faster acquisition rate than the A SEC/DIV setting magnifies the intensified portion of the A acquisition by an amount specified by the following formula:

$$\text{Magnification} = \frac{\text{A SEC/DIV setting}}{\text{B SEC/DIV setting}}$$

When using the A INTEN mode for this application, the B TRIGGER MODE should be set to RUNS AFTER (Delay). For this mode, the intensified zone indicates where the B acquisition will occur relative to the A acquisition. It also indicates the time duration of the B acquisition relative to A. For the TRIG AFTER (Delay) B TRIGGER MODE, the intensified zone only indicates when a B acquisition COULD be started, if a valid B Record Trigger occurs. The zone does not indicate whether a trigger does occur or what the time duration of the B acquisition would be if it does occur.

Use the following procedure for magnification using delayed acquisition modes:

1. Display the test waveform in one of the channels. Set the VOLTS/DIV control for five vertical divisions of display.

2. Set the A SEC/DIV control to display one or more waveform cycles.

3. Set the HORIZONTAL MODE to A INTEN and the B TRIG MODE to RUNS AFTER (Delay).

4. Set the B SEC/DIV control to an acquisition rate 10 times faster than the A SEC/DIV setting. Adjust the brightness of the display (DISP) and the A INTEN zone (INTENS) for adequate contrast between the two portions of the trace.

NOTE

If increasing the intensity for INTENS did not result in a visible intensified zone, pre-set DELAY TIME to minimum. An intensified zone, approximately two divisions long, should appear near the Trigger Point Indicator ("T") on the displayed waveform.

5. Push the DELAY TIME button to display that menu. Set Δ TIME OFF if it is ON. Use the Cursor/Delay control knob to position the intensified zone to the part of the display to be magnified.

6. Set the B SEC/DIV control to a setting which completely intensifies the part of the display to be magnified. Reposition the intensified zone as required (see Figure 3-6a).

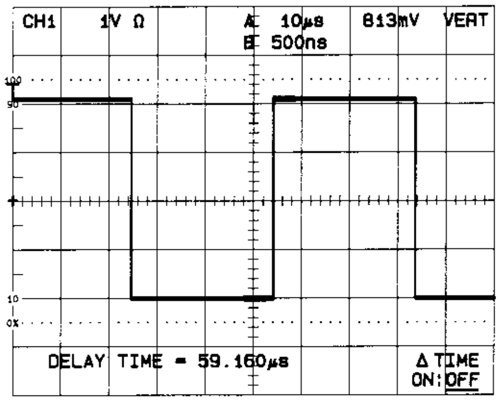
7. Change the HORIZONTAL MODE to B. The intensified portion of the display will be displayed at the SEC/DIV setting of the B time base (see Figure 3-6b).

EXAMPLE: For the waveform displayed in Figure 3-6b, the display readout indicates "A 10μs" and "B 500ns". Therefore,

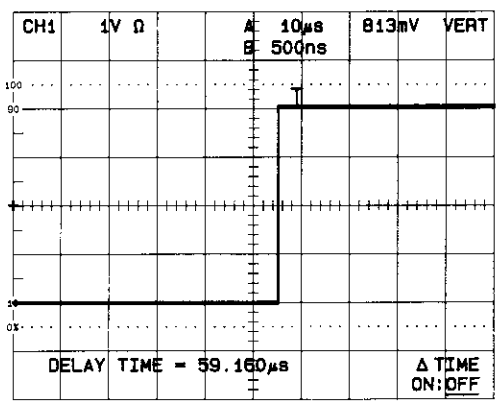
$$\text{Magnification} = \frac{\text{A SEC/DIV setting}}{\text{B SEC/DIV setting}} = \frac{10\ \mu\text{s}}{500\ \text{ns}} = 20$$

NOTE

The magnified zone will be 20 divisions long when displayed in B mode. Horizontally position the display as required to see the entire magnified area.



a. Square wave with the zone to be magnified intensified.



b. Square wave with the zone magnified at the B acquisition rate.

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Figure 3-6 (a and b). DELAY TIME used as a positionable magnifier.

Other Delay Applications

The intensified zone was positioned (in the previous procedure) by delaying the B System's acquisition relative to the A System's acquisition. The DELAY TIME readout displayed a time which related the B acquisition to the A acquisition.

Specifically, the DELAY TIME readout indicates the following:

a. For B TRIGGER mode set to RUNS AFTER (Delay), the readout indicates the elapsed time between when the Record Trigger occurs for the A acquisition and when the Record Trigger is generated for the B acquisition.

b. For B TRIGGER MODE set to TRIG AFTER (Delay), the readout indicates the elapsed time between when the A Record Trigger occurs and when a valid B Trigger will be allowed to initiate a B record trigger.

You are not limited by the duration of the A SEC/DIV setting when specifying the delay time. Delay times of up to 2,621.4 times the B SEC/DIV setting are available. While the intensified zone can not be observed for delay settings beyond the end of the A acquisition, the B HORIZONTAL MODE will display such acquisitions. In this way, you can view events occurring long after the events displayed for the A acquisition have passed.

The same delay times available for the RUNS AFTER mode are available for the TRIG AFTER mode. You can set up the desired delay, make the trigger control settings desired for the B Trigger System, and display the waveform. The RUNS AFTER mode may be used to search for the event to be displayed, by gradually increasing the DELAY TIME setting until the event is displayed. The scope can then be switched to the TRIG AFTER mode.

NOTE

See "General Information for Delayed Acquisition Usage" at the end of this subsection, for limitations and cautions regarding use of the DELAY TIME and Δ DELAY TIME.

Δ Delay Time and Frequency Measurements

A second time delay is available for B acquisitions. The Δ (Delta) DELAY TIME feature allows a second delay to be specified between when the A acquisition occurs and when the B acquisition occurs. Specifically, the Δ DELAY TIME readout indicates the following:

a. For B TRIGGER MODE set to RUNS AFTER (Delay), the readout indicates the elapsed time between when the Record Trigger occurs for the A acquisition and when the Record Trigger is generated for the B acquisition.

b. For B TRIGGER MODE set to TRIG AFTER (Delay), the readout indicates the elapsed time between when the A Record Trigger occurs and when a valid B Trigger will be allowed to initiate a B record trigger.

The DELAY TIME and Δ DELAY TIME functions provide a means to make high resolution time/frequency measurements of displayed waveforms. Use the following procedure to measure the time between the occurrence of two displayed events:

1. Perform Steps 1 through 4 of the last procedure, and manipulate the A SEC/DIV control (in Step 2) so that both points to be measured are displayed (see Figure 3-7a).

2. Push the DELAY TIME button to display that menu and set Δ TIME on.

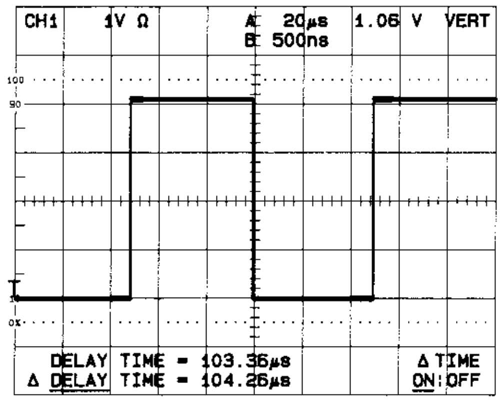
3. Preset both DELAY TIME and Δ DELAY TIME to minimum if two intensified zones are not visible. Two overlapping zones, about two divisions long, should be displayed at the Trigger Point Indicator ("T") on the waveform.

4. Select DELAY TIME and use the Cursor/Delay control knob to position both the main delay and the Δ delay intensified zones to the first reference point. (Pressing the DELAY by TIME button toggles the effect of the Cursor/Delay control between DELAY TIME and Δ DELAY TIME.)

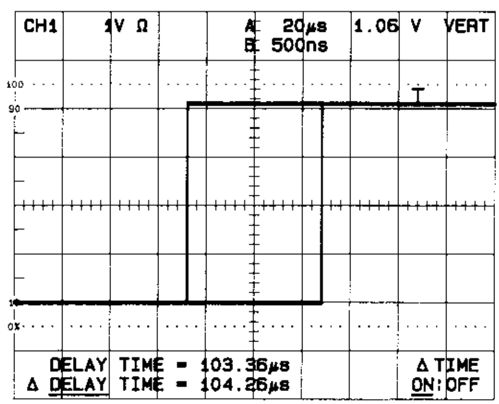
5. Select Δ DELAY TIME and position the Δ delay intensified zone to the second reference point.

6. Set the HORIZONTAL MODE to B. Adjust the Δ DELAY TIME to superimpose the two reference points. Adjust the DELAY TIME and/or horizontal POSITION as required to view the displayed references. See Figure 3-7b.

The Δ DELAY TIME readout indicates the time difference between the occurrence of the two reference events when the two events are superimposed.



a. Square wave displayed with the intensified zones bracketing its period.



b. Square wave displayed magnified at the B acquisition rate.

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Figure 3-7 (a and b). Δ DELAY TIME used to measure the period of a square wave.

As shown during the performance of the last procedure, the two B delayed acquisitions are displayed at the same vertical position when obtained from a single channel. Table 3-1 and Figure 3-8 indicate where the main delay and Δ delay B acquisitions are obtained and displayed for the various VERTICAL MODE settings.

Table 3-1
Delay Displays versus Vertical MODE

VERTICAL MODE	Main Delay Acquisition	Δ Delay Acquisition
CH 1 (only)	CH 1	CH 1
CH 2 (only)	CH 2	CH 2
CH 1 and CH 2	CH 1	CH 2
ADD or MULT	func[a]	func

[a]Either ADD or MULT.

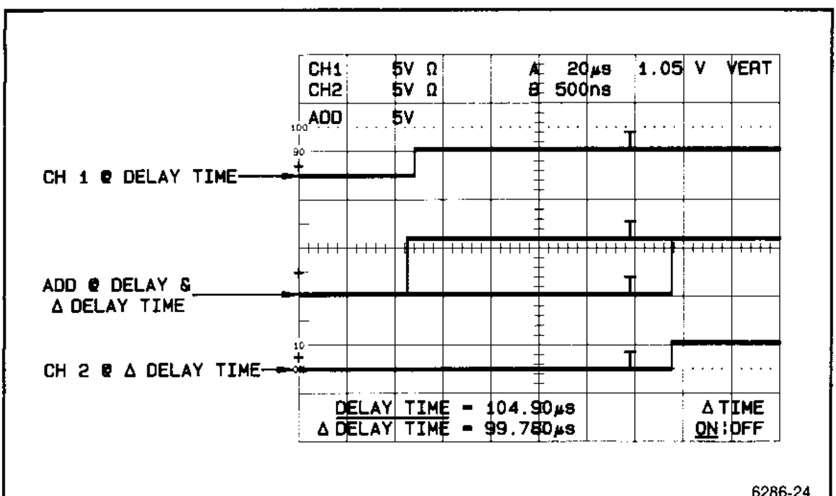


Figure 3-8. Delay and Δ Delay acquisitions as displayed for CH1, CH2, and ADD (or MULT) VERTICAL MODE.

Delay By Events Measurements

This instrument provides a third feature for delaying acquisitions—DELAY by EVENTS. This mode delays the A Record Trigger (around which the A acquisition is displayed) from the normal A Triggering event. The result is an A acquisition delayed from the normal A Trigger event by the number of valid B Trigger events received by the B Trigger System.

You set the number of B triggers to be counted before making the A acquisition by specifying the number of events. Setting the number of events is done using the Cursor/Delay control knob while the DELAY by EVENTS menu is displayed.

You also set up the B Trigger system criteria for the source selected as the EVENTS source. The source can be the A acquisition waveform, or any of the other internal or external source selections available for the B TRIGGER SOURCE menu. Note that if the External Clock Feature is turned on for the B TRIGGER MODE menu, the A and B acquisition rates will be set by the repetition rate of the signal selected as the B trigger source.

All the DELAY by TIME features are available for use when displaying the B acquisition. With DELAY TIME and Δ DELAY TIME set to minimum, all acquisitions (A and both B delayed acquisitions—main delay and delta delay) are delayed from the A Normal Trigger by the number of B trigger events specified. The A INTEN and DELAY by TIME modes can then be used as described in earlier procedures to magnify and measure the DELAY by EVENTS A acquisition.

Use the following procedure to delay the A acquisition by B trigger events:

1. Input the signal which will provide the trigger to start the events counting into CH 1 or CH 2.

2. Input the signal which will provide the triggers to be counted into the desired source (CH 1, CH 2, EXT1, or EXT2).

3. Set the A TRIGGER SOURCE to the channel selected for Step 1 and trigger the display.

4. Set the B TRIGGER SOURCE to the source selected in Step 2.

5. Set B TRIGGER MODE to TRIG AFTER and set the HORIZONTAL MODE to B.

6. Set B TRIGGER CPLG and LEVEL control for a triggered display.

7. Return the HORIZONTAL MODE to A and the B TRIGGER MODE to RUNS AFTER.

8. Select DELAY by EVENTS and set EVENTS ON|OFF to ON.

9. Use the Cursor/Delay control knob to set the EVENTS COUNT to the desired number of events. The resultant display will be delayed from the Normal A Trigger (event) by that number.

The A Record Trigger ("T") is the event around which the A acquisition is displayed. The A Record Trigger displayed is delayed from the A triggering event (specified in Step 3) by the number of events specified in Step 9. Source of the events was specified in Step 4.

General Information for Delay Acquisition Usage

1. TRIGGER POSITION. When using the DELAY by TIME feature to set up exact time delays, the time between A and B acquisitions is affected by the TRIGGER POSITION settings for A and B. In general, set the A and B TRIGGER POSITION to equal settings. See STORAGE APPLICATIONS in this section for further information regarding the position of the record trigger.

2. ENCOUNTERING MAXIMUM DELAY. Maximum setting allowed for DELAY TIME, Δ DELAY TIME, or the sum of both delays is 2621.4 times the B SEC/DIV setting. Note that the maximum delay decreases as the B acquisition rate is increased. If the B SEC/DIV setting is increased to settings having lower maximum delay limits than the delay(s) set at a lower setting, the delay setting(s) is truncated to the limit for the new setting. It will then be necessary to return the B SEC/DIV control to the slower setting and readjust the delay time(s). Note that the maximum time delay allowed does not affect the amount of time delay available for the DELAY by EVENTS function.

> **EXAMPLE:** If B SEC/DIV is set to 10 μs, the maximum allowed delay time is $2621.4 \times 10\ \mu s = 26.214$ ms. Assume delay time is set to 20.000 ms and an event is on screen. If the B SEC/DIV setting is increased to 5 μs, the maximum allowed time is $2621.4 \times 5\ \mu s =$ 13.212 ms. The event is no longer displayed; return the B SEC/DIV to 10 μs and set the DELAY TIME back to 26.214 ms to see the event.

Special Applications

Cursor Measurements

The CURSOR FUNCTION offers fast and flexible measuring capabilities. With the exception of the Δ DELAY TIME mode for measuring time delay, the cursor measurements are more accurate than the graticule type measurements described in the "General Applications" sub-section. It is also quicker to use them than to interpolate the graticule markings when accurate measurements are required.

Voltage Measurements

Use of the VOLTS cursors yields increased accuracy (2% compared to 3% in NORMAL and AVG acquisition modes) over use of the graticule for measuring display amplitudes. Although requiring "set-ups" and cursor manipulation, cursor measurements may save time over graticule measurements since the measurement results can be read directly without computation.

Two cursor modes are available for amplitude measurement—Δ (delta) and ABS (absolute). For the Δ mode, two cursors are displayed, and the readout indicates the difference in amplitude between the two cursors. The ABS mode displays only one cursor, and the cursor readout indicates the amplitude of the displayed cursor with respect to the display ground reference.

The base units for amplitude displays are volts. In addition, two special unit types are available (percentage and decibels) for special measurement applications. Use of the base and special units is illustrated in the procedures that follow.

Delta Voltage Measurements

Use the following procedure to make differential voltage measurements on displayed waveforms (see Figure 3-9):

1. Obtain a triggered display on screen of the waveform to be measured.

2. Push the CURSOR FUNCTION button to display the CURSOR FUNCTION menu.

3. If VOLTS is not underscored in the menu, push VOLTS to do so. If more than one display source is presently selected (CH 1 and ADD for example), the ATTACH CURSORS TO: menu will be displayed. Push the menu button to attach the cursors to the source displaying the waveform to be measured.

NOTE

If only one display source is selected the cursors will automatically be attached to that display source and the ATTACH SOURCES TO: menu will not be displayed.

4. If VOLTS cursors are already selected when the CURSOR FUNCTION menu is displayed in Step 2, push the CURSOR FUNCTION button again to display the ATTACH CURSORS TO menu and attach the cursors to the desired source.

5. Push the CURSORS UNITS button. Select VOLTS units and set the Δ¦ABS menu choice to Δ for the menu displayed.

6. Use the Cursor/Delay control knob to align the active (segmented) cursor to the first reference voltage level on the displayed waveform.

7. Push the CURSOR SELECT button to switch the active cursor and align the now active cursor to the second reference voltage level on the display.

8. Read the difference in volts between the amplitudes of the two references directly from the cursor readout displayed.

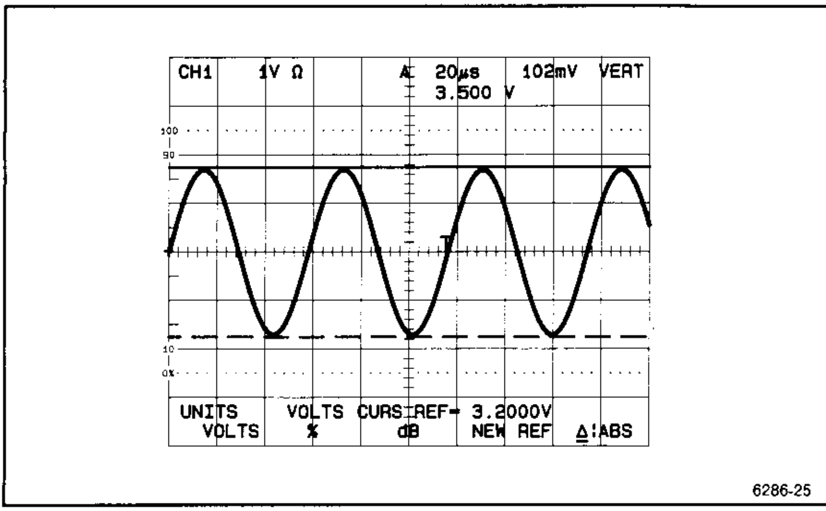


Figure 3-9. Measuring a 3.5 V sine-wave signal using VOLTS cursors.

Ratio Between Two Voltages

The special units will generally be used when making ratiometric measurements (measurements that compare corresponding quantities on two different waveforms and express the results as the ratio of one compared to the other) between two signals. For example, the input voltage signal versus the output voltage signal for a signal amplifier could be compared to determine the ratio between the two signals (i.e., voltage gain) in decibels or percent. Use the following procedure to measure such ratios:

1. Display one of the two signals of interest in CH 1, the other in CH 2.

2. Perform the procedure outlined in Steps 2 through 7 of the previous "Delta Voltage Measurement" to set up the cursor measurement and to align the cursors to the reference signal peaks (see Figure 3-10a). Attach the cursor to the channel in which the reference signal is displayed for Step 3 and 4 and select "%" for the unit type in Step 5.

3. Push NEW REF for the displayed menu. Note the cursor readout indicates 100%. See Figure 3-10a.

4. Align the cursors to the peaks of the signal to be compared to the reference. See Figure 3-10b.

5. If the CH 1 and CH 2 VOLTS/DIV controls are set to the same deflection factor, the cursor readout indicates the ratio between the comparison and reference signals in percent.

6. If the CH 1 and CH 2 VOLTS/DIV controls are not set to the same deflection factor, push the CURSOR FUNCTION button twice to display the ATTACH CURSORS TO: menu and attach the cursors to the channel displaying the comparison signal.

7. The cursor readout now indicates the ratio between the comparison signal and the reference signal in percent. See Figure 3-10b.

As mentioned previously, dB (decibels) can be selected as the special unit for ratiometric measurements. If dB had been selected for the measurement units in the previous procedure, the cursor readout would indicate the number of decibels by which the comparison signal was larger or smaller than the reference signal.

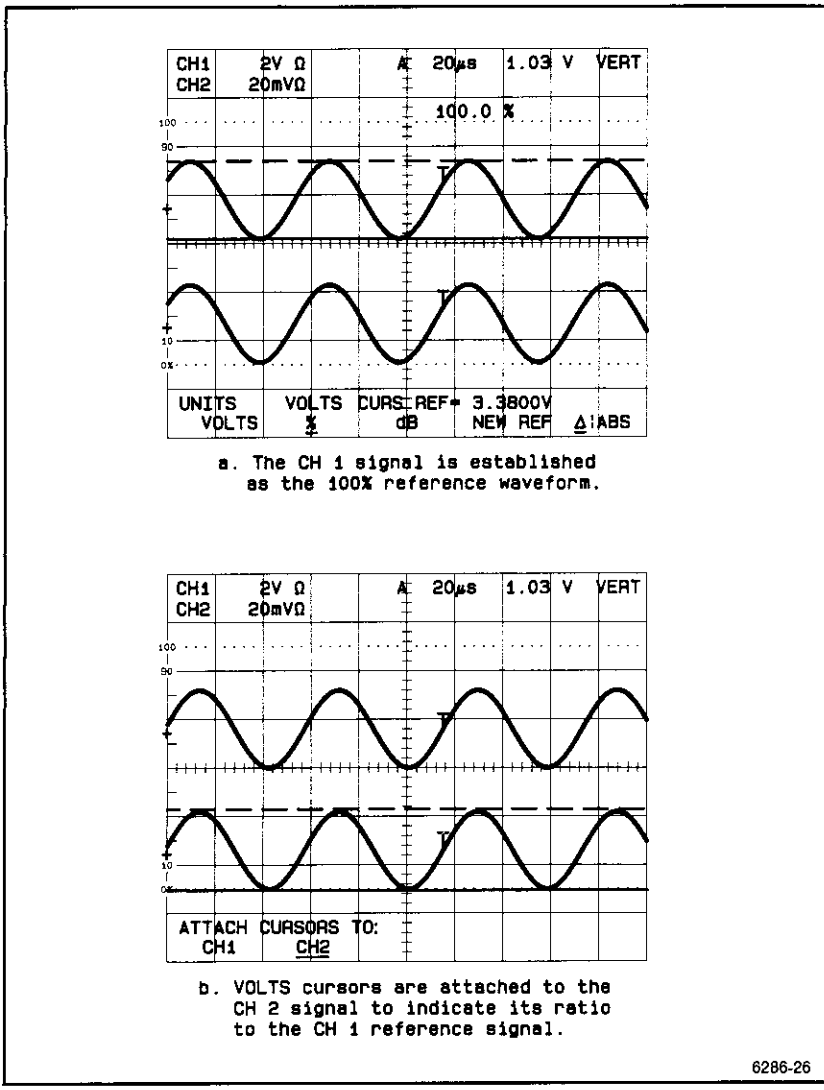


Figure 3-10(a and b). Measuring the ratio between the amplitudes of two sine-wave signals.

Ratiometric comparisons can be made between levels on the same signal (such as the ratio between a front corner aberration on a square wave versus the overall amplitude of that square wave), as well as between signals displayed from several display sources (such as between a reference signal in CH 1 versus signals displayed in CH 2, REF 1, etc.). In all cases, the method is essentially the same as just outlined:

a. Establish the desired signal (or portion of the signal) as a reference.

b. Bracket the signal to be compared to the reference with the cursors (attach to that signal source as required).

c. Read the ratio directly from the cursor readout in the units selected. If more display sources are displaying signals for comparison, move the cursors to those signals and position the cursors to read the ratio between each signal and the reference. Establish a new reference whenever desired.

Absolute Voltage Cursor Measurements

Use the following procedure to perform ground-referenced measurements on displayed waveforms:

1. Perform Steps 1 through 4 of the "Delta Voltage Measurements" procedure.

2. Push the CURSORS UNITS button. Select VOLTS units and set the Δ¦ABS menu choice to ABS.

3. Use the Cursor/Delay control knob to align the cursor to the desired level on the displayed waveform.

4. Read the voltage level of the waveform (at the cursor) with respect to ground from the cursor readout. (See Figure 3-11.)

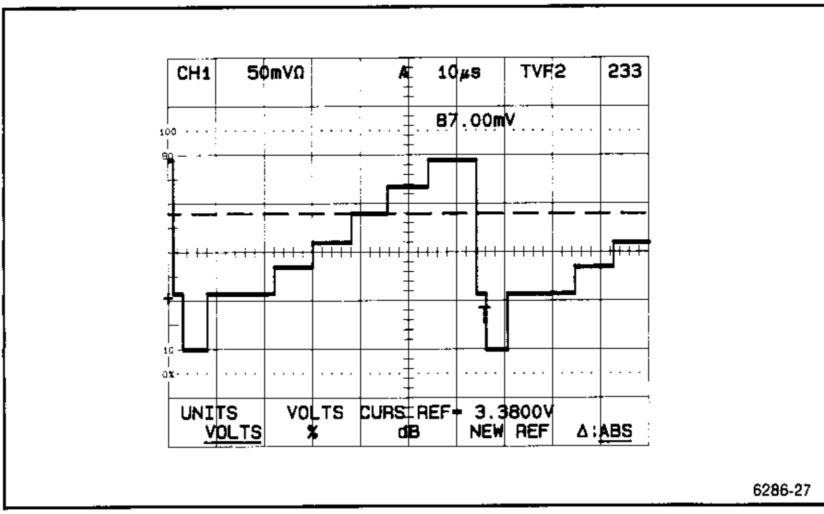


Figure 3-11. Voltage measurement of a step on a stair-case signal using the VOLTS cursor function in the ABS mode.

Ratiometric measurements can be made by methods similar to those outlined in the descriptions for "Delta Voltage Measurements" for special units. For example, the noise level during the off times of a pulse train can be compared to the pulse level during on times. If the decibel is the special unit used, the readout will indicate the number of decibels by which the noise level (with respect to ground) is below the pulse level (again, with respect to ground). Generally, apply the method outlined for performing ratiometric measurements in the Δ cursor mode, adjusting the cursor to the levels for comparison instead of bracketing those levels as in Δ cursor mode. Remember to reattach the cursors as required when comparison signals from different display sources were acquired at a different VOLTS/DIV setting than that of the reference display source.

Time and Frequency Measurements

As for amplitude measurements, use of cursors for time measurements increases accuracy. An internal crystal-controlled clock circuit determines the accuracy of the time cursors, which is specified as 0.001% over two divisions. Since 0.001% of two divisions is less than a ten thousandth of a division, the accuracy of cursor measurements essentially depends on the accuracy of their placement on the display by the user. The accuracy of the graticule will be within approximately 1% of the cursor accuracy.

The same two cursor modes used for amplitude measurements, Δ and ABS, are available for time measurements. For the Δ cursor mode, the cursor readout indicates the elapsed time between the two cursors. For the ABS mode, the readout indicates the time between the single cursor and the Record Trigger point, around which the acquisition is displayed. For both modes, the cursor(s) are automatically attached to the A acquisition rate for A and A INTEN HORIZONTAL MODES and to the B acquisition rate for the B HORIZONTAL MODE.

In addition to the automatic attachment that occurs when switching between the A and B time bases, the cursors can also be attached to saved signals stored in Reference memory allowing time measurements on those waveforms based on the SEC/DIV setting at which they were acquired. Furthermore, the cursor displayed in ABS mode can be attached to either the DELAY TIME or the Δ DELAY TIME display when the Δ TIME mode is ON and more than one "live" display source (CH 1, ADD, etc) is displayed.

The base units for time measurements are seconds. The special unit types are percentage and degrees. The following procedures will suggest the usage of both base and special unit types.

Δ Time Cursor Measurements

Use the following procedure to make differential time measurements on displayed waveforms:

1. Obtain a triggered display on screen of the waveform to be measured.

2. Push the CURSOR FUNCTION button to display the CURSOR FUNCTION menu.

3. If TIME is not underscored in the menu, push TIME to select the time cursors. If more than one display source is presently selected (CH 1 and ADD, for example) the ATTACH CURSORS TO: menu will be displayed.

NOTE

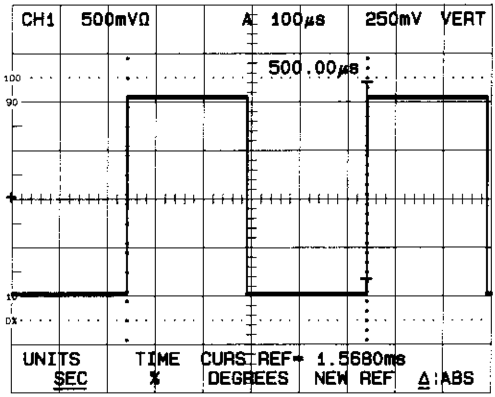
It is not necessary to attach the TIME or 1/TIME cursors to a Vertical Mode (CH 1, ADD, etc.). Ignore the ATTACH CURSOR TO: menu for TIME and 1/TIME cursor use, except when saved reference waveforms are displayed. If reference waveforms are displayed, the ATTACH CURSOR MENU TO: menu will display those sources for selection.

4. Push the CURSORS UNITS button. Select SEC units and set Δ¦ABS to Δ for the menu displayed.

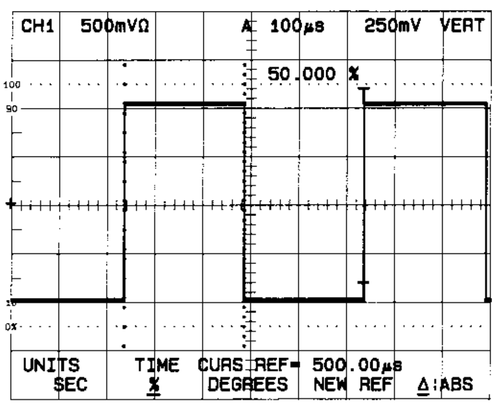
5. Use the Cursor/Delay control knob to align the cursors to the two desired reference points on the displayed waveform. Push the CURSOR SELECT button to toggle between the two cursors (the cursor with the most dots is active) as required.

6. Read the difference in time (seconds) between the two reference points directly from the cursor readout displayed. See Figure 3-12a.

7. Push CURSOR FUNCTION and change the function from TIME to 1/TIME. If the two reference points selected in Step 5 bracketed one cycle of a periodic waveform (as in Figure 3-12a) the readout now indicates the frequency in Hz.



a. Measurement of the period of a square wave.



b. Measurement of the duty cycle of a square wave.

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Figure 3-12 (a and b). Time measurements using TIME Cursor function and modes.

Ratio Between Two Time Periods

As with VOLTS cursors, TIME (or 1/TIME) cursors can be used to measure ratios between quantities, in this case two time periods. The special units used can be either percentage or degrees. The following procedure illustrates the usage by measuring the duty cycle of a periodic rectangular pulse.

1. Perform Steps 1 through 3 of the "Δ Time Cursor Measurements" procedure.

2. Set the SEC/DIV to display one or two cycles of the pulse.

3. Push the CURSORS UNITS button. Select % units and set the Δ¦ABS choice to Δ for the menu displayed.

4. Adjust the cursors as in Step 5 of the Δ Time Cursor Measurements procedure. The two reference points are those required to bracket one cycle of the rectangular pulse (see Figure 3-12a).

5. Push the NEW REF menu button to establish one cycle of the pulse as the 100% reference for the cursors. Note the readout now indicates 100%.

6. Adjust one of the two cursors so that only the positive-going portion of the waveform cycle is bracketed by the cursors (see Figure 3-12b).

7. Read the ratio of the presently bracketed time period to the time period established as a reference in Step 5. For Figure 3-12b the ratio was:

$$\text{Duty Cycle} = \frac{\text{Time Pulse Duration}}{\text{Time Pulse Period}} \times 100 = 50\%$$

The general formula for ratio time comparisons is:

$$\text{Readout (\%)} = \frac{\text{Present Cursor Time Period}}{\text{100\% Reference Time Period}} \times 100$$

Note that ratiometric measurements can be made between signals displayed in different display sources. For example, the 100% reference can be established for a time period in CH 1 and the comparison signal bracketed in CH 2. Be sure to attach the cursors to the proper source when save reference waveforms are compared with either other reference waveforms or live waveforms. This attachment is not necessary for comparisons on or between live waveforms as they are acquired at the same acquisition rates. However, reference waveforms may have been acquired at any acquisition rate allowed by the SEC/DIV control.

Also note that the special units selected for TIME and 1/TIME measurements can be DEGREES. In that case, the reference units will be 360° instead of 100% as in Step 5 of the previous procedure. In the previous procedure, with degrees selected as the units of measurement, the readout will indicate 180° for Step 7 instead of 50%.

Absolute TIME Cursor Measurements

As previously mentioned, the absolute mode is available for TIME cursor measurements. Only one cursor is displayed; the other cursor can be considered permanently placed at the Record Trigger position of the displayed acquisition. All absolute cursor measurements are with respect to the Record Trigger (indicated by a small "T" on the displayed acquisition).

Use the following general procedure for making absolute time cursor measurements:

1. Perform Steps 1 through 4 of the "Δ Time Cursor Measurements" procedure, setting Δ¦ABS to ABS instead of Δ for Step 4.

2. Position the display to view both the Record Trigger ("T") and the point on the waveform that you want to measure. Adjust the SEC/DIV as required.

3. Use the Cursor/Delay control knob to align the cursor to the desired point.

4. Read the time difference between the cursor-aligned point and the Record Trigger point directly from the cursor readout (see Figure 3-13).

Note that when seconds are selected for the units, time can appear as a signed (±) quantity. The sign indicates whether the cursor-aligned point occurs before (−) or after (+) the Record Trigger.

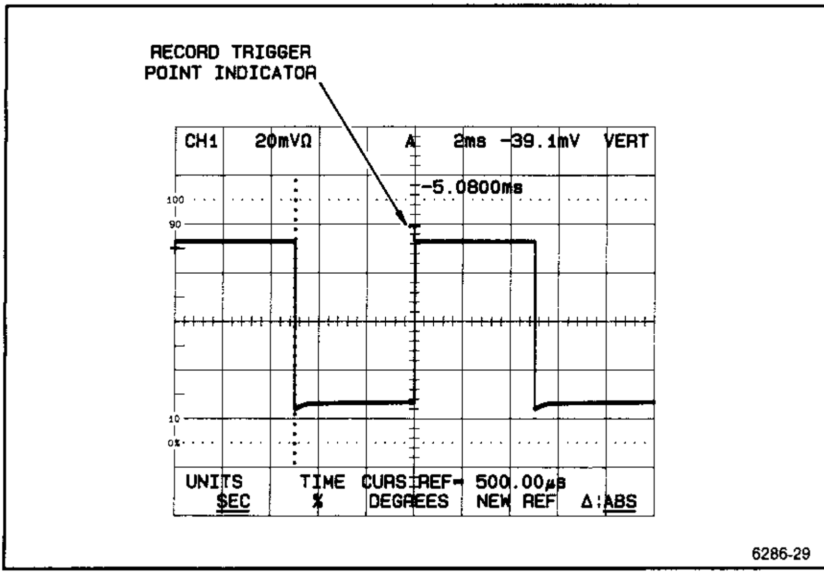


Figure 3-13. Time measurement of an event relative to when the record trigger occurred.

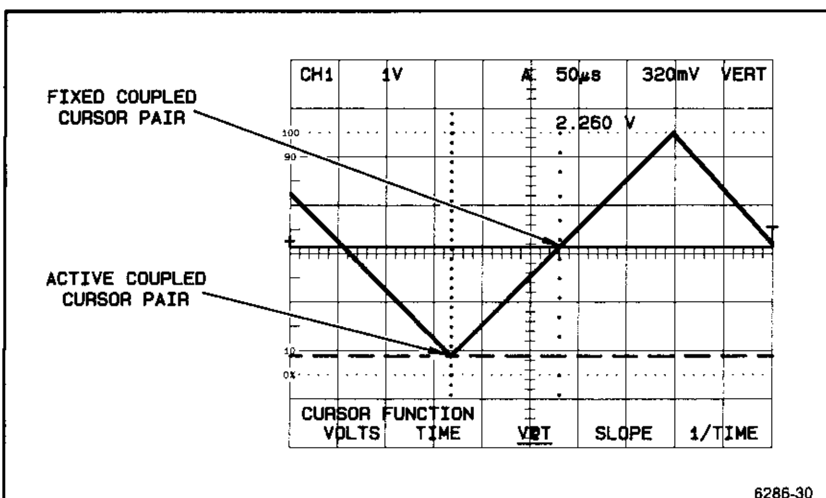


Figure 3-14. VOLTS coupled to TIME cursors displayed on a triangle wave.

Voltage Coupled to Time Cursors (V@T)

The two remaining cursor selections are coupled-cursor modes. For the V@T and SLOPE cursors, the vertical position of coupled VOLTS cursors depends on the placement of the associated TIME cursors on the waveform. In Figure 3-14, the first TIME cursor has been aligned to a time coincident with the peak of the displayed triangle wave. The VOLTS cursor coupled to the TIME cursor is also aligned to that peak. The second TIME cursor is set to a time at which the amplitude is halfway up the positive slope, between the negative and positive peaks. Again, the coupled VOLTS cursor corresponds to that voltage level.

For V@T (Volts at Time) cursor type, both Δ and ABS cursor modes are available. The operation of the two modes is the same as outlined for VOLTS cursors earlier in this section. The cursor readout indicates the voltage difference between the two coupled VOLTS cursors for Δ cursor mode; it indicates the difference between the single, coupled VOLTS cursor and the ground reference for the ABS cursor mode.

SLOPE cursors do not have an absolute mode selection. There are always two VOLTS cursors (coupled to their two TIME cursors) displayed. When the CURSOR UNITS selection is SLOPE, the readout value will be displayed in V/s and be determined by:

$$\underset{(\text{V/s})}{\text{Readout}} = \frac{\text{Voltage Difference between VOLTS Cursors}}{\text{Time Difference between TIME Cursors}}$$

V@T MEASUREMENTS. Use the following procedure when making V@T cursor measurements:

1. Trigger a display on screen of the waveform you're going to measure.

2. Push the CURSOR FUNCTION button to display the CURSOR FUNCTION menu.

3. If V@T is not underscored in the menu, push V@T to select the coupled cursors. If more than one display source is presently selected (CH 1 and ADD, for example) the ATTACH CURSORS TO: menu will be displayed. Push the menu button to attach the cursors to the source displaying the waveform to be measured.

NOTE

If only one display source is selected, the cursors will automatically be attached to that display source, and the ATTACH SOURCES TO: menu will not be displayed.

4. Push the CURSORS UNITS button and set VOLTS on. Set Δ¦ABS to the desired mode.

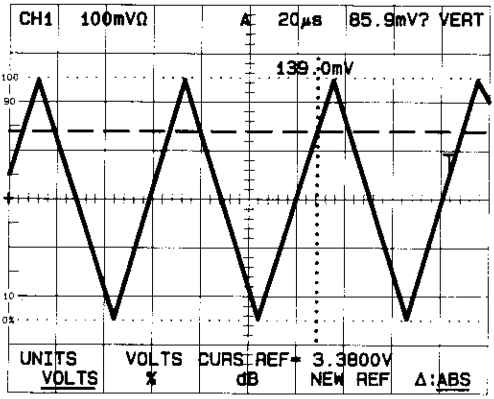
5. Depending on the mode selected for Step 4, align the TIME cursor or cursors to the desired measurement point(s) on the waveform.

NOTE

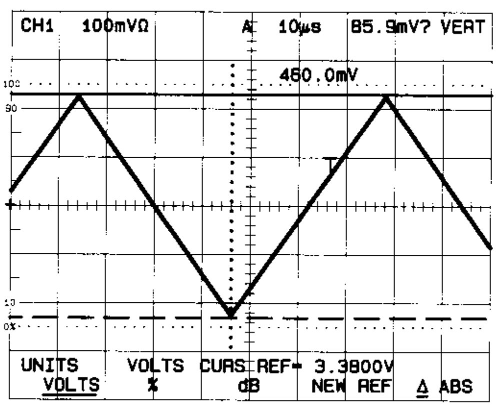
When using cursors in a coupled mode, note that the active cursor is segmented for the VOLTS cursor and contains the most dots for the TIME cursor.

6. Read the voltage directly from the readout.

The value displayed is the voltage with reference to ground if ABS mode was selected in Step 4 of the previous procedure. If Δ mode was selected, the value is the difference in voltage between the coupled cursors. In both cases, the voltage measured is at the point on the display where the TIME cursor(s) positioned the coupled VOLTS cursor(s). See Figure 3-15 (a and b) for examples of V@T measurements for both the ABS and Δ cursor modes.



a. Measurement of the voltage (ground referenced) at the point coincident with the time cursor (Absolute Mode).



b. Measurement of the voltage difference between two points coincident with the two time cursors (Delta Mode).

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Figure 3-15 (a and b). V@T measurements on triangle-wave signals.

V@T TIME CURSOR PLACEMENT. The V@T cursors can be used to provide high-accuracy frequency or period measurements for periodic waveforms. A main factor in the accuracy of such measurements is the uncertainty of cursor placement. Step 3 in the following procedure shows you a method for precise placement of the cursors. Use the following procedure to perform such measurements:

1. Perform Steps 1 through 4 of the V@T measurement procedure, setting Δ¦ABS to Δ (delta) mode for Step 4.

2. Align the cursors to just bracket one cycle of the periodic waveform displayed.

3. Fine adjust the position of one of the TIME cursors until the VOLTS cursors are superimposed and the cursor readout indicates 0.0 V. (The ACQUIRE mode can be set to AVG if noise causes difficulty in obtaining a 0.0-V reading.) See Figure 3-16a.

4. Push the CURSOR FUNCTION button and select the TIME cursors. The readout will now indicate the time period for one cycle of the displayed waveform. Select the 1/TIME cursors. The readout now indicates the frequency in Hz. See Figure 3-16b.

Slope Measurements

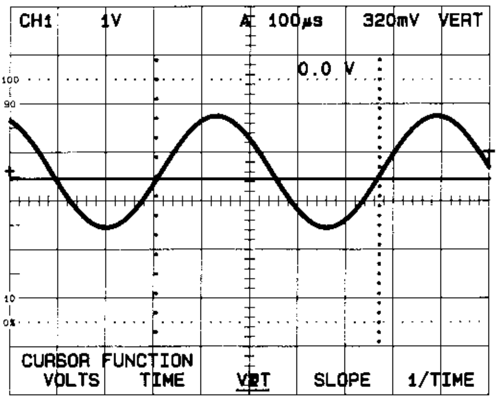
Use the following procedure to measure the average slope of a displayed waveform. The portion of the waveform to be measured is defined by the SLOPE cursors.

1. Perform Steps 1 through 3 of the V@T Measurements procedure, selecting SLOPE for Step 3.

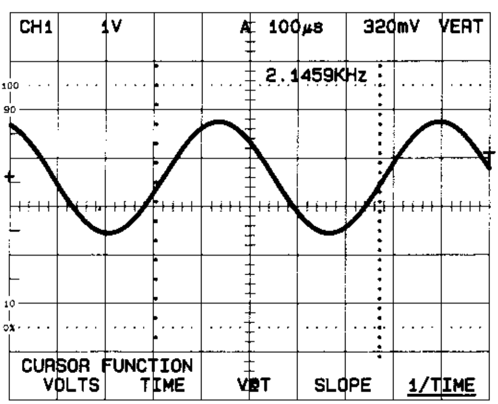
2. Push the CURSORS UNITS button and set SLOPE on.

3. Position the TIME cursors to the points on the waveform between which the slope of the waveform is to be measured.

4. The cursor readout indicates the average slope between the two points in V/s (see Figure 3-17).



a. Time cursors adjusted to bracket the period of the sine wave. Note 0.0 V cursor reading.



b. Frequency measurement of the sine wave. Note the function change to 1/TIME.

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Figure 3-16 (a and b). High resolution measurement of the frequency of a sine-wave signal.

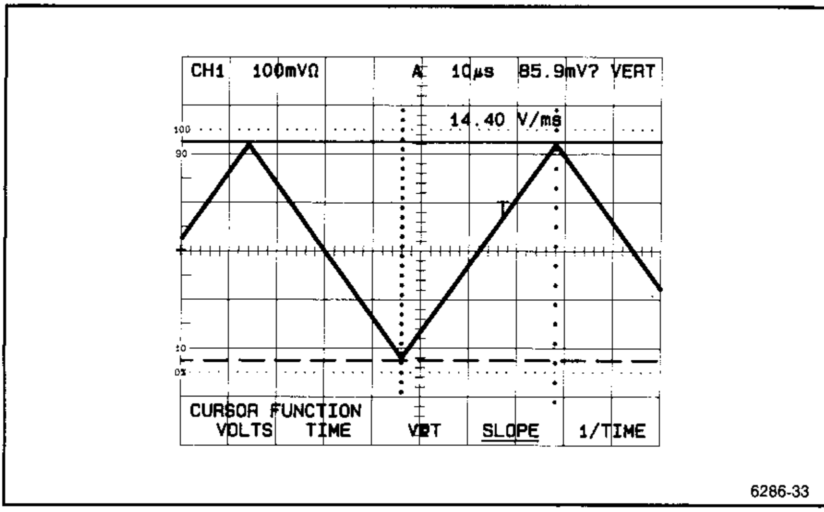


Figure 3-17. Slope measurement on a triangle-waveform.

Special Units for Coupled Cursors

The special units for both types of coupled cursors are percent and decibels. References can be established and ratiometric measurements obtained using the same general method outlined in the "Ratio Between Two Voltages" procedure. Take care to attach the cursor(s) to the proper display source (CH 1, ADD, REF1, etc.).

When special units are used for comparing two slopes, steeper slopes result in higher value readings, lesser slopes in lower readings. If a 2 V/ms slope is established as the 100% reference and a 4 V/ms slope is compared to it, the readout will indicate 200% as a ratio. If the same slopes are compared with decibels as the special units, the readout will indicate 6 dB. If the 4 V/ms slope was used as the 100% reference, the readout will indicate 50% and −6 dB for percent and dB special units respectively.

A*B Trigger Source Application

The composite trigger function allows the use of a combination of two different sources for triggering acquisitions when you use the composite trigger function. With the A TRIGGER SOURCE menu set to A*B on, you select a trigger source from the A TRIGGER SOURCE menu and one from the B TRIGGER SOURCE menu. The two sources can then be used to trigger the A acquisition sequence.

The A*B trigger function logically ANDs the two sources. In other words, the triggering conditions set up by you (can be different for the different sources) must be met by both the A AND B trigger sources before the acquisition is initiated. When both Trigger Systems have their triggering criteria met (or are "true"), the Record Trigger is output (or is "true") and the A acquisition occurs. This action is analogous to the familiar AND logical function, hence the name A AND B Trigger Source function. The following paragraphs precisely define the criteria required for the A Record Trigger (and therefore the acquisition) to occur.

For an individual source to be true, the following conditions must be met:

a. If TRIGGER SLOPE is set to + (positive) AND the level of the triggering signal exceeds (is more positive than) the triggering level set by the TRIGGER LEVEL control, then the source is true; otherwise, it is false.

b. If TRIGGER SLOPE is set to – (negative) AND the level of the triggering signal is less (is more negative) than the level set by the TRIGGER LEVEL control, the source is true; otherwise, it is false.

For a Record Trigger to be true (occur), the following conditions must be met:

a. Both A and B sources must be true as defined by items a and b above.

b. There must be a transition through the level set by the TRIGGER LEVEL control for AT LEAST ONE of the two trigger sources.

c. The transition must be in the same direction (+ or −) as established by the TRIGGER SLOPE setting for the source.

The A*B Trigger Source function should be used when you want to view events which occur or should occur only when two other events coincide. An application occurring in microprocessor-based systems involves accesses to RAM by the microprocessor.

Typical microprocessor systems use the CS (Chip Select) and WE (Write Enable) inputs to write data to a particular RAM IC. With the WE pin held at the logic low state, a WRITE data function will occur when the CS pin transitions to the low state. If each signal is applied to the scope's inputs, and one signal is selected for the A TRIGGER SOURCE and the other is selected for the B TRIGGER SOURCE, you can set the controls of each trigger system (LEVEL, SLOPE) to detect whenever the conditions necessary for a WRITE occur on the particular pin the trigger system is monitoring. You can then observe the state of the individual data lines using a probe connected to one of the vertical input BNC connectors to determine the state of the data lines at the time the WRITE occurs.

Use the following procedure when making A*B TRIGGER SOURCE measurements:

1. Connect the signal to be viewed to CH 1 or CH 2 input.

2. Set the appropriate VOLTS/DIV control for an on-screen display.

3. Apply one of the trigger-source signals to one of the input BNC connectors (CH 1, CH 2, EXT TRIG 1, or EXT TRIG 2).

4. Connect the second trigger-source signal to one of the unused inputs. Use the EXT TRIG inputs for one or both of the trigger signal sources as required to allow the vertical input channels to remain open for viewing the signals to be monitored.

5. Push TRIGGER SOURCE and set A*B¦WORD to A*B.

6. Set the same source as used in Step 3 on for the displayed menu.

7. Select TRIGGER MODE and select the desired mode.

8. Select TRIGGER COUPLING and select the desired coupling mode.

9. Use the TRIGGER LEVEL control to set the Trigger Level Readout to the required triggering level and press the SLOPE button to set + or − signal slope as required for the triggering conditions to be met.

10. Push A/B TRIG to select the B Triggering System. Select TRIGGER SOURCE and select the same source as used in Step 4.

11. Repeat Steps 8 and 9 to select the Trigger Coupling Level, and Slope criteria for the second Trigger SOURCE.

12. The scope is now set up to trigger on a composite of both sources and will acquire data if the proper triggering conditions are met for both the A and the B Trigger SOURCE. Push A/B TRIG to switch between A and B Trigger Systems as desired. Change the previously established triggering criteria as needed to develop the proper trigger conditions.

Storage Applications

This subsection to BASIC APPLICATIONS contains information on applications and usage of the various acquisition modes. It also covers use of the SAVE and SAVE ON Δ features to store those acquisitions as well as use of the DISPLAY REF and other functions which control how the stored acquisitions are displayed.

Acquire Modes

This instrument has three main acquisition modes—NORMAL, ENVELOPE, and AVG (Average). In addition, there are two other modes that affect how signals are acquired. The first mode, ROLL, can be used with the NORMAL and ENVELOPE modes to affect the way their acquisitions are displayed. The second is REPET (Repetitive). It is used to enhance the acquisition of high frequency, repetitive waveforms.

NORMAL Mode

The NORMAL acquisition mode results in waveform displays most like those obtained with non-digital oscilloscopes. Changes in the waveform are quickly seen as the newly acquired waveform data replaces earlier waveform data in the display. "Operators Familiarization" in Section 2 of this manual details the control setup required to make NORMAL mode acquisitions. Use this mode when features characteristic of the other modes are not required.

AVG (Average) Mode

AVG mode is used to eliminate or reduce random noise from the displayed signals. By selecting the weighting factor of the acquisitions to be averaged, you can change how much the signal-to-noise ratio is improved over a NORMAL signal acquisition. Table 3-2 specifies the selections available for number of acquisitions averaged (the weighting factor), as well as the Signal-to-Noise Improvement Ratio (SNIR) for each selection. The effect of the averaging weighting factor on signal noise can be seen in Table 3-2.

Table 3-2
SNIR vs Number of Acquisitions

Number of Acquisitions	SNIR	SNIR (dB)
2	1.41	3.0
4	1.98	5.9
8	2.75	8.8
16	3.84	11.7
32	5.34	14.6
64	7.51	17.5
128	10.6	20.5
256	14.9	23.4

Several factors should be considered when using AVG mode for signal averaging.

1. When certain controls or menu selections are changed, a new series of acquisitions begins for the signal averaging sequence. If the number of acquisitions you specify is not acquired before one of the listed controls is changed, the scope quits averaging that series of acquisitions and begins averaging a new sequence of acquisitions. The controls that have an effect are as follows:

a. All VERTICAL or HORIZONTAL MODE changes.

b. Changes in the VOLTS/DIV settings for either CH 1 or CH 2.

c. Any change to the CH 1 or CH 2 VERTICAL POSITION controls.

d. Changes to CH 1 or CH 2 COUPLING menus.

e. Changes in the TRIGGER MODE setting.

f. Pushing the MENU OFF/EXTENDED FUNCTIONS button.

g. Changes to the DELAY TIME or DELAY EVENTS setting.

2. Low-frequency and low-repetitive rate signals require more time to complete the acquisition cycle. When the SEC/DIV settings are slow (or a long time exists between valid triggers), a series of acquisitions can require an extended time to be averaged. As an example, if you specify 256 acquisitions at a SEC/DIV setting of 5 s/div, the total time required to complete the averaging sequence is over 7 hours. Be aware of this time factor when selecting the weighting factor for the AVG mode.

3. AVG is not allowed as an acquisition mode when the display is in ROLL mode (ROLL mode is discussed later in this subsection). If ROLL mode is initiated while the acquisition mode is AVG, the acquisition mode is automatically switched to NORMAL mode. Initiating AVG when ROLL mode is in effect turns off ROLL mode, changing the A TRIGGER MODE from ROLL to NORMAL.

4. Use of the Δ DELAY TIME feature is also not allowed when AVG is selected. Selection of AVG mode will prevent Δ Delayed B acquisitions from being displayed (unless a previously acquired REF waveform is displayed) and "NO Δ DELAY IN AVG" will be displayed with the STORAGE ACQUIRE and DELAY by TIME menus.

5. Proper display amplitude, timing, and triggering should be set up in NORMAL acquisition mode. The TRIGGER MODE menu should also be set to NORMAL for low-repetitive rate signals to assure that all averaged acquisitions are the result of the desired trigger event. Otherwise, Record Triggers could be forced (AUTO and AUTO LEVEL modes) resulting in uncorrelated acquisitions being averaged.

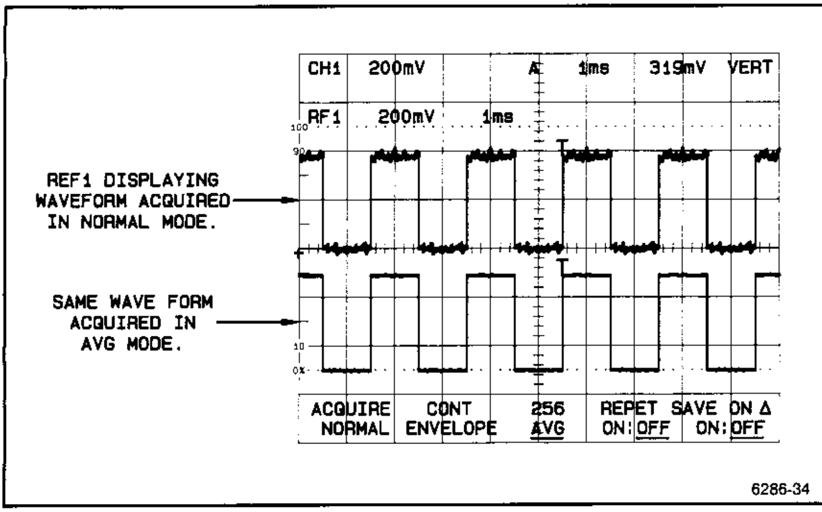


Figure 3-18. Effect of signal averaging on a noisy square wave.

ENVELOPE Mode

The ENVELOPE acquisition mode is a repetitive process. The number of acquisitions you specify is acquired and the resulting waveform envelope displayed. Each data point digitized during each successive acquisition is compared to the maximum and minimum values of the same data point stored from previous acquisitions. If the data point is greater than the previous maximum value or less than the previous minimum value, it will replace the value it exceeds. If the data point falls between the previous minimum and maximum values, it is discarded.

One typical use for the envelope mode is to monitor a signal line for some point of interest. If you are interested in, for example, a trigger-related amplitude change or switching transient, the envelope mode can be used to capture such an event. You would typically set up the trigger and other control settings to allow display of the event, and then set the number of acquisitions for the envelope sequence to CONT. Since the CONT setting results in continuous acquisitions being stored and displayed, your constant attention is not required.

Several factors should be considered when using ENVELOPE mode for signal acquisitions.

1. You can specify 1, 2, 4, 8, 16, 32, 64, 128, 256, or CONT (continuous) as the number of acquisitions required per envelope sequence.

2. Like AVG mode, changing certain controls or menu selections starts a new series of acquisitions for the envelope sequence, the differences being that ENVELOPE does not reset on Vertical POSITION changes, and CONT ENVELOPE does not reset on DELAY TIME setting changes. If the number of acquisitions you specify are not acquired before one of the affecting controls are changed, the scope quits displaying the envelope waveform it has acquired and discards the stored minimum and maximum values. It then begins a new envelope acquisition sequence.

3. When ENVELOPE mode is used with ROLL acquisition mode, the number of acquisitions specified for the envelope sequence is irrelevant. For ROLL mode, the number of acquisitions in a sequence is always one, due to the way this mode acquires and displays data (see ROLL mode later in this subsection). ENVELOPE mode is useful with ROLL mode, however, due to the faster sampling rate ENVELOPE mode provides. (The faster sampling rate allows short duration events down to 2 ns in width to be captured and displayed.)

4. REPET acquisition mode is not allowed when ENVELOPE mode is selected.

5. It is usually easier to set up the proper display amplitude, timing, and triggering in NORMAL acquisition mode, especially if you specify many acquisitions per envelope sequence. Using NORMAL, you avoid capturing the minimum and maximum data points caused by manipulation of the front-panel controls.

ROLL Mode

ROLL mode allows you to continuously view a slowly changing signal. When in ROLL mode, the scope displays newly acquired data points in a continuous stream with each newly acquired data point appearing at the right side of the graticule. As new data points are acquired, the previous data point "rolls" toward the left side of the graticule, creating a constant flow of data across the CRT screen as new data points displace the old. The effect is similar to that of a chart recorder.

You can use ROLL mode when you want to view the slowly changing signal in a continuous fashion. When ROLL mode is not used, the scope must be triggered on an appropriate event relative to the events you wish to display. At the SEC/DIV settings that slowly changing signals (with low-repetition rates) require, the time between displays of trigger acquisitions can be lengthy. In addition, you may not know the trigger parameters for the events to be viewed. Since ROLL mode is an untriggered mode, with acquisitions displayed continuously as described above, you can view, as well as save on screen or REF memories, the events of interest.

Consider the following factors when using ROLL mode:

1. To enter ROLL mode the scope must have AUTO selected for the A TRIGGER MODE. When the A SEC/DIV control is set to any acquisition rate from 100 ms to 5 s, the ROLL mode will automatically be entered and the AUTO menu label will change to ROLL.

2. ROLL mode is only available when HORIZONTAL MODE is set to A. If A INTEN or B modes are selected, the scope will switch from ROLL to AUTO mode and begin making triggered (or auto-triggered) acquisitions.

3. ROLL mode cannot be used at the same time AVG acquisition mode is selected. If AVG mode is initiated, the TRIGGER MODE will switch to NORMAL and, if the input signal meets the trigger parameters set, the scope will begin making trigger acquisitions.

4. The scope displays 10 divisions of the 20-division waveform record. All 20 divisions are displayable using the Horizontal POSITION control. It is advantageous to adjust the position control so the last 10 divisions are displayed on screen. This position allows you to see each new data point as it first enters the 20-division acquisition window. Therefore, changes in signal parameters, as well as changes in control settings affecting the display, are quickly seen. (For instance, if you change the Vertical POSITION setting, it could take up to 50 seconds for the change to appear on screen if the left-most 10 divisions of the acquisition were positioned on screen and the A SEC/DIV set to 5 s.)

REPET Mode

The REPET (repetitive) mode allows you to extend the usable vertical bandwidth for displaying high frequency waveforms. The maximum sample rate of the instrument (100 megasamples/second) limits the bandwidth to 40 MHz for waveforms acquired during a single acquisition. For acquisition rates faster than 500 ns/division, the scope must interpolate between sampling points when not in REPET mode. For periodic, repetitive waveforms, REPET mode equivalent-time samples over many acquisitions to acquire those data points which normally must be interpolated. This process of randomly sampling successive acquisitions of a waveform extends the bandwidth to 150 MHz.

REPET mode can be used with both NORMAL and AVG acquisition modes (not ENVELOPE). It can be used with all HORIZONTAL and TRIGGER MODE settings. When the STORAGE ACQUIRE menu has REPET set ON, the scope will automatically equivalent-time sample at SEC/DIV settings of 200 ns and faster.

SAVE Storage Mode

Any display acquired can be saved on screen, regardless of which of the various acquisition modes was used. When the STORAGE SAVE button is pushed, the scope ceases to make acquisitions and the waveforms displayed on screen are "frozen". This saved display can be expanded up to three VOLTS/DIV settings for a 10X vertical expansion, as well as expanded up to six SEC/DIV setting for 100X horizontal expansion. Waveforms can also be positioned vertically or horizontally as required. Use the following procedure to save waveforms on screen:

1. Display the desired waveforms in CH 1 and/or CH 2 and select the desired VERTICAL MODE(s).

2. Push the STORAGE SAVE button to save the displayed waveforms.

3. To expand a displayed saved waveform vertically, change the VOLTS/DIV control setting of the displayed channel to the next most sensitive setting.

EXAMPLE: A 0.5-V sine-wave is displayed in CH 1 with the VOLTS/DIV control set to 1 V, and the STORAGE SAVE button is pressed. Changing the CH 1 VOLTS/DIV control yields the results shown in Table 3-3.

Table 3-3
Vertical Expansion Factors

VOLTS/DIV Setting	Amplitude (Divisions)	Expansion Factor
1 V	0.5	1
500 mV	1.0	2
200 mv	2.5	5
100 mv	5.0	10

NOTE

Changing either the CH 1 or CH 2 VOLTS/DIV controls will expand a saved display of an ADD or MULT Vertical MODE waveform. The ADD Vertical MODE VOLTS/DIV setting indicated on screen will be the same as indicated for CH 1. This setting may not be correct. See the discussion under "Unwanted Signal and Noise Cancellation" in the "General Applications" portion of this section for information on interpreting the ADD Vertical MODE VOLTS/DIV setting.

4. To expand a saved waveform horizontally, change the SEC/DIV control to a faster acquisition rate setting (see NOTE below).

EXAMPLE: A 10-kHz sine wave is displayed in CH 1 with the SEC/DIV control set to 1 ms, and STORAGE SAVE is pressed. Changing the SEC/DIV control yields the results shown in Table 3-4.

Table 3-4
Horizontal Expansion Factors

SEC/DIV Setting	Cycles per Division(s)	Expansion Factor
1 ms	10 per div	1
500 μs	5 per div	2
200 μs	2 per div	5
100 μs	1 per div	10
50 μs	1 per 2 div	20
20 μs	1 per 5 div	50
10 μs	1 per 10 div	100

NOTE

When expanding waveforms horizontally, you should leave the HORIZONTAL MODE at the setting in effect at the time STORAGE SAVE button was pressed, if that setting was either A or B. However, if the HORIZONTAL MODE was A INTEN, it should be changed to the A HORIZONTAL MODE.

When STORAGE SAVE is first pressed, the waveforms are saved and the SAVEREF SOURCE menu is displayed along with a message indicating the number of acquisitions that occurred prior to saving the acquisition sequence. The number of acquisitions is important in that the saved waveform is an acquisition sequence (as for ENVELOPE or AVG acquisition modes), and the number indicates how many of the acquisitions you specified occurred before the sequence was stopped and saved. The menu is important because it lets you store away the saved waveform(s) as a reference(s).

SAVEREF SOURCE and DISPLAY REF

The SAVEREF SOURCE menu lets you select which on-screen waveform is to be stored in a SAVEREF memory location. The choices available as sources are the VERTICAL MODE settings in effect when the waveforms were saved. If CH 1, CH 2, and ADD were the modes selected prior to saving the display, those will be the sources available for storage.

Two other selections are also available as sources. These sources are REF and STACK REF. Choosing REF causes the SAVEREF SOURCE-REF submenu to be displayed, allowing the use of any of the SAVEREF memories as a source (this feature allows waveforms to be copied from one REF source to another). Pushing STACK REF as a menu selection causes the displayed waveforms to be saved in REF memory locations as indicated by Table B-13 in Appendix B of this manual. Note that the destinations of the waveforms depend on the VERTICAL MODE settings and that waveforms stored in certain REF locations are "pushed" to new REF locations.

Use the following procedure to store waveforms in and display waveforms from SAVEREF memory locations:

1. Perform Steps 1 and 2 of the "SAVE Storage Mode" procedure. Perform Steps 3 and 4 of that procedure if it is desired to store the waveform in an expanded form.

2. Push the menu button corresponding to the displayed source that is to be stored.

3. Vertically position the displayed waveforms to the desired position (waveforms will not be vertically positionable when displayed from their REF location).

4. If the STACK REF menu button was pushed for Step 2, the displayed waveform(s) are stored as indicated in Table B-13; otherwise, the SAVEREF DESTINATION menu is displayed. Push the menu button corresponding to the REF location where the source waveform is to be stored.

The displayed waveform is now stored in the SAVEREF memory specified. To display the stored waveform perform the following steps:

5. Push DISPLAY REF to display that menu.

6. Push the menu button corresponding to the SAVEREF location in which the waveform is stored (the location chosen in Step 4). The stored REF waveform is now displayed at the same vertical position as the source waveform.

NOTE

If the source waveform is still on screen, either in the "live" or SAVE mode, it will be necessary to reposition it vertically (if it has not been repositioned since it was stored) in order to see the DISPLAY REF waveform.

7. Press HORIZ POS REF. Push the menu button under the REF waveform requiring positioning.

8. Set REF POS to IND (independent) and use the HORIZONTAL POSITION control to position the REF waveform as desired.

9. Push the menu button under DISPLAY REF to return to that menu. The HORIZONTAL POSITION control now positions the "live" but not the SAVE waveform(s). Recall the HORIZ POS REF menu. Setting LOCK back on lets you position all waveforms, saved or live, in unison.

Several factors should be considered when storing and displaying SAVE waveforms with the scope.

1. As mentioned in the previous procedure, waveforms cannot be positioned vertically when displayed from REF memory locations. It is important to position them (in either the live or SAVE mode) before they are stored.

2. If phase-related waveforms are stored in REF memory locations, it is important to remember that moving one or more of the waveforms horizontally (using the HORIZ POS REF function) will remove the phase relationship. Repositioning the waveforms so that their Trigger Point Indicators ("T") are aligned will restore the phase relationship. Setting HORIZ POS REF to LOCK restores the relationship automatically.

3. SAVE Waveforms that have been expanded will be stored in the expanded form when moved to a SAVEREF memory.

SAVE ON Δ Mode.

The scope can be set to automatically enter the SAVE Mode when it acquires a waveform having amplitude values outside certain "envelope" limits. Using the ENVELOPE acquisition mode (either via the Front Panel or GPIB), you can create an envelope waveform and store it in one of the REF memory locations. If the envelope waveform is then displayed using the DISPLAY REF function, it can be used as a comparison waveform for "live" waveforms to be acquired. With the scope SAVE ON Δ feature ON, the acquired waveform will be compared against the REF waveform (when it is displayed), and the SAVE MODE entered if the acquired waveform exceeds the envelope limits of the REF waveform. (See Table B-14 in Appendix B for the designated relationships between the Vertical Modes displayed and the reference used to make the SAVE ON Δ.)

This portion of the sub-section outlines a method for using SAVE ON Δ, using the Front Panel controls to develop the envelope REF waveform. Use of the GPIB (General Purpose Interface Bus) to develop the reference depends on the particular equipment used to generate the waveform and control the GPIB interface of the scope; however, a general outline of a procedure is given in "USING THE GPIB" following "FROM THE FRONT PANEL." (See the Programmers Reference Guide for the various commands the scope uses in waveform transfer.) Using the Programmers Reference Guide, together with the Operators Manuals for the equipment used, a system programmer can develop methods for entering comparison REF waveforms via the GPIB.

FROM THE FRONT PANEL. If only a dc-error limit waveform is to be developed, a sample of the waveform is not needed. In the continuous ENVELOPE acquisition mode, use the VERTICAL POSITION control to create the comparison envelope by positioning a baseline trace to the desired positive and negative limits. For example, positioning the baseline trace two divisions above, and then 2 divisions below, graticule center creates a four-division envelope around graticule center. Once the envelope is saved and displayed, any excursions outside that envelope by the waveform being acquired will result in the scope entering the SAVE mode, and the waveform is saved on screen.

To create a horizontal window on the comparison envelope signal, the HORIZONTAL MODE is set to B, and a signal conforming to the ideal waveform is acquired. The horizontal window is obtained by varying the DELAY TIME setting slightly to position the waveform to the left and right, thereby defining the horizontal limits for the envelope. The vertical envelope limits are created as before, by positioning the waveform vertically around the signal baseline. The waveform is then saved in the correct SAVEREF memory for making the live waveform comparison, and then displayed. The scope is left in B Horizontal Mode for acquiring the live waveforms and making the SAVE ON Δ comparison (see Figure 3-19).

The following procedure creates a comparison envelope for a particular waveform (in this case a 5-V, 1-kHz square wave) so that it can be monitored for any amplitude changes greater than ± 0.5 V and phase or frequency shifts greater than 5%. You should use this procedure as a guide for developing your own envelopes for other types of waveforms.

1. Input the square wave into the desired Channel(s) and set VERTICAL MODE as desired.

2. Set the A SEC/DIV control to 1 ms and set HORIZONTAL MODE to B.

3. Set the B SEC/DIV control to 200 μs and B TRIG MODE to RUNS AFTER (Delay).

4. Position the displayed waveform at the required vertical position on screen (remember, when it is stored as a REF waveform it cannot be positioned vertically).

5. Push the DELAY by TIME button, and set Δ TIME ON:OFF to OFF.

6. Set the DELAY TIME readout to a value that allows the waveform to be positioned several horizontal divisions in both directions.

7. Push STORAGE ACQUIRE and select the ENVELOPE mode. Set the number of acquisitions to CONT.

8. Push DELAY by TIME and note the DELAY TIME readout value.

9. Rotate the Cursor/Delay control knob clockwise until the readout indicates 0.1000 ms less than the value noted in Step 8. Note that the envelope increases ½ division to the left of the waveform.

10. Vertically position the square wave up ¼ division, then down ¼ to begin creating the ±¼ (0.5 V) division vertical envelope.

11. Rotate the Cursor/Delay control knob counterclockwise until the readout indicates 0.1000 ms less than the value noted in Step 8. Note that the envelope increases ½ division to the right of the waveform.

12. Position the waveform up ½ division (it was left at the −¼ position in Step 10) to complete the envelope waveform (see Figure 3-19a).

13. Return the DELAY TIME setting to the same value as noted in Step 8.

14. Push STORAGE SAVE and save the envelope waveform in the proper REF memory location. See Table B-14 in Appendix B to determine which REF is appropriate for the VERTICAL MODE in effect.

15. Change the acquisition mode to NORMAL.

16. Push DISPLAY REF and display the REF selected in Step 14.

17. Center the waveform to be monitored within the REF envelope, using the VERTICAL and HORIZONTAL POSITION controls.

USING THE GPIB. A general outline of a method that may be used to develop an envelope waveform for comparison using the GPIB interface follows. The procedure allows the scope to do as much of the work as possible in creating the waveform.

1. Create an envelope waveform in B HORIZONTAL MODE using the Vertical POSITION controls and the CURSOR/DELAY control knob (as described in "FROM THE FRONT PANEL") to define the rough limits of the envelope to be used for comparison.

2. Use WFMpre? to get the envelope waveform preamble portion of the message, letting the scope do the work for you.

3. Acquire the envelope waveform using CURVE? to obtain the waveform data points. The programmer must have set up arrays to receive and hold the curve and preamble data.

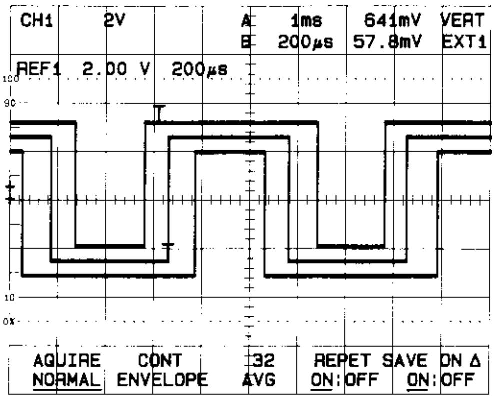
4. Adjust any of the 512 envelope data point MAX-MIN pairs stored in the waveform data array as necessary to create the comparison limits wanted. Fast rising edges need some horizontal width to widen the envelope for jitter. How this is done depends on what you want your comparison envelope to look like, and the exact manner in which it is done must be left to the programmer.

5. Set the DATa ENCdg for ASCii, RPBINary, or RIBINary as required by the type of data. Normally, the scope expects waveform data to be sent in two's complement format (RIBINary).

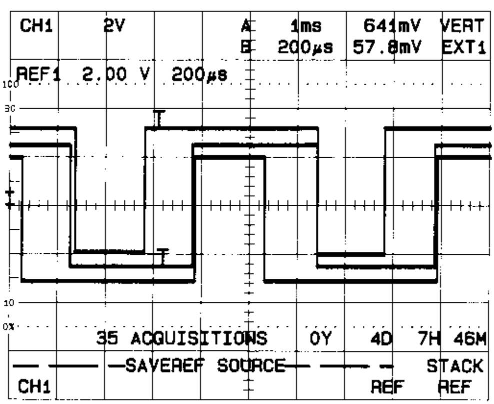
6. Set DATa TARget in which to store the reference memory. Remember that waveforms are compared against designated reference memories. See Table B-14 in Appendix B for the correct destination to make a comparison.

7. Send the waveform preamble string using WFMpre followed by the captured preamble data as the arguments.

8. Send the envelope waveform data to the scope using the CURve command followed by the waveform data.



a. Square wave centered in the REF1 envelope for monitoring.



b. Square wave captured as it moves out of the envelope on the 35 acquisition. Note the change to the SAVE menu.

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Figure 3-19 (a and b). Using the SAVEREF function with ENVELOPE mode to monitor and save a square wave.

Extended Features Applications

This instrument has three features that can be used separately or in tandem to extend its usefulness as a test and measurement tool when compared to conventional oscilloscopes. These features are AUTOsetup, MEASURE, and the AutoStep Sequencer (PRGM).

The AUTOsetup feature forces a front-panel setup that yields a triggered, viewable display based on the signals present at the CH 1 and CH 2 input connectors. Using the AUTOsetup menu, users can direct AUTOsetup to display several cycles of the signal on screen (VIEW mode), or to display either the PERIOD, PULSE, or leading or falling EDGE of the waveform. HI or LO RESolution is also menu selectable, allowing the display to be tailored for best viewing on screen (LO RES) or best measurement resolution over the 20-division horizontal and the 10.24-division vertical acquisition windows (HI RES).

MEASURE is a dual-mode, parameter-extraction feature. Executing the SNAPSHOT mode causes the scope to extract as many of the 20 available parameters as is possible (depends on the user-specified front-panel settings) for display. It is called SNAPSHOT because the scope uses only ONE waveform acquisition for its "snapshot" of the 20 parameters. Also available is the Continuous-Update MEASURE mode. Up to four parameters are selected from the 21 available (the same 20 available with SNAPSHOT, plus DELAY). With this mode, the displayed parameters are extracted from successive waveform acquisitions resulting in a constant updating of the parameter values while they are displayed. For both the SNAPSHOT and continuous-update MEASURE modes, the method (algorithm) of waveform characterization (the waveform must be characterized before the parameters can be extracted) is user-selectable. The waveform levels (proximal, distal, etc.) used to determine measurement reference points are also settable.

The AutoStep Sequencer is a feature that allows the user to store front-panel sequences for later recall. Certain actions can be associated with each front-panel stored, such as pausing at steps in the sequence for photography of the display, outputting of waveforms via the GPIB, etc. Provision is also made for looping through a set of front-panel setups. Taken together, these features allow users with repetitive measurement tasks to write their own measurement routines. Such recallable routines can greatly reduce the effort needed to repeatedly perform such measurements.

AUTOsetup

"Quick and Dirty" Display of a Signal

If you just want to quickly view a signal with minimum consideration of scope settings, do the following:

1. Input the signal to CH 1. Set VERTICAL MODE to CH 1 only and push AUTOsetup.
2. If VIEW is underlined, CH 1 should be displayed with between 3 and 5 cycles on screen. The waveform should be approximately within the center 4 divisions vertically if there is no DC offset, or within the top or bottom 4 divisions with offset.

NOTE

References to vertical sizing should be interpreted as target values when pertaining to AUTOsetup modes. For instance, in step 2 the scope attempts to target (choose) a VOLT/DIV setting that displays 4 divisions vertically on screen. The actual setting chosen may yield more or less than 4 divisions, depending on the amplitude of the signal and the available VOLTS/DIV settings. Different AUTOsetup modes use different target values, but the concept remains the same.

3. If VIEW is not underlined, set it on in the AUTOsetup menu and re-execute AUTOsetup to obtain the results described in step 2.

You should consider VIEW the mode to use for overall viewing of waveforms. VIEW uses different rules for determining the vertical scale for single and dual-channel displays than those used for the remaining parameter-oriented modes. Before looking at the dual-channel displays, the single-channel application for the remaining AUTOsetup modes is explored.

"Quick and Dirty" Displays of Parameters

Single-channel viewing of parameters is just as easy as displaying a waveform in view mode. Do the following to display the period, edge, or pulse of waveforms:

1. Input the signal to CH 1 or CH 2. Set VERTICAL MODE to the channel containing the signal (leave the alternate channel and ADD/MULT off) and push AUTOsetup.
2. If the desired parameter is not underlined in the menu, change the mode to that desired. Set RES HI¦LO to LO (LO is best for viewing waveform parameters).
3. Push AUTO to re-execute AUTOsetup using the mode and resolution specified in step 2.

The parameters will be displayed as follows:

a. PERIOD: For LO RES settings, at least one cycle is displayed on screen with the trigger position set to 132 for best assurance that the whole period is acquired. For HI RES, at least one cycle is displayed in the 20-division horizontal record with the trigger position the same as for LO RES. The waveform is sized vertically to fit within the center five (target value) vertical divisions on screen and the TRIGGER SLOPE setting is PLUS (+) for both the LO and HI RES settings (change SLOPE setting, as desired).

b. PULSE: For LO RES settings, the pulse (defined as the portion of the cycle having the narrowest pulse width for rectangular waveforms) is displayed on screen. With the TRIGGER POSITION set to 1/32 for best assurance the whole pulse width is acquired. For HI RES, at least one cycle is displayed within the 20-division horizontal record with the same TRIG POSITION as for LO RES. The waveform is scaled vertically as for PERIOD. The SLOPE will be set to display the leading edge of the selected pulse.

c. EDGE: The rising or falling edge is displayed as specified by the toggle menu selection for EDGE. For LO RES, the rise/fall time is located within the center 3 horizontal divisions of the 20-division record. For HI RES, the rise/fall time is located within the center 9 divisions. The waveform is scaled vertically as for PERIOD.

Dual-Channel AUTOsetup Displays

This procedure is for AUTOsetup on signals input to both CH 1 and CH 2.

1. Input the signal that is to trigger the acquisition (and determine the horizontal scale) into CH 1. Input the other signal into CH 2.
2. Set VERTICAL MODE to both CH 1 and CH 2.
3. Push AUTO to display the AUTOsetup menu. When AUTOsetup finishes executing, set the mode and resolution desired.
4. Push AUTO to re-execute AUTOsetup using the mode and resolution set in step 3.

The display delivered by AUTOsetup depends on the mode selected from the menu and the relation of the CH 2 signal to the CH 1 signal. The CH 1 signal is triggered on and scaled horizontally according to the criteria for the mode selected. This is as explained in the previous two applications procedures. Whether or not CH 2 is triggered depends on if it's time-related to CH 1. In all procedures so far, CH 1 PROVIDES THE TRIGGER AND THE HORIZONTAL SCALE; therefore, CH 2 must be time-related to CH 1 for a stable display. (The only way CH 2 can provide the trigger is to be the only VERTICAL mode selected for a single-channel AUTOsetup).

The vertical scale is independent for the two channels, but differs according to the AUTOsetup mode chosen. For VIEW mode, the displays (including DC offset) are scaled to fit within 2 vertical divisions. The CH 1 display is located within ± 2 divisions of the vertical graticule line that is 2 divisions above graticule center. The CH 2 display is scaled and positioned to fit within ± 2 divisions of the graticule line 2 divisions below graticule center. This scheme separates the two displays for best viewing to convey DC information. In the remaining modes, the vertical scaling depends on the RES setting. For LO RES, the ac components (see consideration 4, below) in both channels are scaled to the 3 divisions centered around graticule center; for HI RES they are scaled to fit within the 5 divisions around the graticule center. This action results in an overlapping display for comparing parameters.

Considerations for Using AUTOsetup

1. AUTOsetup cannot be used to display waveforms saved in REF memory.

2. AUTOsetup cannot be used to display parameters that are outside the range of instrument specification. For instance, a 50-volt signal cannot be vertically sized to within the center 5 vertical divisions for a VIEW AUTOsetup, since such sizing requires a greater VOLT/DIV setting than the maximum of 5 V. Likewise, there are limitations for trigger sensitivity, maximum and minimum acquisition rate, bandwidth, etc. The user must determine those limitations based on the specifications listed in Section 6.

3. AUTOsetup cannot be used to reliably display signals for which AUTOLEVEL trigger mode cannot trigger a display (signal must be ⩾5 mV and ⩾50 Hz). The instrument sizes the waveforms horizontally to be displayed as previously described according to the AUTOsetup mode selected. If this sizing results in a setting of 100 ms/DIV or slower, the waveform cannot be properly displayed.

4. AUTOsetup can be used with ADD and MULT displays. In ADD mode, the added signal is used as the trigger source and the source for horizontal scaling; in MULT mode, the CH 1 source is used. These rules remain in effect whether the CH 1 and/or CH 2 sources are displayed or not. The position of the ADD or MULT display is the algebraic sum of the position of the base level trace for CH 1 and CH 2 as determined by the AUTOsetup mode used. The vertical scale of the ADD or MULT display is determined first by the scale set by AUTOsetup for the mode chosen, then by the normal rules for ADD and MULT mode operation (see General Applications in this section for more information). Again, the CH 1 and CH 2 sources do not have to be turned on to affect the position and scale of the ADD/MULT display.

5. AUTOsetup makes certain changes to the front-panel when executing. In general, the minimum changes needed to display the signal are made.

a. The front-panel is set up for an acquisition using the A HORIZONTAL MODE and TRIGGER SYSTEM. All CURSOR and DELAY modes are turned off and NORMAL ACQUIRE acquisition mode is used.

b. If either the CH 1 or CH 2 input coupling setting is GRD (ground), AUTOsetup changes it to DC; otherwise, the coupling is left as previously set. INVERT is set to OFF for both channels.

c. TRIGGER COUPLING is set to DC and TRIGGER SOURCE is set to VERT. The actual source used for the VERT source setting depends on the VERTICAL MODE setting (see Table 5-1 in Section 5).

d. A complete list of the front-panel settings affected by execution of AUTOsetup can be found in Table 16, Appendix B.

6. The DC offset of the waveform can affect the vertical sizing of AUTOsetup waveforms. VIEW mode always scales the entire waveform, both ac component and DC offset. The previous descriptions regarding vertical sizing of waveforms for other AUTOsetup modes assumed that any DC offset in the waveforms could be handled using the ± 10 division position range for each vertical channel. In other words, the descriptions assumed that the waveforms could be sized considering only the ac component of the waveform. This is not always true; in fact, the instrument tests to see if it is true before sizing the waveform. Basically, it determines whether the VOLT/DIV setting needed to size the ac component is adequate to allow the vertical position setting to offset the DC offset. If it is, the instrument sizes the waveform as described previously. If it isn't adequate, the instrument sizes the entire display (ac plus DC offset) to fit within the allotted vertical range. The range allotted is the same as for VIEW mode, regardless of the AUTOsetup mode selected.

7. In the first procedure, the NOTE mentioned that values given for vertical sizing should be considered target values. This is true for all AUTOsetup modes for vertical and horizontal scaling as well. In general, HI RES settings limit the vertical and horizontal scales to keep the display within their respective acquisition windows (10.24 and 20 divisions, respectively) and LO RES settings limit the scales to keep the display on screen. The target values used are as previously indicated.

8. As indicated by these application procedures (and by earlier familiarization procedures in Section 1 and 2), the AUTOsetup feature is easy and convenient to use. However, since AUTOsetups on waveforms can require changes in the front-panel settings not immediately apparent (many have been considered here), it is recommended that operators become familiar with the description for AUTO found in this section for best results when using AUTOsetup. Also, AUTOsetup will be examined in conjunction with the applications for MEASURE.

MEASURE

SNAPSHOT, A Quick Measurement of Waveform Parameters

1. Input the waveform for measurement to the desired channel.

2. Obtain a triggered display of the waveform parameters to be measured.

3. Push MEASURE to display the menu.

4. Select SETUP to display the SETUP menu.

5. Select the METHOD the instrument is to use to determine the TOP and BASE of the waveform. The following settings are recommended:

   a. Use MIN/MAX when measuring sine, triangle waves, ramps, and other waveforms that show a somewhat constant rate of level change except at the positive and negative peaks.

   b. Use HIST (histogram) when measuring waveforms that make relatively rapid transitions to longer-duration levels, such as square waves, rectangle waves, and pulses.

   c. Use CURSOR only when you have considered the waveform to be measured and the parameters to be extracted and you wish to establish the TOP and BASE levels on the waveform. If that is the case, use the following procedure to set the levels:

      1. Set METHOD to CURSOR in the MEASURE SETUP menu.

      2. Push the front-panel button CURSOR FUNCTION and set VOLTS on in that menu.

      3. Push the front-panel button CURSOR UNITS and set the UNITS to VOLTS and Δ¦ABS to Δ in the displayed menu.

      4. The cursor set to the most positive level on the waveform will define the TOP. Set the active cursor to the level you want for TOP.

5. The cursor set to the most negative level on the waveform will define the BASE. Push CURSOR SELECT to enable the alternate cursor and set it to the level you want for BASE.

NOTE

If TOP and BASE levels established by the cursor settings are outside the peak-to-peak amplitude of the waveform, error messages will be returned for such measurements as rise and fall time. The error messages are in the form of written messages when the Continuous-Update method for MEASURE is used and a series of "?" marks when SNAPSHOT is used.

6. Push MEASURE to return to the main MEASURE menu and select SETUP to return to that menu.
7. Push LEVEL if the Time Reference Points, distal, proximal, and Mesial and Mesial2, are to be changed. The rules for setting the levels follow:
    a. Proximal level must be the least-positive level set on the waveform.
    b. The distal level must be the most-positive set on the waveform.
    c. The mesial levels must be more positive that the proximal level and more negative than the distal level.
    d. Levels established outside the peak-to-peak amplitude of the waveform or out of the order specified in steps a-c can result in error messages for some waveform measurements (see Appendix C).

LEVEL is like CURSOR in that you change the levels for the Time Reference Points when you have considered the waveform and the measurement to be made and determined more desirable levels than the default (10%, 90%, 50%, and 50% for PROXIAL, DISTAL, MESIAL, and MESIAL2, respectively). If that's the case, use the following procedure to change the level(s) as needed:

a. Push the menu button labeled by the level (distal, proximal, etc.) to be changed.
b. Select % or VOLTs units using the toggle-menu button labeled %¦VOLT.
c. Use the CURSOR/DELAY knob to set the value above the selected Time Reference Point to the level desired. Observe the criteria for setting the level established by criteria a-c in this step (7). Also, note that the level cannot be set outside the 0% and 100% range.

NOTE

You can set the levels outside the 0-100% levels on the waveform if you are using VOLTS as units. As previously noted, such settings can cause error messages for some measurements. It is up to the user to make sure the voltage levels set as Time Reference Points are within the peak-to-peak amplitude of the waveform being measured.

d. Repeat steps a-c until all levels you wish to set are adjusted. Push MEASURE to return to that menu.

8. Push SNAPSHOT. If more than one display source is displayed a target menu is displayed; if so, select the target (CH1, CH2, etc.) containing the waveform to be measured.

Interpreting the Display

Once SNAPSHOT is selected (and the target selected as necessary), the scope displays a list of 20 parameters on screen. (The display source and method of TOP and BASE determination are also displayed.) Associated with each parameter in the list are either measurement values resulting from the extractions that occurred during the SNAPSHOT, or strings of question marks in the place of such values. A third case, where the value is displayed but a "?" mark replaces the "=" sign, may also be present in the display.

Case 1: A parameter displayed with a question-mark string instead of a value indicates that the instrument failed to find the characteristics on the waveform needed to extract the parameter. For instance, PER (period) would display the string if the SEC/DIV setting was too fast to acquire the 3 transitions (edges) necessary to define one waveform cycle.

Case 2: A Parameter displayed with a value, but a question-mark replacing the equals sign, indicates that the instrument found the characteristics necessary to extract the parameter and obtained a value. However, it also detected something about the instrument that makes the measurement suspect. For instance, perhaps a waveform with a 100-ns rise time was SNAPSHOT at a SEC/DIV setting of 5 μs. Since there are usually 50 sample points obtained per horizontal division:

$$\frac{100\ \text{ns}}{5\ \mu\text{s}} \times 50\ \text{samples} = 1\ \text{sample point}$$

With only one sample available for the rise time duration, the rise time measurement is suspect. You should adjust the instrument to display the rise time over several horizontal divisions and re-execute SNAPSHOT if an accurate rise time measurement is needed.

Case 3: In the case where no question marks are displayed with the parameter, the value given can generally be accepted. However, you should always consider factors such as the samples obtained for the parameter when accepting the values given. For instance, in the case of the 100-ns rise time, increasing the SEC/DIV setting will, at some point, remove the question mark and yield only the value for successive "snapshots". However, increasing the SEC/DIV further will increase the accuracy of the measurement as more sample points are obtained during the rise time duration. In general, set up the instrument to display the parameters you wish "snapshot" over as much of the horizontal 20-division record and the vertical 10.24-division window as possible.

The error messages associated with case 1 and 2 for SNAPSHOT can be seen by displaying the parameter in question in the Continuous-Update mode for MEASURE (assuming the waveform is repetitive). This mode is examined later in this section. Also, Appendix C in this manual discusses the error messages, Time Reference Points, and other considerations for both MEASURE modes.

Characterization of the Leading Edge of a Pulse

Use the following procedure as a general guide to characterize a set of parameters on a waveform.

1. Make sure all of the parameters you wish to characterize can be displayed adequately using a single front-panel setup.

   The application here assumes that it is desired to measure rise time, overshoot, undershoot, and peak-to-peak amplitude of a positive-going pulse. Since undershoot occurs right before, and overshoot occurs right after the positive-going edge on the waveform, we should be able to display all three parameters with adequate resolution. Other parameters, such as fall time, might not be obtained, so they are ignored for this SNAPSHOT. Since a pulse is assumed, and steady-state values for the pulse ought to be obtained before and after the transition, peak-to-peak voltage will also be considered a valid parameter, in spite of the fact that less than one cycle of the waveform may be acquired.

2. Set up the front panel to display the characteristics with good vertical and horizontal resolution.

   Since we want to look at the front corners of our pulse, let's use the EDGE mode of AUTOsetup to display the leading edge of the waveform:

   a. Input the pulse into the desired channel and set VERTICAL MODE to the corresponding channel. Set up the input coupling as desired.

   b. Push AUTOsetup. When it finishes executing, set the mode to EDGE (_/¯) and RES to HI.

   c. Re-execute AUTOsetup.

   The display obtained should indicate to you whether the parameters are displayed adequately to yield good measurement results. As an example, Figure 3-20 shows the results from executing the previously described AUTOsetup. The rise time is displayed over most of the ten on-screen divisions and the steady-state levels can be seen by repositioning horizontally.

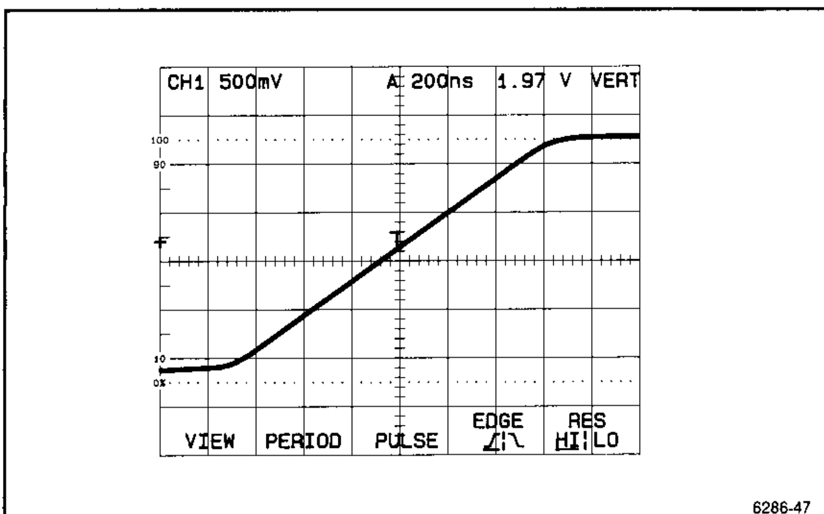


Figure 3-20. AUTOsetup for EDGE (Rising).

NOTE

AUTOsetup automatically turned REPET ON for this measurement since the acquisition rate required for displaying the rise time parameter exceeded 500 ns/DIV.

3. Push MEASURE and set up the AUTOsetup measurement as desired, using the method described for setting the TOP and BASE and the Time Reference Points if required. (If you use CURSOR METHOD, decrease the SEC/DIV setting to see more of the steady-state levels for best cursor placement. Return to the previous setting when finished.)

Since a pulse is to be measured here, normally HIST (undershoot and overshoot can't be extracted using MIN/MAX method) would be selected for METHOD, and the PROXIMAL and DISTAL Time Reference Points would be left at default levels for a measurement on the standard rise time levels (10% and 90%, respectively). The MESIAL and MESIAL2 levels are also left at default levels. They are not a consideration here since we are not interested in the SNAPSHOT values relating to TIME and/or DELAY.

4. Return to the main MEASURE menu. Push SNAPSHOT to execute.

The parameters are displayed with their values. An example of a snapshot for the waveform obtained with AUTOsetup is shown in Figure 3-21.

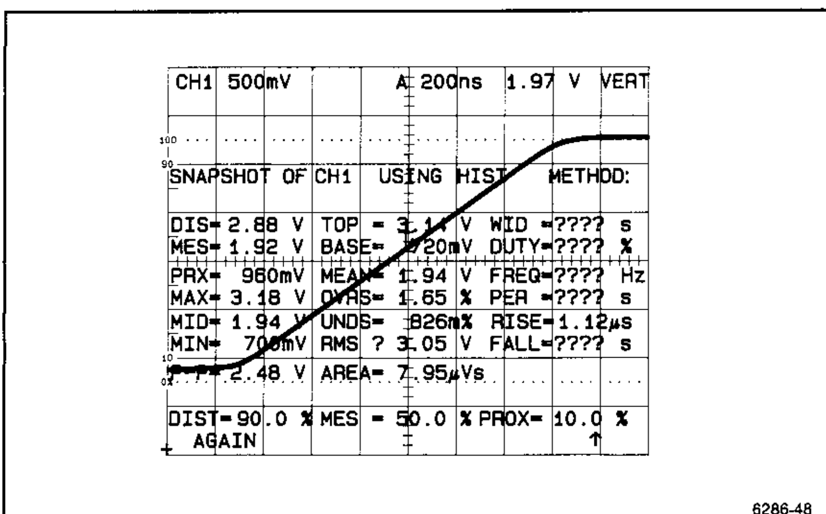


Figure 3-21. SNAPSHOT of a Pulse's Rise Time.

In the figure, those parameter values we wanted to measure are displayed and we accept the values because we set up the scope to display those parameters. Note, however, that those parameters such as DUTY, FREQ, PERiod, FALL time, etc. are displayed with the question-mark string since only one edge (the rising edge) of the waveform was acquired. Note also that the RMS value has the question mark replacing the "=". The RMS calculation is normally performed over the first valid period of the waveform that is found. Since no valid period is currently present, RMS is calculated over the full 1024-point waveform. The "?" indicates to the user that this has occurred.

The other values in the display could be accepted for the most part. The TOP and BASE levels are accepted because we selected the method to determine them. We accept the Time Reference Point levels since we accept the TOP and BASE levels. We might question MIN for the waveform because we didn't acquire the falling edge and it could have more or less aberrations than was present at the start of the rising edge. Also, MEAN (for mean average) should be considered the mean between the two levels since a whole cycle was not acquired and the duty cycle could not be taken into account when determining the mean.

Parameter Measurements Using the Continuous-Update Mode

An important point to remember about SNAPSHOT is that the parameters are extracted for one single triggered acquisition. It is necessary to press AGAIN in the SNAPSHOT menu (or re-execute from the main MEASURE menu) to update the parameter values for successive acquisitions.

With the Continuous-Update mode for MEASURE, up to four out of twenty-one parameters can be displayed at one time. Unlike SNAPSHOT, these parameters are regularly updated as successive acquisitions are triggered. Using the Continuous-Update mode is very similar to using SNAPSHOT mode, as these application procedures illustrate.

Use the following procedure to display parameters using the Continuous-Update mode for MEASURE:

1. Use steps 1-6 of the SNAPSHOT procedure, "A Quick Measurement of Waveform Parameters," with the following additions:

   a. At step 3, turn WINDOW ON or OFF as desired.

WINDOW, when on, forces the parameters to be extracted from only that area on the 20-division horizontal acquisition that is bracketed by the TIME CURSORS. WINDOW does not affect SNAPSHOT mode.

   b. After displaying the main MEASURE menu in step 4, set MARK ON or OFF as desired before proceeding to next step.

MARKs, when on, will display two "X" marks on the waveform. These marks indicate the area on the waveform from which time-related parameter values are extracted.

Remember, when setting up the front-panel for parameter extraction, setting the levels determining Time Reference Points, and setting the METHOD for TOP and BASE determination, the considerations outlined in steps 1-6 of "A Quick Measurement of Waveform Parameters" apply.

2. Push MEASURE to return to the main menu.
3. Push MEAS TYPE to display the menu that specifies the parameters to be displayed.
4. Use the three arrow-labeled buttons to select the first parameter to be displayed.

Parameters are selected by moving the underline in the matrix so that it underlines the parameter to be turned on. Use the button labeled "→" to move left-to-right and down the parameter matrix as one would read a paragraph. Use the button labeled "←" to reverse the direction. Use the button labeled ↓ to move down any individual column in the matrix.

5. Once the desired parameter is underlined, push ON in the menu to turn that parameter on. When on, the parameter will be bracketed with asterisks ("*"). See Figure 3-22. The parameters PK-PK (peak- to-peak) and PERIOD are on; RISE is selected (underlined) but presently turned off.

6. If there is more than one display source on screen, a target menu is displayed. If it is present, select the source containing the waveform from which the parameter is to be extracted.

The parameter is now displayed, with the chosen (or default, if only one source is displayed) source indicated, in the upper-left quadrant of the screen. The parameter value is regularly updated and will change if the waveform varies.

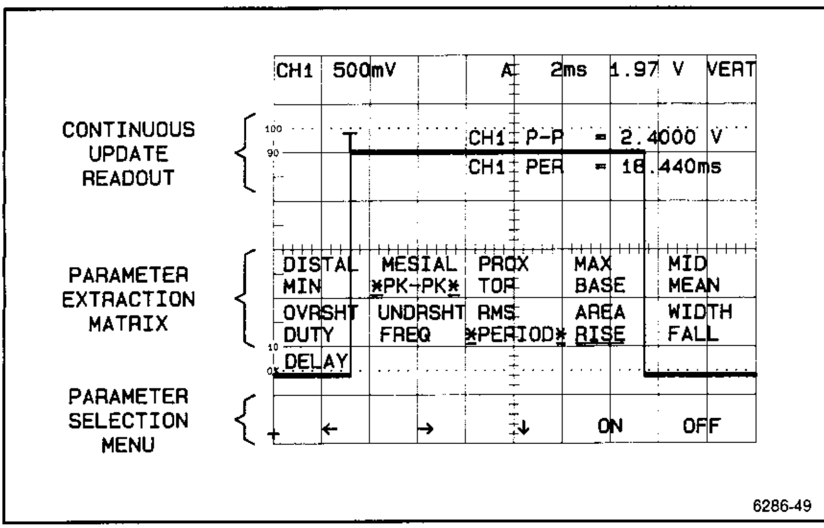


Figure 3-22. Continuous-Update Mode for MEASURE.

7. Repeat steps 4-6 of this procedure to select up to four parameters for display. To turn off parameters perform steps 4-6, pressing OFF in the menu instead of ON for step 6.

Delay Measurements Between Signals

Often a measurement of the delay between a gated signal and the gating signal is desired. The following procedure illustrates some such measurements using the DELAY parameter for the Continuous-Update mode for MEASURE. The WINDOW and MARK features for the mode are also illustrated. Use this procedure as a general indicator of the elements you should consider when using MEASURE in the Continuous-Update mode.

1. Make sure all the parameters you wish to characterize can be displayed using a single front-panel setup.

The application here assumes that it is desired to measure delay times between the positive-going edge of a gating waveform and the rising and falling edges of a relatively short-duration, positive pulse. An example of how you might determine the setup is illustrated in the next step.

2. Set up the front panel to display the characteristics with good vertical and horizontal resolution.

   Since the delay between the edges of our pulse is unknown, let's use the VIEW mode of AUTOsetup to take a look at both waveforms:

   a. Input the gating square wave into CH 1 and the resultant pulse waveform into CH 2. Set VERTICAL MODE to CH 1 and CH 2. Set up the input coupling as desired.

   b. Push AUTOsetup. When it finishes executing, and if VIEW was not the mode in which it executed, set the mode to VIEW and re-execute.

The display obtained should indicate to you how to further set up the front-panel for display of parameters to yield good measurement results. As an example, Figure 3-23 shows the results after executing the previously described AUTOsetup. Since the edges of the pulse occur so long after the rising edge of the gating pulse, the present display could be used for making the measurements. (If the edges were closer and could be displayed within the 20-division horizontal window, you might re-execute in EDGE mode.) However, since the gate is in CH 1 (and therefore determines the horizontal scale) let's re-execute AUTOsetup in the HI RES PERIOD mode to obtain increased resolution for our delay measurements. Figure 3-24 illustrates the waveforms after execution in the PERIOD mode. The vertical attenuation was decreased, acquisition rate increased, the TRIGGER SLOPE changed to "−", and the vertical position adjusted for best viewing.

NOTE

The last execution of AUTOsetup illustrates another way it can be used. You execute VIEW mode to get an overall look at the waveform and choose another AUTOsetup mode that ought to get a display close to that required for the measurement. After executing that mode, only minimum front-panel adjustment is needed to "fine-tune" the setup for your measurement. Figure 3-24 is a result of this process.

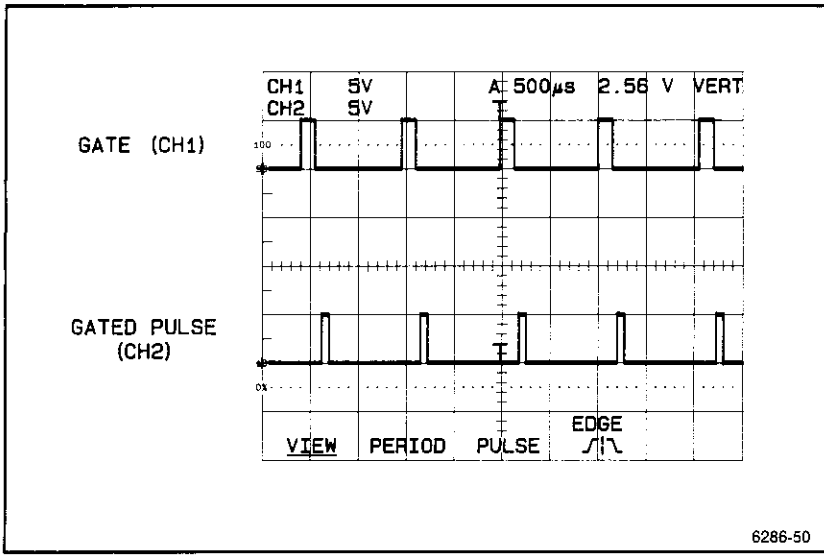


Figure 3-23. Dual-Channel AUTOsetup in VIEW mode.

3. Push MEASURE and set up the AUTOsetup measurement as desired, using the method described for setting the TOP and BASE and the Time Reference Points if required. (If you use CURSOR METHOD, decrease the SEC/DIV setting to see more of the steady-state levels for best cursor placement. Return to the previous setting when finished.)

As for the previous SNAPSHOT application, the waveforms input are rectangular and HIST (histogram) is the proper METHOD to select here. Also, since we are measuring transition times on the edges, we probably need not be concerned with the placement of the PROXIMAL and DISTAL edges; the default values are fine. The MESIAL and MESIAL2 edges are important since they are the Time Reference Points between which DELAY is measured (see Appendix C). However, since the transitions are relatively fast compared to the overall delay to be measured, the default setting of 50% is adequate. WINDOW and MARKS are turned on for this application.

NOTE

In the case of measuring short delays between edges, the MESIAL levels might be adjusted to allow for aberrations in the transitions or to pick a particular amplitude level.

4. Return to the main MEASURE menu. Push MEAS TYPE to display the parameter matrix.
5. Select DELAY and turn it ON.
6. Select CH 1 as the DELAY FROM target. The DELAY TO target menu will appear. Select CH 2.

The DELAY parameter is now displayed (see Figure 3-24). Note that the arrow in the parameter indicates the delay was measured FROM CH 1 to CH 2. Also note the MARKs that were turned on earlier in step 3. These marks indicate that the measurement is from the falling edge of the gate to the rising edge of the pulse. If the MESIAL level had been changed in step 3, the MARK would be adjusted up and down on the edge accordingly. The same is true for the MESIAL 2 level on the delayed pulse's rising edge.

LOCATING THE MEASUREMENT ON TARGET WAVEFORMS. You may wonder how the instrument decides where to put the marks, i.e., where to make the measurement in the 20-division record. Often the user determines where the measurements are made by setting up the scope so that only the characteristic corresponding to the parameters of interest is displayed. For example, the procedure used to characterize a rising edge of a pulse set up the scope so that the rise time encompassed much of the 20-division horizontal window. The only edge acquired was the leading edge, so that edge was used.

In general, if more than one area in the record can be used to extract a specified TIME-RELATED parameter, the scope uses the first area that occurs in the record for the display source targeted for measurement. Thus, if 10 cycles of a sine wave are acquired, the scope uses the first cycle to determine the PERIOD, FREQuency, DUTY cycle, etc. If the parameter extracted is AMPLITUDE RELATED, the entire 20-division waveform record is used.

NOTE

An exception for amplitude-related parameters is RMS. RMS is normally defined as being measured over a one waveform cycle. This instrument uses the first cycle found in the waveform record to calculate RMS.

MEASUREMENT LOCATION FOR DELAY. The DELAY parameter is a special case because there are always two target sources—the one the delay is FROM and the one the delay is TO. DELAY is defined as the time at the MESIAL2 crossing minus the time at the MESIAL crossing. The MESIAL crossing always occurs on the target source defined as the DELAY FROM target (CH 1, in our applications procedure), and MESIAL2 on the DELAY TO target (CH 2). The scope finds the first edge that occurs, positive or negative, on the FROM source, and locates its MESIAL crossing. Next it finds the first edge occurring on the alternate source, positive or negative, and locates the MESIAL2 crossing. The difference is computed and is positive for delays which have the MESIAL2 edge occurring after the MESIAL edge in the record, and is negative for those delays where the MESIAL2 edge is found first.

Figure 3-25 illustrates the importance of the front-panel setup in determining the edges used for DELAY measurements. The waveforms marked REF1 and REF2 are the CH 1 and CH 2 waveforms previously shown in Figure 3-24. The front-panel was readjusted for Figure 3-25 to display the CH 1 and CH 2 waveforms at a different horizontal and vertical scale and to reposition them for saving. These waveforms were then saved in REF 1 and REF 2 respectively and then displayed using the DISPLAY REF function. The waveforms referred to as CH 1 and CH 2 in the figure are live versions of the REF 1 and REF 2 waveforms with one exception—the TRIGGER POSITION has been changed from the 1/32 for the REF waveforms (established by the AUTOsetup pulse mode; not settable from the TRIGGER POSITION menu) to 1/4 position (note the difference in trigger position for the live and REF waveforms).

Examine the readout for DELAY. The MEASURE function has been used to display the DELAY from REF1 to REF2. Since REF1 and REF2 are merely saved and displayed versions of the CH 1 and CH 2 waveforms in Figure 3-24, the REF1→REF2 DELAY of Figure 3-25 agrees with that for CH1→CH2 in Figure 3-24. (Note that the MARKS indicate the measurements occur on the same edges for both figures.) Now examine the readout for CH1→CH2 and the corresponding waveforms in Figure 3-25. Note that the first edge found in the record for these two targets is the rising edge of the gated pulse (CH 2), and the second edge found is the rising edge of the gate square wave (CH 1), since these are the earliest edges acquired in their records when the TRIG POSITION is ¾. The CH1→CH2 DELAY is now measured from these two edges and is negative since the first edge found belonged to the CH 2 waveform.

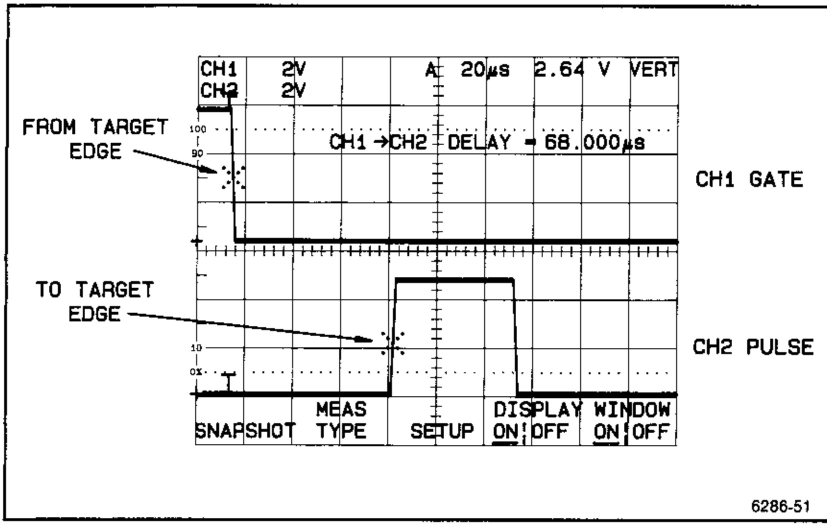


Figure 3-24. DELAY Measurement between a Pulse and Gate.

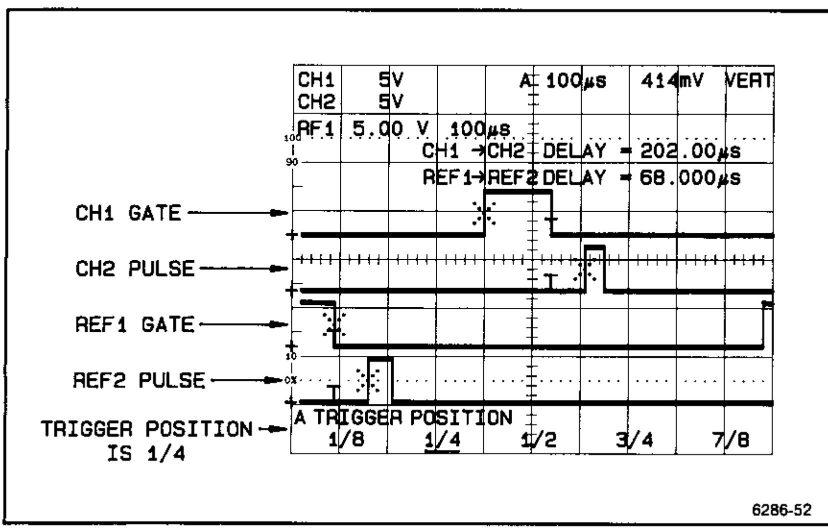


Figure 3-25. DELAY Measurement Locations on Waveforms.

CONTROLLING MEASUREMENT LOCATION. What if you need to measure DELAY (or any other of the parameters) for other areas on the waveforms? The WINDOW function, turned on in step 3 of this procedure, provides a way to control the area on the waveform used for extraction of the parameter. Let's continue our procedure:

7. Push MEASURE to display the main menu as necessary. Set WINDOW to ON.
8. Set the SEC/DIV control to display several cycles of the CH 1 gate and the CH 2 gated pulse.
9. Push CURSOR FUNCTION and turn on the TIME CURSORS. Attach the CURSORS to either channel since both are acquired at the same SEC/DIV setting.
10. Push CURSOR UNITS and set Δ¦ABS to Δ.
11. Using the CURSOR SELECT button to toggle between cursors, adjust the cursors to bracket the area on the waveform to be measured.

Figure 3-26 shows the previously acquired waveforms with the cursors defining the measurement area (REF1 and REF2 were turned off and the CH 1 and CH 2 waveforms repositioned). Examine the CH 1 and CH 2 waveforms in Figure 3-25 and compare them with Figure 3-26. Note that the marks are confined within the cursor-bracketed area in Figure 3-26. Also note that the marks are on the edges nearest the TIME cursors for alternate display sources. For DELAY, the instrument always finds the edge nearest the cursor, one for each source, with the left-most cursor finding the edge on the DELAY FROM source and the right-most cursor finding the edge on the DELAY TO source. Using the CURSORS you can measure the edges between any two edges on alternate waveform records over the entire 20-division record.

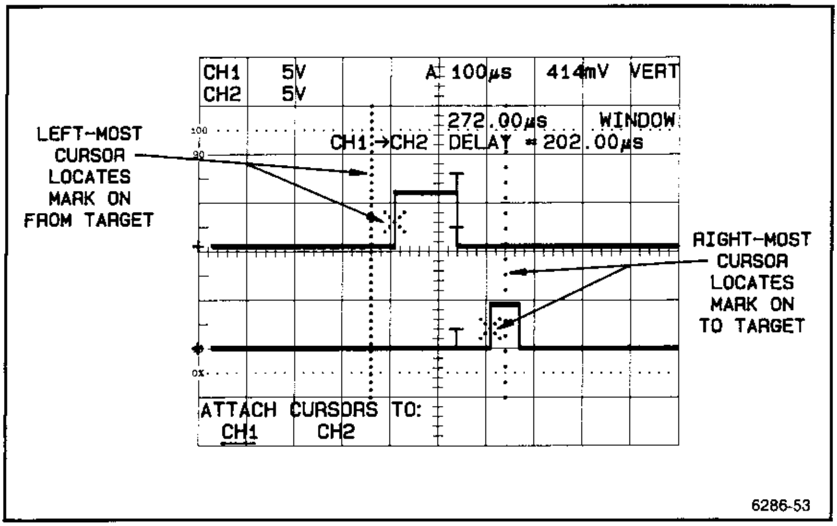


Figure 3-26. WINDOW Mode Controls Measurement Location.

For locating measurements (windowing) using the TIME CURSORS, remember the following rules:

DELAY MEASUREMENTS: To select the edge (regardless of its polarity) on the source the delay is to be measured FROM, adjust the active cursor so it's just to the left of the edge desired. Select the alternate cursor and adjust it to the edge on the source the delay is to be measured to (this cursor must be to the right of the first cursor).

TIME-RELATED MEASUREMENTS: Adjust the TIME CURSORS to bracket (window) the area on the waveform from which you wish to extract time parameters (RISE, FALL, PERIOD, FREQ). In general, the first available area which contains adequate characteristics to provide the measurement (3 edges for PERIOD, FREQ, DUTY; 1 edge for RISE and FALL) are used for the measurement. Period, Frequency, and Duty Cycle are extracted from the three edges that occur first in the record in the area bracketed by the cursors. Rise and Fall times are extracted by taking the difference between the proximal and distal points on the waveform if the cursors bracket BOTH of those levels. If the cursors do not bracket both levels, the section of the edge between the two cursors is measured.

AMPLITUDE-RELATED MEASUREMENTS: Adjust the TIME CURSORS to bracket the area on the waveform from which you wish to extract amplitude parameters (TOP, PK-PK, MESIAL, MEAN, etc.). In general, amplitude parameters are extracted over the entire area bracketed by the cursors, using the TOP, BASE, and MIN/MAX levels found within that area.

NOTE

RMS extractions use the entire bracketed area also, allowing RMS measurements of base-line noise and complex waveforms.

AUTOSTEP SEQUENCER (PRGM)

Storage of a Single Front-Panel Setup

Use this procedure to store a single front-panel setup under a label of your choice:

1. Press the PRGM front-panel button to display the main AUTOSTEP SEQUENCE menu.
2. Press the SAVE menu button. This calls up a sub-menu for labeling your front-panel setup with a 1-6 character name so it can be recalled later.
3. Use the arrows under ROLL-CHARS to create a label for the front-panel setup as outlined here in steps a-d:
   a. Select the first character for your label. Press the ↓ to step forward through the alphabet first and then through the digits 0-9. The upward arrow steps from 9-0 and from Z-A. (There is a "blank space" character between the digit 9 and letter A.)
   b. When you have displayed the letter or digit for the first character of the label, push CURSOR <> to move to the next character. Repeat step a to select the letter or digit for the next character of your label.
   c. Repeat step b to include up to 6 characters in your label. You can return to any character by continually pushing the cursor button, since it reverses direction after the first and sixth character is selected.
4. Push menu button labeled SAVE when your label is complete to assign it to the front-panel settings.

NOTE

You can create labels with as few as one character and can leave any character position (1-6) blank. Simply push SAVE when the label has the number of characters you want in the positions you want them.

5. When SAVE is pushed, the scope displays a message indicating your chosen label and telling you to set up the controls. Set up the instrument front-panel controls as desired.

   In general, all front-panel settings can be stored in a front-panel setup with the exception of those accessed via the MENU OFF/EXTENDED FUNCTIONS button. In addition, front panel controls that cause status-type menus to be displayed (SNAPSHOT, STATUS, GPIB STATUS, TRIG STATUS, and HELP) cannot be saved.

6. Push PRGM to display the ACTIONS menu. The ACTIONS menu allows you to specify different functions to be executed when the front panel is recalled.

   In general, the ACTIONS are only set ON when sequences using multiple front-panel setups are created; however, simple front-panel saves may also incorporate ACTIONS.

Creation of a Sequence

1. Create a label by doing the following:

   a. Push PRGM to display main SEQUENCE menu.

   b. Select Save from the menu.

   c. Create a 1-6 character name using arrow keys for the displayed menu, or leave the default name unchanged as desired.

   d. Push SAVE to label the sequence to be created.

2. Create a series of front-panel setups and associated ACTIONS for subsequent steps that will accomplish your test or measurement task:

   a. Set up the front-panel for your measurement task.

   b. Push PRGM and turn the actions to be associated with this task ON using the buttons labeled with the arrows and the "Y:N" labeled button. Actions are set according to the following criteria.

- Set PAUSE on if you wish the sequence to pause before proceeding to the next step (so measurements can be made, photographs taken, etc.).
- Set BELL ON if you need an audible indicator that the step has completed.
- Set AUTOsetup on if you want to use that feature to automatically set up the front-panel. The AUTOsetup occurs AFTER the front-panel is loaded and will change the setup.
- Set REPEAT if you wish to loop back to this step after performing the last step in this sequence. Only one loop is used per sequence—the one set for the latest step in the sequence.
- Set SELF-CAL and/or SELF-TEST on if you wish to perform those internal routines before loading the front-panel and making measurements. Typically these two actions are performed in an initialization step at the beginning of the sequence.
- Set PROTECT on if you wish to protect this sequence from accidental removal. This action is only effective if set in the first sequence step. See "Using PRGM" in the "Operators Familiarization" in Section 2 for information on removing protected sequences.
- Set PRINT/PLOT on to output information as defined by the DEVICES submenu (3rd LEVEL) in the OUTPUT menu. See OUTPUT in Section 5 for more information about this menu. See the Programmers Reference Guide for more information about using this instrument in a GPIB/Controller environment.
- Set SRQ on if you want to send an SRQ to the GPIB at the completion of this step. See the Programmers Reference Guide for more information on sequencer SRQ's.

c. When the ACTIONS are specified, push NEXT STEP in the menu to proceed to create the next step. Set up each successive sequence step as outlined in part a and b of this procedure step.

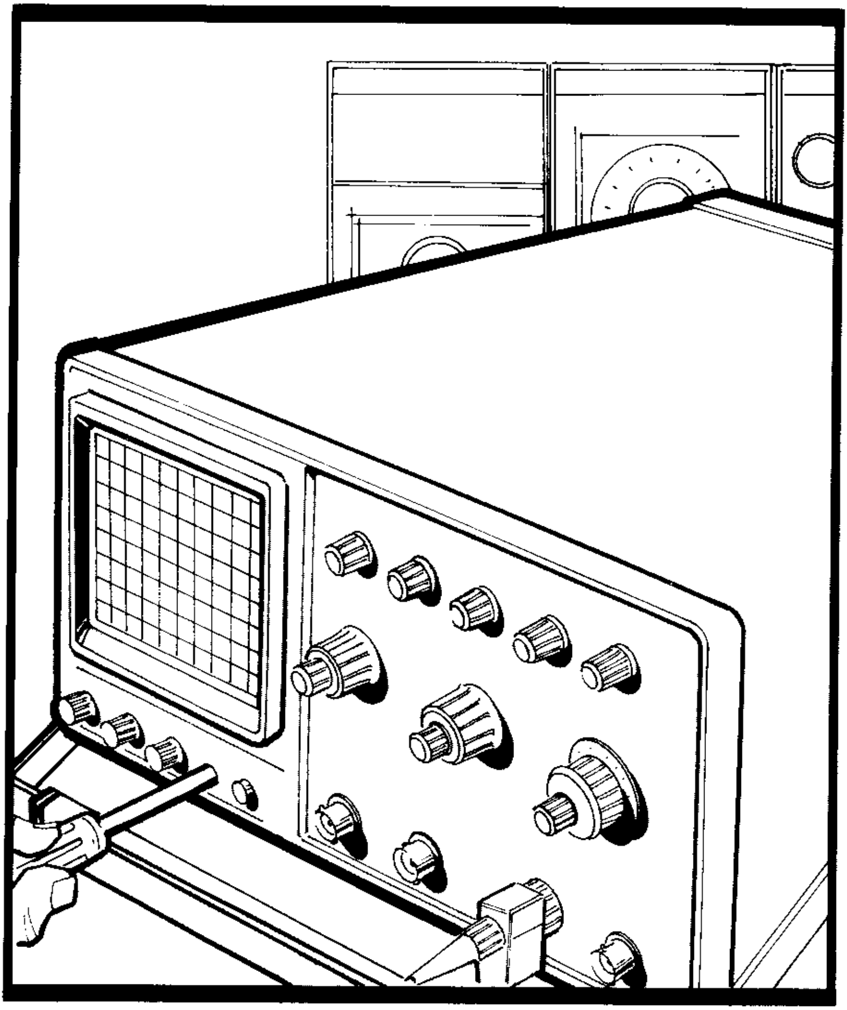
3. Save the Sequence. Push SAVE SEQ instead of NEXT STEP when you are finished creating the sequence steps. The sequence is saved under the label specified in step 3.

Using a Sequence

1. Choose the sequence for RECALL by doing the following:
   a. Push PRGM to display main SEQUENCE menu.
   b. Select RECALL from the menu.
   c. Use the arrow keys to select the desired sequence, and push RECALL in the displayed menu.
2. Steps will begin to execute. Wait for any pause in the sequence.
3. At PAUSE make measurements, photograph the display, or output waveforms as desired.
4. Continue sequence. From the front-panel, push PRGM. From the rear panel, the input BNC labeled SEQUENCE IN can step the sequence. (The BNC accepts TTL levels and steps the sequence on the falling edge of a pulse. See "SEQUENCE IN" in Section 5 for more information.)
5. Repeat steps 2-4 until all steps execute and measurements are taken.
6. After execution of last step, and if REPEAT is set as an ACTION in this sequence, change input connections as required (install new device to be tested, adjust test equipment, etc.).
7. Push PRGM to loop back to the step with REPEAT set on. Continue to perform steps 3-6 as needed. If REPEAT is not set on in the sequence, the last sequence step exits to the main SEQUENCE menu.
8. Push EXIT in the menu when it is desired to discontinue running a paused sequence. If a sequence is running continuously (PAUSE is not set for any step), it may be aborted by pushing PRGM.

SECTION 4

Checks and Adjustments



Checks and Adjustments

Introduction

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 these operator's checks and adjustments, refer the instrument to a qualified service person.

For new equipment checks, before proceeding with these instructions, refer to "Preparation for Use," Section 1 of this manual, to prepare the instrument for the initial start up before applying power.

Verify that the POWER switch is OFF (in the out position, with the green indicator switched to black), then plug the power cord into an appropriate ac-power-source outlet supplying the correct nominal voltage (CHECK the LINE VOLTAGE SELECTOR switch).

If, during the performance of these procedures, an improper indication or instrument malfunction is noted, refer the instrument to a qualified service person.

If you are not familiar with the operation of the front-panel controls, you may wish to review Section 2, "Operations," before commencing with the checks and adjustments. The following procedure is written to be followed in sequential steps and is short enough that it takes only a few minutes after the warmup period.

Starting Setup

1. Press the POWER switch button (ON with a green indicator showing in the button) and allow the instrument to warm up. (Ten minutes is required before the "NOT WARMED UP" message will be removed from the CAL/DIAGNOSTICS menu displayed under EXTENDED FUNCTIONS.)

2. Press the PRGM front-panel button when the "RUNNING SELF TEST" message is cleared from the display.

3. Press the INIT PANEL menu button. This sets the front-panel controls to predefined states. Basically, the resulting setup is a single-channel, auto-level triggered display mode, with none of the special features on. The complete INIT PANEL setup is given in Table B-16 of Appendix B for the user's reference.

4. Perform the SELF-CAL procedure. (A demonstration procedure of SELF CAL is given in "Operator's Familiarization," Section 2, and a detailed description of the built-in calibration and diagnostics is given in Appendix A of this manual.)

5. After finishing the SELF-CAL, turn off the EXTENDED FUNCTIONS menu and press the ACQUIRE Storage Mode button to obtain a baseline trace; then press the SAVE Storage Mode button.

Trace Rotation Adjustment

1. Check that the baseline trace is parallel with the horizontal graticule lines.

NOTE

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

2. If the baseline trace is not parallel to the center horizontal graticule line, use a small straight-blade screwdriver or alignment tool to adjust the TRACE ROTATION pot for proper alignment of the trace.

Focus and Astigmatism Adjustment

1. Press the STATUS button.

2. Use the INTENSITY control knob to reduce the intensity of the readout characters to a lower level.(Pressing STATUS automatically increases the READOUT intensity to 65%, as indicated in the display.)

3. Check the display for good focus over the entire graticule area.

4. If the display is not in good focus, adjust the FOCUS pot for the best focus over the entire graticule area.

NOTE

If the ASTIG adjustment is already set properly, all portions of the display will come into sharpest focus at the same adjustment position of the FOCUS pot.

5. If focusing is not uniform, alternately adjust the ASTIG and FOCUS pots (a small amount at a time) for the best-defined display over the entire graticule area.

Vertical Gain Check

1. Press the CURSOR FUNCTION button and select VOLTS cursors.

2. Align the active cursor (dashed line) with the third horizontal graticule line up from the center.

3. Press SELECT and align the other cursor (now active) with the third horizontal graticule line below center (for a six-division difference between the VOLTS cursors).

4. Check that the VOLTS readout is 600 mV ±6 mV (594 mV to 606 mV).

Horiztontal Gain Check

1. Select TIME cursors.

2. Align the active cursor (one with most dots) with the third vertical graticule line left of the center.

3. Press SELECT and align the other cursor with the third horizontal graticule line to the right of center (for a six-division difference between the TIME cursors).

4. Check that the TIME readout is 6.0000 ms ±0.06 ms (5.94 ms to 6.06 ms).

5. Turn the CURSORS off by pressing the TIME menu button.

Probe Low-Frequency Compensation

Misadjustment of probe compensation is a possible source of measurement error. The attenuator probes are equipped with compensation adjustments. To ensure the best measurement accuracy, always check probe compensation before making measurements.

1. Connect the two supplied 10X probes to the CH 1 and CH 2 BNC input connectors.

2. Connect the probe tips to the CALIBRATOR loop and connect the probe ground leads to scope ground.

3. Press PRGM and initialize the panel setup by again pressing the INIT PANEL menu button.

4. Press BANDWIDTH and set the Bandwidth Limit to 20 MHz.

5. Set the CH 1 VOLTS/DIV setting to 100 mV.

6. Press ACQUIRE and use the CH 1 Vertical POSITION control to center the four-division CALIBRATOR square wave in the graticule area.

7. Check the square-wave signal for overshoot and rolloff (see Figure 4-1). If necessary, use a small-bladed screwdriver to adjust the low-frequency compensation for a square front corner on the square wave.

8. Press the VERT MODE button and press the CH 2 menu button to turn on CH 2 in the display. Then, press the CH 1 menu button to turn off that channel.

9. Set the CH 2 VOLTS/DIV setting to 100 mV and vertically center the CALIBRATOR signal.

10. Repeat Step 7 for the second probe on the CH 2 BNC input connector.

NOTE

Refer to the instruction manual supplied with the probe for more detailed information about the probes and adjustment procedure.

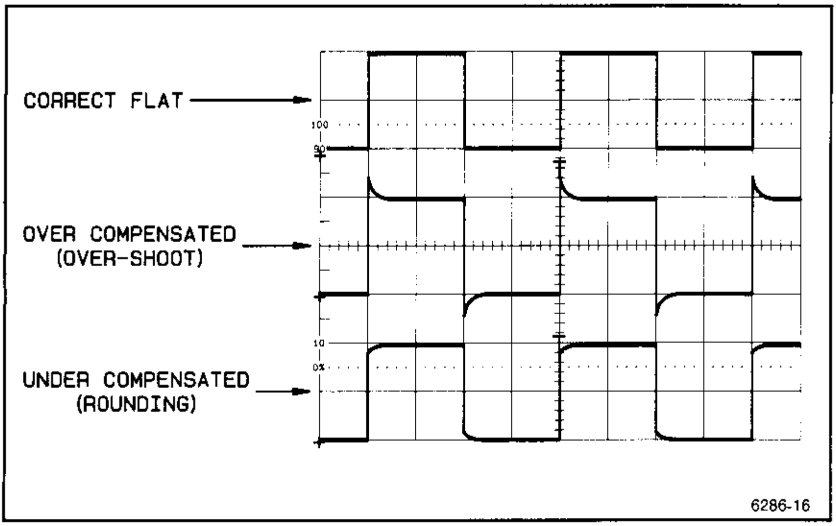
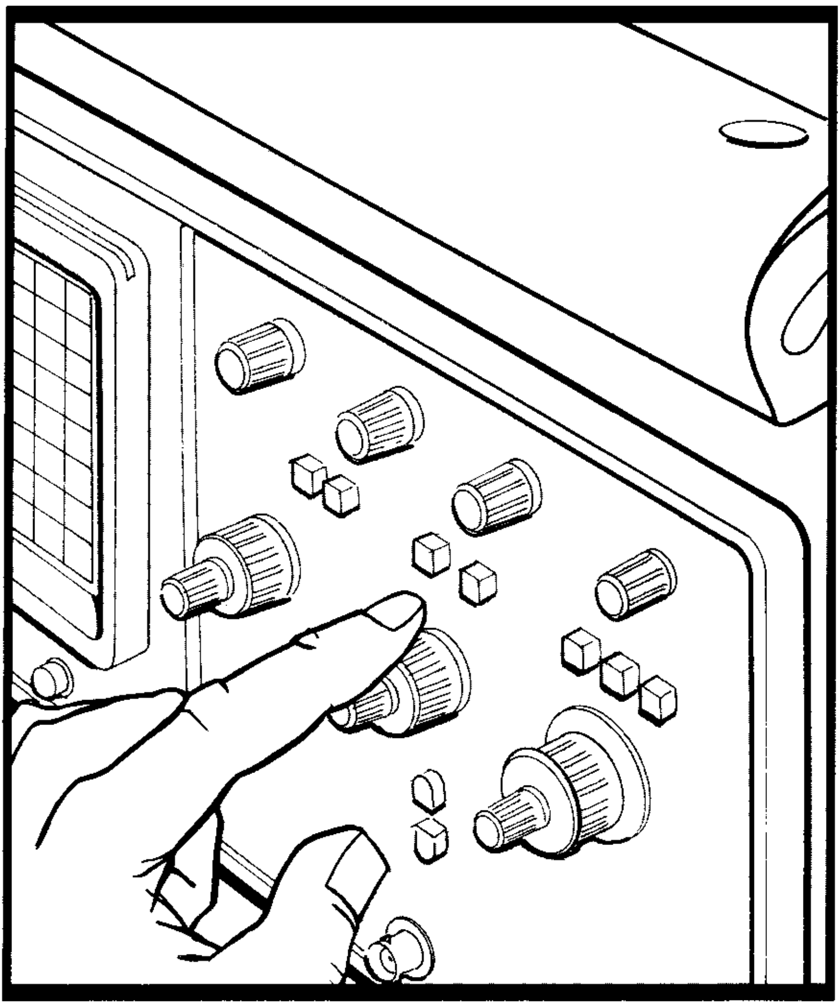


Figure 4-1. Probe low-frequency compensation.

SECTION 5

Controls, Connectors, and Indicators



Controls, Connectors and Indicators

This section is the primary reference for instrument function. It locates and describes the function of each control, connector, and indicator on the scope front and rear panels. To become familiar with scope operation, perform the familiarization procedures and read the information given in Sections 1 and 2 of this manual. Refer to this section when more detail regarding a particular control, connector, or indicator function is needed.

NOTE

The HELP feature can be used to display operating information about most scope front-panel controls. After reading the description for usage of HELP, users may wish to use the feature to read the on-screen information for each front-panel control, either before or in conjunction with, reading the descriptions in this section. HELP is described in "Extended Features" in this section.

CRT Display, Menu Buttons and Power

Refer to Figure 5-1 for location of Items 1 through 10.

(1) **Menu Buttons** These five push buttons, mounted in the bezel under the CRT, are used to make selections from the menu displayed along the bottom of the CRT. Operation of these bezel buttons is programmable by the System Microprocessor, and the way they operate depends on the specific function being controlled. Pushing the button may toggle a mode or function on and off (i.e., 50Ω ON!OFF or increment a number count (ENVELOPE 2, 4, etc.), or may turn off other functions associated with other menu buttons if they're not compatible with the one being selected (an example is ADD and MULT modes for the VERTICAL MODE menu—turning ADD on turns MULT off and vice-versa).

When only a single choice is displayed above a button, pressing that menu button either activates the function or calls up a second- (or lower-) level menu for selection of additional functions. When a function is ON, it is indicated by underscoring the menu label. A function may be turned off by pressing the same bezel button that turned it on, or it may be necessary to press another menu button (select an alternate function) to turn it off. A list of all front-panel control menus is found in Table 5-1 at the end of this section.

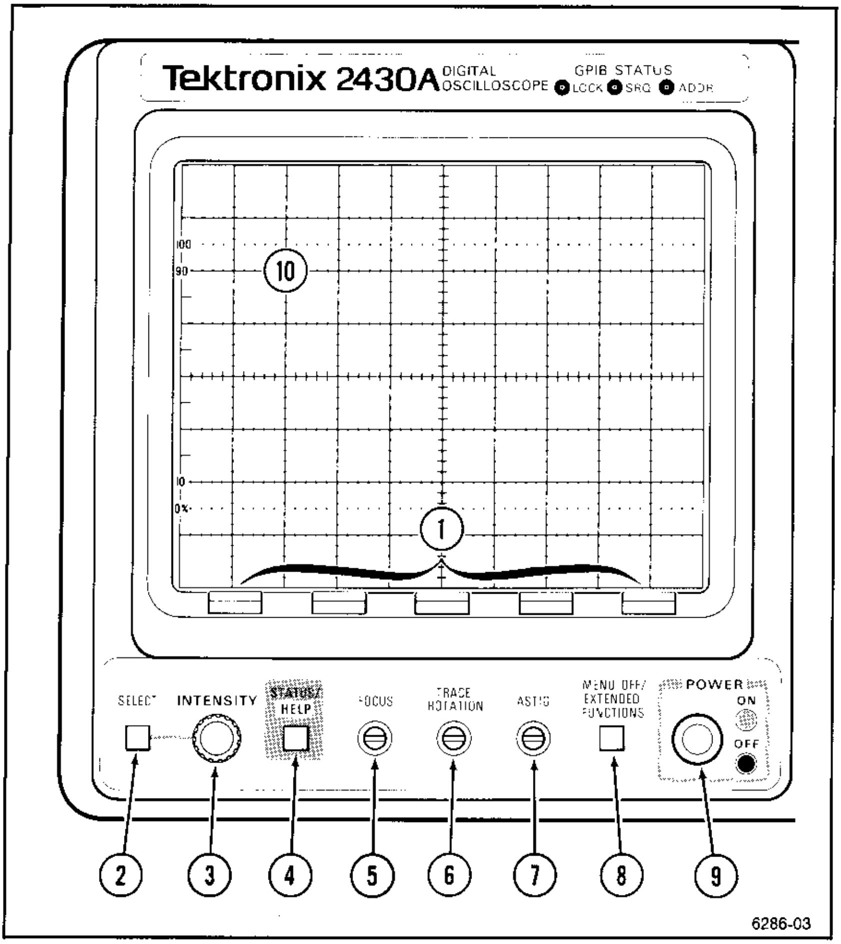


Figure 5-1. POWER, DISPLAY Controls, and MENU Buttons.

(2) **SELECT Button**

Displays the INTENSITY Menu. A single INTENSITY knob controls the four intensity adjustments (readouts, waveform, intensified zone, and graticule illumination). The function the INTENSITY knob controls (READOUT, DISP, INTENS, or GRAT) is chosen by pressing the associated menu button. The activated choice (indicated by an underline when the SELECT menu is displayed) remains controlled by the INTENSITY knob until another selection is made by the user. If the INTENSITY menu is displayed and the menu is not DISP, pressing SELECT switches the menu to DISP. Subsequent presses toggle the menu between READOUT and DISP.

Pressing the menu button under VECTORS ON¦OFF toggles between vector (line) and dot waveform displays in YT (vertical vs time) mode. XY displays are done using dots only.

(3) **INTENSITY Control Knob**

Adjusts the following: readout intensity, waveform brightness, contrast between the non-intensified and intensified areas of the A INTEN Horizontal Display Mode, or graticule illumination, as determined by the activated choice in the SELECT menu.

4 **STATUS/HELP Button**

Displays the complete operating status of the scope to help the user determine which control or function setup is preventing a display of the traces. The list includes the VOLTS/DIV for each VERTICAL MODE source, HORIZONTAL MODE, STORAGE ACQUIRE MODE, A and B TRIGGER SOURCE, A and B TRIGGER LEVEL, trigger status, the waveforms selected for display, etc. The readout intensity is boosted to 65% to ensure a visible status list, and the INTENSITY control knob is temporarily directed to control the intensity of the READOUT display.

The status list is a summary of the operating system settings with all enabled functions underlined (see Figure 5-2). The INTENSITY settings are shown as a percent of the total range so that a user can determine if the display intensity is set too low for viewing.

Pressing the front-panel MENU OFF button, or any front-panel button or control that calls up a menu, removes the status display from the screen and returns the instrument to the normal waveform display. Also, pressing STATUS/HELP a second time returns the instrument to the menu it was previously displaying.

NOTE

The HELP feature is also selectable from the menu displayed when the STATUS/HELP front-panel button is pushed. The HELP feature is covered in "Extended Features" in this section.

5 **FOCUS Adjustment**

Used to optimize the focus of the display. This is a screwdriver adjustment that requires little attention after the initial setting. An auto-focusing circuit tracks any intensity changes during normal operation of the instrument and keeps the display focused.

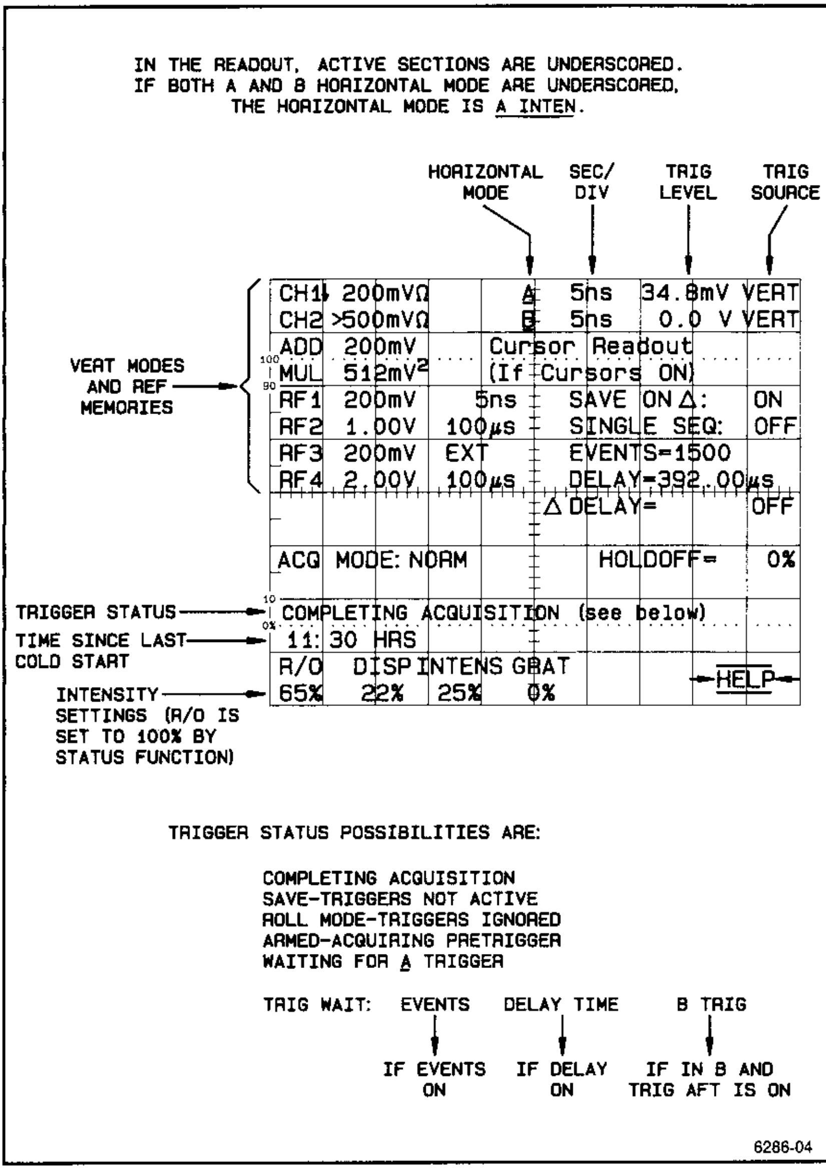


Figure 5-2. STATUS readout display.

6	**TRACE ROTATION Adjustment**	Aligns the CRT trace with the horizontal graticule lines. Once this screwdriver adjustment is set, it requires only occasional readjustment during normal operation of the instrument.
7	**ASTIG Adjustment**	Used in conjunction with the FOCUS adjustment to obtain optimum focusing over the entire CRT display. Once set, this screwdriver adjustment requires little attention during normal operation of the instrument.
8	**MENU OFF/EXTENDED FUNCTIONS Button**	Turns off any displayed menu or turns on the EXTENDED FUNCTIONS menu if a menu is not being displayed. The EXTENDED FUNCTIONS menu provides access to special features not implemented in other control menus. See Appendix A for operation of the EXTENDED FUNCTIONS.

NOTE

Pressing MENU OFF performs more than merely turning off displayed menus. When pressed to remove a menu display, all the scope hardware is reset to match the soft front-panel settings, the CRT display is completely erased and rewritten (any messages written via the GPIB interface will be eliminated), and any acquisitions in process are restarted.

9	**POWER ON/OFF Switch**	Turns instrument power on and off. Press in for ON; press again for OFF. An internal indicator in the switch shows green when the switch is on and black when it is off. Front-panel settings that remained unchanged for at least 1 second prior to turning off the scope can be restored when the scope is turned on again. The scope must be set to PWR ON LAST in the EXTENDED FUNCTIONS menu to return the settings. If set to PWR ON INIT, the scope front panel is initialized to a predetermined setup (see Table B-15 in Appendix B for those INIT settings).
10	**CRT**	Produces the visible waveform and readout displays. The CRT display area is 80 mm vertically by 100 mm horizontally. Internally-etched graticule lines eliminate parallax-viewing error between the trace and the graticule lines. Rise time percentage measurement points are at the left edge of the graticule.

Vertical Controls

Refer to Figure 5-3 for locations of Items 11 through 20.

(11) **CH 1 OR X and CH 2**

Provides for application of external signals to the inputs of Channel 1 and Channel 2 vertical attenuators. A signal applied to the CH 1 OR X connector provides the horizontal deflection for XY displays. A probe-coding contact ring on the CH 1 and CH 2 BNC connectors enables attenuation-coded probes to be recognized by the scale-factor-switching circuit. The Channel VOLTS/DIV readouts are automatically changed to reflect the attenuation factors of coded probes recognized by the scope.

(12) **VERTICAL MODE Button**

Calls up the menu used to select the vertical mode of operation. All the menu buttons for this menu, except the one labeled "YT¦XY", operate in a push-on/push-off mode; pressing the button toggles the function associated with that button on and off). Pressing the YT¦XY menu button toggles between YT (Y-axis vs time) and XY (X-axis vs Y-axis) display modes.

ADD and MULT are mutually exclusive functions and can not be on simultaneously. Toggling one on toggles the other off. Also, ADD and MULT cannot be turned on when ENVELOPE ACQUIRE mode is selected or when XY VERTICAL MODE is selected. Turning on either ENVELOPE or XY modes turns off ADD or MULT and removes those choices from the VERTICAL MODE menu.

CH 1 Selects the signal applied to the Channel 1 input for display. A second press of the CH 1 button removes the Channel 1 signal from the CRT display.

CH 2 Selects the signal applied to the Channel 2 input for display. A second press of the CH 2 button removes the Channel 2 signal from the CRT display.

ADD

Performs a digital add of the Channel 1 and Channel 2 waveform data. Neither CH 1 nor CH 2 needs to be displayed to obtain the ADD waveform, as both Channel input signals are digitized whether displayed or not.

The VOLTS/DIV setting at which the Channel 1 and Channel 2 waveform data points were acquired is not considered when the two waveforms are added; only divisions of signal amplitude are added to produce the ADD display. Therefore, a one-division Channel 1 signal, when added with a one-division in-phase Channel 2 signal, results in a two-division ADD display.

The ADD waveform vertical scale factor is always the same as that at which the CH 1 signal is being acquired (or was acquired if in SAVE). This allows the CH 2 VARIABLE control to be used for nulling out interfering signals from the ADD waveform while still being able to use the CH 1 VOLTS/DIV setting to make calibrated VOLTS cursor measurements. However, if CH 1 is uncalibrated, both the ADD VOLTS/DIV readout and the CH 1 VOLTS/DIV readout will display the uncal symbol (>), and any VOLTS measurements on the ADD waveform made using cursors will be in divisions.

MULT

Does a digital multiplication of Channel 1 and Channel 2 waveforms. The MULT function provides a means of displaying a power waveform and making instantaneous power measurements. Since the scale factor of a current probe (or the resistance value of the test setup) used to obtain the current waveform is not known to the scope, the scale factor of the resulting multiplication is in units of volts squared.

After the multiplication is completed, the total dynamic range of the resultant signal is 256 times larger than either multiplicand. Consequently, to produce a dynamic signal range that is displayable within the available dynamic range of ten divisions, the multiplication resultant is scaled down by a factor of 5.12. With scaling, two, 5-division bipolar (equal positive and negative waveform excursions around zero) signals multiplied together will result in a display that is 4.88 divisions in amplitude (plus 2.44 and minus 2.44 divisions). Without scaling, the resultant waveform would be 25 divisions peak-to-peak, well out of the display capabilities of the CRT.

The zero value for either waveform multiplied is the ground reference of the acquiring channel. Consequently, any signal level that goes below the ground reference (also, below the average DC value in AC coupling) is treated as a negative value. The zero value for the resultant MULT waveform is the sum of Channel 1 and Channel 2 Vertical POSITION controls, where positions above center screen are positive and those below center screen are negative.

YT:XY

Switches between a Y-axis versus time (YT mode) or an X-axis versus Y-axis (XY mode) representation of the displayed signal. In XY mode, the signal applied to the CH 1 input supplies the horizontal deflection and the CH 2 signal supplies the vertical deflection.

Channel 1 vs Channel 2 and REF1 vs REF2 can be simultaneously selected to present an XY display of both for comparison.

(13) **CH 1 and CH 2 VOLTS/DIV Switches**

Select the calibrated vertical deflection settings from 2 mV per division to 5 V per division in a 1-2-5 sequence of 11 steps. The controls are continuous rotation detent switches with no end stops. The VOLTS/DIV switch setting is displayed in the CRT readout. That readout also changes automatically to reflect the attenuation factor of coded probes that are connected to the vertical inputs.

A saved waveform can be expanded vertically up to 10X by turning the VOLTS/DIV knob to a more sensitive setting after entering SAVE Storage Mode. Expansion adds three additional VOLTS/DIV settings: 1 mV, 500 μV, and 200 μV per division. The waveform is returned to its original VOLTS/DIV setting when the VOLTS/DIV setting is switched back to the position at which it was acquired. Waveforms are not allowed to be vertically scaled to a VOLTS/DIV setting greater than that at which they were acquired. However, the VOLTS/DIV readout will continue to change with each new switch setting to reflect the VOLTS/DIV setting at which the next acquisition will be made when the ACQUIRE button is pressed.

In AVG mode, extra resolution of the acquired waveform permits live expansion to the three added VOLTS/DIV settings. A signal being acquired in AVERAGE mode at one of the three added VOLTS/DIV positions reverts to 2 mV per division when AVERAGE mode is turned off.

NOTE

When averaging with a weighting factor of 32 or greater, the finite-precision-fixed-point arithmetic used to compute the weighted difference between sampled data points will truncate the answer. The loss of decimal places in the result biases it toward discrete digitizing levels. This phenomena may be seen in the averaged display under low-noise situations when vertically expanding small-amplitude waveforms (either "live" or in SAVE mode), especially with continual averaging using a weighting factor of 256.

(14) **CH 1 and CH 2 COUPLING/ INVERT Buttons**

Call up a coupling menu used to select the method of coupling the CH 1 and CH 2 input signals to the vertical attenuators. If AC input coupling is in effect and the 50 Ω input termination is then selected, the input coupling will automatically switch to DC. Conversely, if the 50 Ω termination is ON and AC COUPLING is selected, 50 Ω input termination will be canceled.

While a COUPLING menu is being displayed, pressing the associated front-panel COUPLING/INVERT button rotates through the three input coupling choices (AC, DC, and GND). However, AC is not selectable using the COUPLING/INVERT button if 50 Ω termination is ON.

AC Input signal is capacitively coupled to the vertical attenuator. The dc component of the input signal is blocked. The lower −3 dB frequency limit is 10 Hz or less when using either a 1X probe or a properly terminated coaxial cable; it is 1 Hz or less using a compensated 10X probe. With AC Coupling selected, the trigger level readout will be followed by a question mark to indicate that the DC level of the applied trigger signal is unknown.

DC All frequency components of the input signal are coupled to the vertical attenuator. Input resistance is 1 MΩ to ground.

GND Grounds the input of the associated vertical amplifier to provide a zero (ground) reference voltage display. Input resistance is 1 MΩ to ground. In the GND position, the digitized vertical value of the grounded trace is saved in memory as a reference level. Selecting GND COUPLING automatically disconnects 50 Ω termination.

50 Ω DC All frequency components of the input signal are coupled to the vertical attenuator, with the input terminated by 50 Ω to ground. If excessive signal power is applied to a vertical input connector with the 50 Ω DC input termination ON, the input coupling on the overloaded channel will automatically revert to 1 MΩ GND and the COUPLING menu will be recalled along with the 50 Ω OVERLOAD message. Accordingly, the user should not use 50 Ω input setting if the circuit under test might be damaged by the loss of termination. The overload message will remain displayed with the COUPLING menu until either a new coupling choice is successfully made or the menu is turned off.

When instrument power is turned OFF, 50 Ω input termination is automatically switched out to prevent possible unmonitored overloading of the termination resistor.

INVERT Inverts the polarity of the signal being acquired by the associated channel. Both Channel 1 and Channel 2 may be inverted. The INVERT function does not invert a signal after going to SAVE Mode.

(15) **CH 1 and CH 2 VARIABLE Buttons** Call up the VARIABLE VOLTS/DIV function menu for the associated channel. The menu provides controls for continuously variable uncalibrated vertical deflection factors between the calibrated settings of the VOLTS/DIV switches.

↑/↓ **Buttons** Control the variable attenuation factor. The ↓ selection displayed with the VARIABLE menu adjusts the maximum deflection factor of the associated channel to at least 2.5 times the calibrated deflection factor.

Pressing the ↓ menu button increases the attenuation factor (display amplitude decreases), and pressing the ↑ menu button decreases the attenuation factor (down to the CAL limit only). Holding either button down causes the attenuation to change continuously until either the maximum or minimum variable attenuation limit is reached depending on the arrow direction of the button pressed.

CAL Removes all variable attenuation in effect when pressed and returns to the calibrated deflection factor set by the VOLTS/DIV switch setting.

Changing the variable gain has no effect on a SAVE waveform. However, the new variable-gain setting will be reflected in the next waveform that is obtained from the affected channel upon returning to the ACQUIRE mode.

16 **BANDWIDTH Button** Calls up a menu that allows the user a choice of three acquisition system bandwidths: 20 MHz, 50 MHz, and Full. Each press of the BANDWIDTH button with the menu displayed rotates through the bandwidth selections in the following manner:

20 MHz → 50 MHz → FULL → 20 MHz.

FULL BANDWIDTH represents an analog bandwidth ⩾150 MHz.

The USB (Useful Storage Bandwidth) and USR (Useful Storage Rise Time) information displayed represents the upper limits of the frequency components and the fastest rise time of a signal that can be acquired with good results considering the BANDWIDTH, SEC/DIV setting, and acquisition mode currently in effect. USB is the lower of either the selected bandwidth limit or the sample frequency divided by 2.5. USR is defined as the greater of either 0.35 divided by the selected bandwidth limit or 1.6 times the sample interval. USB and USR numbers are not displayed for ENVELOPE Acquisition Mode.

NOTE

This bandwidth menu is also used to turn the SMOOTH function on or off for normal and average mode acquisitions. See the description for "SMOOTH ON/OFF" under "Storage System ACQUIRE" in this section.

(17) **CH 1 and CH 2 VERTICAL POSITION Control**

Change the vertical position of the associated channel signal display. Rotation of the control clockwise moves the associated trace up; counterclockwise rotation moves the trace down. Waveforms that are vertically positioned out of the graticule viewing area may be located by the presence of the trigger-point (T) and ground-level (+) indicators at the top or bottom edges of the graticule area. These indicators remain attached to the on-screen waveforms, but they cannot be positioned beyond the on-screen limits.

When XY display mode is in effect, the CH 1 POSITION control horizontally positions the display, with clockwise rotation moving it to the right. CH 2 POSITION control does the vertical positioning of the XY display. XY displays may be horizontally positioned to the extreme left or right edge of the graticule but will remain visible there.

The CH 1 and CH 2 VERTICAL POSITION pots are position-rate controls. The center position area of the controls produce linear positioning. Rotating a control into the spring-loaded region produces rate positioning of the display. The farther a knob is rotated toward the end-stop position, the faster the positioning rate is. Releasing the knob returns it back to the linear-positioning region of the pot.

Cursors

The scope provides cursors for performing parametric waveform measurements. Voltage, time, frequency, slope, decibels, degrees, and percent units give the cursors a wide variety of applications. A numeric readout on the CRT reflects either the difference between the position of two cursors (delta measurement mode) or the difference between a single cursor and a fixed reference (absolute measurement mode).

The CURSOR/DELAY position knob is shared with the DELAY by TIME, the DELAY by EVENTS, and the MEASUREMENT LEVEL functions (Refer to CURSOR/DELAY knob, Item 30). When one of the CURSOR buttons is pressed (FUNCTION, UNITS, or SELECT), the knob is directed to position the cursors.

In a YT mode display using Δ (delta) cursors, the CURSOR SELECT button toggles the states of both cursors between active and fixed. In ABS (absolute) cursor mode, the SELECT button has no cursor selection effect as only one cursor is displayed—that one being the last active cursor selected in delta cursor mode.

When VOLTS, V@T, or SLOPE delta cursors are being used in XY display mode, pressing CURSOR SELECT will sequentially activate all four displayed cursors, one at a time. In absolute cursor mode, the SELECT button switches between the two displayed cursors (one vertical and one horizontal) when VOLTS and V@T cursors are displayed. There is no absolute mode with SLOPE cursors, and the UNITS menu omits the choice.

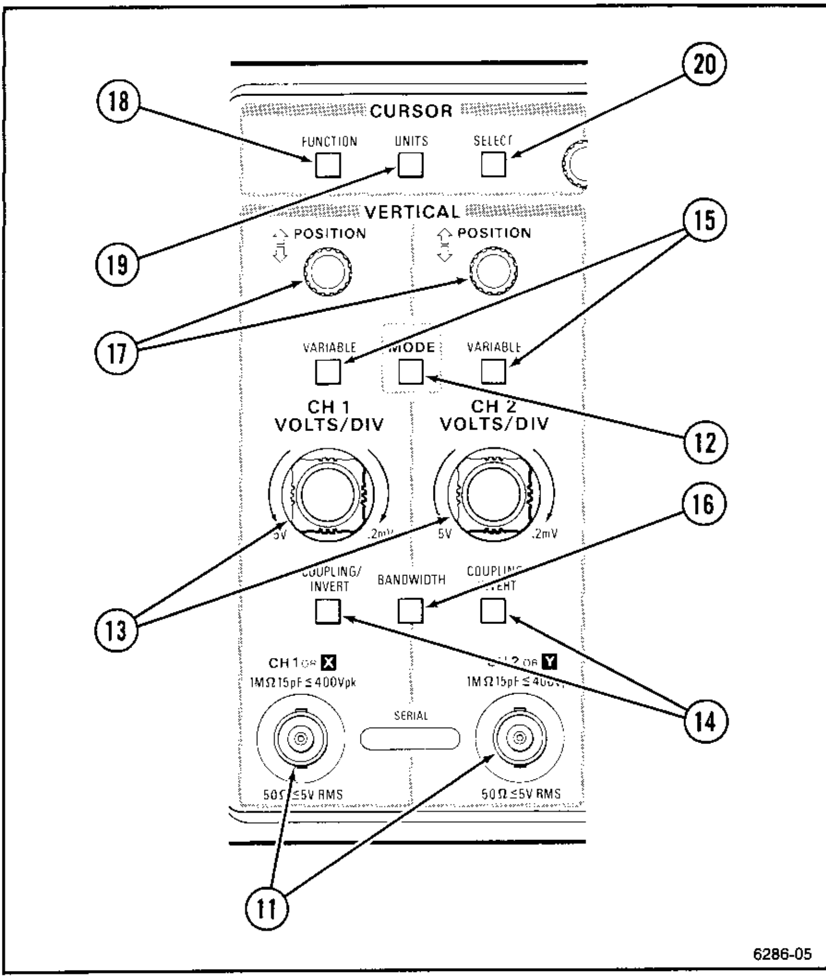


Figure 5-3. Vertical Controls and Connectors.

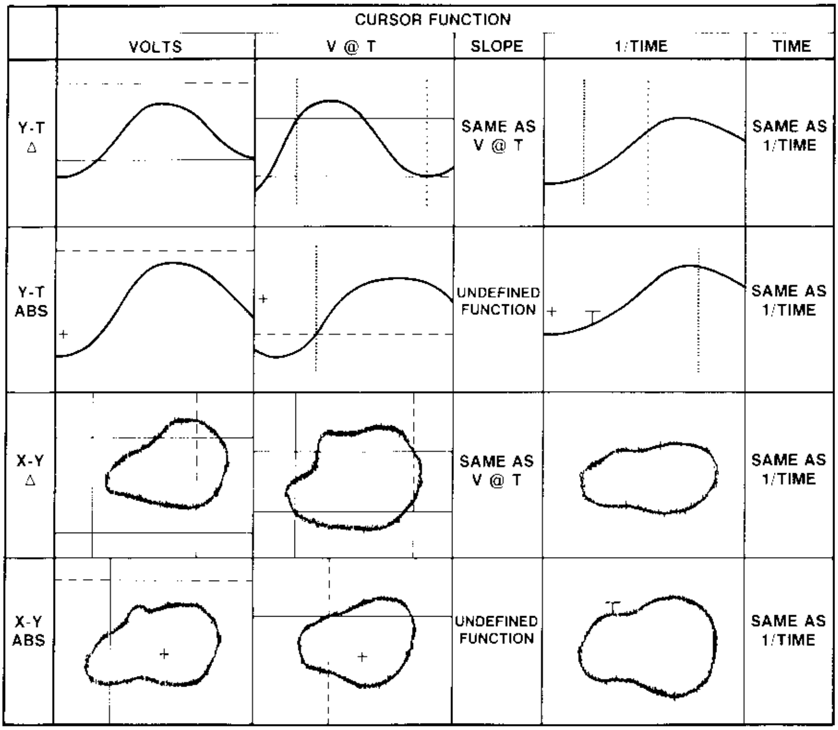


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Figure 5-4. Typical cursor displays.

(18) **FUNCTION Button** — Calls up the CURSOR FUNCTION menu used to select the type of cursors displayed (VOLTS, TIME, V@T, SLOPE or 1/TIME). The selected cursor FUNCTION is indicated by an underlined menu choice. Only one cursor FUNCTION may be selected at a time, and all cursors are off when none of the choices are underlined in the menu. The units of the readout for the measurement being made are selected using the UNITS menu (see Item 19).

VOLTS Displays two horizontal lines extending the full width of the graticule area YT display mode. The active cursor is a dashed line; a solid line represents the fixed cursor in Δ (delta) cursor mode. In ABS (absolute) cursor mode, only one VOLTS cursor is displayed, and it is the dashed active cursor. In the case of absolute cursor mode, the voltage measurement is between the cursor vertical position and the ground reference point. Above the ground reference point, readout is positive; below, it is negative.

TIME Displays two dotted vertical lines extending across the center six divisions of the graticule area. The active cursor exhibits twice as many dots as the fixed cursor in delta cursor mode. In ABSOLUTE cursor mode, only the active cursor is displayed, with the time measurement being made between the cursor position and the record trigger point (marked by a small T on the waveform). An absolute TIME cursor position to the left of the trigger point is negative time; to the right is positive time. In XY display mode, the TIME cursors are small vertical lines attached to the XY waveform.

V@T Displays VOLTS cursors that are coupled to the TIME cursors, the result being that the VOLTS cursors cannot be positioned off the waveform to which they are attached. The basic UNITS of measurement for V@T cursors is volts, and the difference between the VOLTS cursor positions is the displayed readout. V@T cursors are convenient for locating the TIME cursor to precise vertical positions on different waveforms or edges, then switching FUNCTION to either TIME to determine period or 1/TIME to determine frequency. If either of the TIME cursors are positioned to the edge of the display, an "EDGE?" warning message is displayed to let the user know that the displayed time cursor positions may not reflect their actual time position setting.

SLOPE

Displays coupled cursors with a readout that is derived from the VOLTS cursor difference divided by the TIME cursor difference (ΔV ÷ ΔT—V/sec) in YT mode. In XY mode, the readout is derived from the Channel 2 VOLTS cursor difference ÷ the Channel 1 VOLTS cursor difference (ΔY ÷ ΔX—V/V). If either of the TIME cursors are positioned to the edge of the display, an "EDGE?" warning message is displayed to let the user know that the displayed time cursor positions may not reflect their actual time position setting. SLOPE measurements require that two cursor pairs be present at all times; therefore, the choice of Δ¦ABS cursor mode is not presented in the SLOPE UNITS menu.

1/TIME

Displays TIME cursors with the basic UNITS of measurement in hertz. Adjusting the cursor positions to the exact beginning and ending points of a cycle in a periodic signal produces an accurate readout of the signal frequency.

Second-level ATTACH CURSORS Menu

For correct scaling of cursor readouts when more than one waveform is displayed, it is necessary to specify to which waveform the cursors are attached. In those situations, the 2nd-Level ATTACH CURSORS TO: menu will appear each time a cursor type is selected from the CURSOR FUNCTION menu. To redesignate a cursor attachment after the ATTACH menu has been replaced by some other control menu, press the CURSOR FUNCTION button twice to redisplay the ATTACH menu. If the CURSOR FUNCTION menu is displayed, pressing the FUNCTION button once returns the ATTACH menu to the display. Only displayed waveforms will be shown as a menu choice.

(19) **UNITS Button**

Calls up the CURSOR UNITS menu for specifying cursor readout measurement units. Each FUNCTION choice has two types of units; absolute (VOLTS, SLOPE, HZ, SEC) and ratiometric (%, dB, DEGREES). For ratiometric (ratio between two quantities) measurements, the reference value to compare against is set by positioning the cursors to the desired reference settings and then pressing the NEW REF button. The value set as a reference can be either independently established by adjusting the cursors to a given position difference, or it may set to a particular reference waveform parameter such as peak-to-peak voltage or waveform period. The set references are 0 for dB (decibels), 360° for DEGREES, and 0 and 100% for %. If an acquired voltage reference becomes invalid because of switching between variable and calibrated VOLTS/DIV conditions, a "UNITS?" warning message is displayed.

Δ¦**ABS**

Switches between delta and absolute cursor modes. Each press of the menu button toggles the cursor mode. Not displayed in the SLOPE UNITS menu.

In Δ (delta) cursor mode, the measurements made are the difference between the two displayed cursor positions. In absolute (ABS) cursor mode, the measurements are made between the single displayed cursor and the ground reference for VOLTS and V@T cursors and between the cursor and the record trigger point for TIME and 1/TIME cursors. The last selected cursor in delta cursor mode remains as the active cursor in absolute mode.

(20) **SELECT Button**

Switches the cursor states between active and fixed in delta cursor mode. In YT display mode, the SELECT button toggles the active state between the two displayed cursors. In XY display mode, the SELECT button sequentially activates each of the displayed cursors. Positioning of the active cursor is controlled by the CURSOR/DELAY knob. If either DELAY by TIME, DELAY by EVENTS or MEASUREMENT LEVEL menus are displayed, choose other menus or push MENU OFF to return cursor positioning back to the CURSOR/DELAY knob.

External Interface

Refer to Figure 5-5 for location of Items 21 through 24.

21	**EXT TRIG 1 and EXT TRIG 2 Input**	Provide for application of external signals to the A and B trigger system. Coding-ring contacts on the BNC connectors are identical in operation to CH 1 and CH 2 input connectors.
22	**CALIBRATOR Output Connector**	Provides a 0.4 V p-p square-wave signal into a 1-MΩ load, a 0.2-V p-p square-wave signal into a 50-Ω dc-coupled load, or an 8-mA p-p square-wave current signal into a zero-ohm load for an A SEC/DIV setting of 1 ms. The CALIBRATOR output signal is useful for checking the sweep, the delays, and the vertical deflection accuracies; compensating voltage probes; and checking the accuracy of current probes. The correct A SEC/DIV setting for compensating voltage probes is 1 ms with a five-cycle display of the CALIBRATOR signal. The frequency of the CALIBRATOR signal changes with the setting of the A SEC/DIV switch (see Table B-2 in Appendix B for the CALIBRATOR signal repetition rates at each A SEC/DIV setting). The CALIBRATOR signal amplitude at 5 MHz will be at least 50% of the signal amplitude when the A SEC/DIV switch is set to 1 ms per division (500 Hz).
23	**Auxiliary Ground Jack**	Provides an auxiliary signal ground when interconnecting equipment under test with the oscilloscope. The connection is made by means of a banana-tip connector.

GPIB Interface

The GPIB interface provides complete two-way digital communication between the scope and a GPIB controller. A special application of the GPIB interface is used to obtain hard copies on any plotter that uses HPGL—(Hewlett-Packard Graphics Language® such as the Tektronix HC-100 Color Plotter, or the Hewlett-Packard Thinkjet Printer®. This special application is covered under "DEVICES."

The instrument can be instructed to output waveforms via the GPIB either locally from the front-panel or remotely by a GPIB controller. (See the Programmers Reference Guide for GPIB operating information using controllers.) From the OUTPUT menu (1st-Level), the STATUS of the GPIB interface can be obtained, the interface can be SETUP, the DEBUG mode can be turned on and off. Also, waveforms can be output and AutoStep Sequences can be sent (via TRANSMIT/PRINT):

(24) **OUTPUT Button** — Displays the menu for controlling the GPIB interface (GPIB). The menu choices displayed for the GPIB menu are STATUS, DEBUG, TRANSMIT, and SETUP:

STATUS — Displays GPIB parameter settings of interest to a system user.

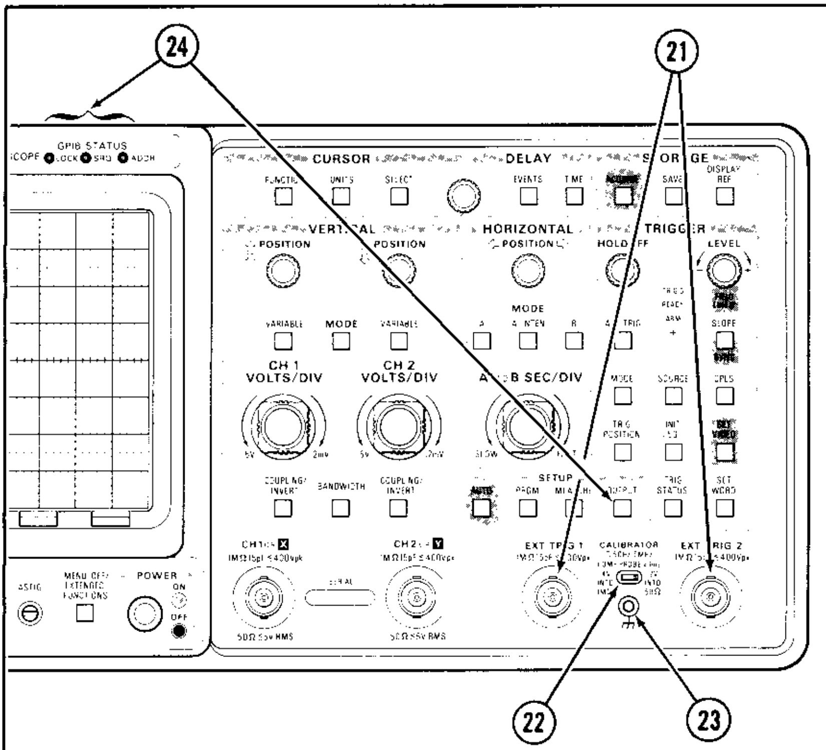


Figure 5-5. External Interface.

DEBUG Pushing DEBUG displays the menu used to control the debugging function of the GPIB interface. DEBUG mode is an important aid to a programmer when tracking down problems in a new system program or when hand entering command strings via the controller keyboard.

DEBUG ON¦OFF Turns DEBUG mode ON or OFF.

BUS¦SCOPE If set to SCOPE, messages received via the GPIB and errors detected by the scope are displayed on the scope CRT. A command string received by the scope that is not understood causes the incoming string to be halted at the end of the semicolon delimiter. A user can then read the string, and the error message that is also displayed, to find out what error occurred. Reception of the message terminator is indicated by a special rectangle symbol at the end of the string. If set to BUS, bytes are not interpreted, but merely displayed.

The characters displayed are from the scope's character set; see the Programmer's Reference Guide to map them to an ASCII set. Set the scope's address to any other GPIB instrument on the bus to see communication to and/or from that instrument. Set GPIB mode for L/only to display all communication on screen.

IN¦OUT Used to specify which messages the scope displays (available for scope mode only). When set to IN, incoming messages only are displayed. Set to OUT, both incoming and outgoing communications are displayed, with the outgoing communications underlined on screen.

SLOW Slows the character update rate on screen. An extra wait is observed on the message terminator.

PAUSE Halts the character update on screen. Controller programs using this mode should have a long time-out constant set.

TRANSMIT Sends an SRQ (service request) to the controller. The following sequence of events is typical of what occurs after the TRANSMIT sends the SRQ:

1. The controller receives the SRQ and identifies its source.
2. The controller sets the DATA SOURCE pointer to indicate which waveform(s) it wants sent.
3. It next issues either a a WAVFRM? query (wants both waveform preamble and data) or a CURVE? query (wants just data).
4. The controller releases the bus, and the scope executes a waveform transmission.

TRANSMIT/ PRINT/ SENDPRGM The TRANSMIT button can also be used to start a print of waveforms to selected printers and plotters as well as to start a transmission of a stored AutoStep sequence to other 2430A's.

Selecting the Hewlett-Packard HP-2225A ThinkJet® Printer or an HPGL compatible plotter (such as the Tektronix HC-100 Color Plotter® or the Hewlett-Packard HP-7470A Graphics Plotter® for output changes the TRANSMIT button label to PRINT. (The 4th-Level menu "Devices" is used to select these devices for output—see "SETUP" in this section.) While printing a waveform, the front-panel controls (except ABORT—see below) are locked out, and the scope is in the SAVE mode. If the scope is in SAVE ON Δ mode with DEVICES on (again, see SETUP), a switch to SAVE mode for an out-of-limit signal causes an output to the printer. When the output is finished, the scope sends a page eject to the printer and switches back to ACQUIRE, SAVE ON Δ mode.

Selecting SEND PRGM in the T/ONLY menu changes the TRANSMIT label to SENDPRGM. The user can then set other 2430A's on the GPIB to L/ONLY and select a sequence to be recalled by underlining its label in the RECALL menu for AutoStep (see 49—PRGM). Selecting the main OUTPUT menu and pushing SENDPRGM cause the selected sequence to be output to the other scopes. As when printing/plotting, the front-panel is locked out while the sequence is transmitted. For further information on sending AutoStep sequences, see the Programmers Reference Guide included with this instrument.

The TRANSMIT/PRINT/SENDPRGM function turns into an ABORT button (after the initial push) that may be used to end transmission. For TRANSMIT, the ABORT automatically sends LF (line feed) and EOI (end-or-identify) to the receiver with an SRQ and status byte to the controller indicating the scope is through talking, and the transmission is ended. Also, performing an ABORT releases the instrument from being locked into the SAVE mode waiting for a response to an SRQ when the controller is unable to respond (wrong address or not programmed to handle the scope).

TRANSMIT is omitted from the OUTPUT menu when the GPIB interface mode has been set to OFF BUS (see "SETUP").

SETUP

Selecting SETUP displays a 2nd-Level menu which lets the user define GPIB interface operation. The menu choices displayed are MODE, TERM, ADDR, and ENCDG (MODE, TERM, and ADDR are not accessible via GPIB commands and must be defined by the user from the front panel).

MODE Provides a 3rd-Level menu with five selectable function choices of T/ONLY (talk only), L/ONLY (listen only), T/L (talk/listen), DEVICES, and OFF BUS (to switch the instrument GPIB interface off the bus). These five selections function as follows:

T/ONLY Switches to the Talk-Only mode and presents a 4th-Level menu which asks the user to choose the format of the message sent. The choices are CURVE ONLY (only waveform data bytes are sent) and W/WFMPRE (all preamble information is sent prior to the waveform data bytes). A third choice, SEND PRGM, allows the scope to send AutoStep sequence to another 2430A (see Programmers Reference Guide).

The CURVE vs. W/WFMPRE format choices for the waveform message are available as queries when the GPIB controller is directing the bus transactions if the scope is in the T/L mode. The CURVE? query asks for only the waveform data, and the WAVFRM? query asks for the entire waveform message.

In T/ONLY mode, the scope is always addressed to talk. The talk-only mode is specifically for use without a GPIB system controller. A listen-only device (such as a tape or disk storage system) operates to receive the transmitted waveform data, and the scope controls the data output. When the user presses the TRANSMIT button, the scope immediately starts handshaking out the waveform message as formatted. If a controller is on the bus, it will not be able to untalk the scope. T/ONLY mode is also used for interfacing to one of the two operating modes of the Tektronix HC-100 Color Plotter. See the HC-100 manual for further information.

L/ONLY Sets the scope to the Listen-Only mode permitting the GPIB controller to issue front-panel setups to the scope in order to implement a specific test setup. The setup data can be either acquired from a previous query of front-panel settings or generated by specific setting commands given to the scope via the GPIB controller.

L/ONLY is also the mode used to set the scope up to receive a AutoStep sequence from another 2430A. See the Programmers Reference Guide for more information.

T/L Selects the normal configuration for full two-way GPIB interface communication. In this mode, the scope GPIB interface has full talker/listener capabilities and can be completely controlled by a system controller.

DEVICES Sets up the GPIB interface to send waveform data to a Hewlett-Packard HP-2225A ThinkJet® printer or a HPGL compatible plotter in an interface mode similar to T/ONLY. The printer or plotter must be set to Listen Only, and it should be the only other device on the GPIB besides the scope itself.

Selecting DEVICES displays a 4th-level menu which allows the user to specify which device (plotter or printer) is currently connected to the scope GPIB port at the rear panel. The menu choices displayed are HPGL PLOTTER, THINKJET PRINTER, and SETUP.

HPGL PLOTTER Sets up the GPIB interface to send waveform data to any plotter that uses HPGL (Hewlett-Packard Graphics Language®), using an interface mode similar to T/ONLY. The plotter must be set to Listen Only.

THINKJET PRINTER Sets up the GPIB interface to send waveform data to a Hewlett-Packard HP-2225A Graphics Printer®, using an interface mode similar to T/ONLY. The printer must be set to Listen Only.

SETUP Selecting SETUP displays a 5th-Level menu which allows the output for the plot or print to be formatted in terms of whether or not readout, graticule, and waveform information is included. The menu choices available are SETTINGS ON¦OFF, TEXT ON¦OFF, GRAT ON¦OFF, WFM ON¦OFF, and PGSIZE US¦A4.

SETTINGS ON¦OFF Allows the user to turn ON or OFF the lines used to display the front-panel settings and menu choices for the scope. These lines are the top three lines on the screen.

TEXT ON¦OFF Allows the user to turn ON or OFF the TEXT lines (the middle-ten lines). Menus displayed on the bottom three lines are not printed unless those lines are user-created messages/menus sent in via the GPIB under the direction of a controller.

GRAT ON¦OFF Allows the user to turn ON or OFF the graticule lines (user sets to OFF if the graticule is not wanted for the plot or printout.)

WFM ON¦OFF Allows the user to turn ON or OFF the waveform(s).

PGSIZE US¦A4 US selects the standard 8.5" × 11" paper and A4 selects the European standard paper.

NOTE

The 1st-Level menu displayed when OUTPUT was pushed (front-panel button) is used to print the information to the plotter or printer; push the menu button labeled PRINT or PLOT to initiate the print or plot.

OFF BUS Isolates the scope GPIB interface from the bus (becomes bus transparent) so that no communication occurs between the scope and the GPIB bus. The TRANSMIT menu choice of the first-level output menu is also omitted when the scope GPIB interface is set to OFF BUS.

TERM Displays a 3rd-Level menu used to select the termination characters sent to identify the end of a message. The choices are EOI (end or identify asserted on the last byte of a message) and LF/EOI (carriage return then line feed with EOI asserted).

ADDR Presents a 3rd-Level control menu used to set the scope bus address. This is the address that must be sent to the scope to cause it to transmit waveforms or listen to commands sent on the bus. ↑ and ↓ arrow buttons in the menu display are used to increment the address up to 30 or decrement it down to 0 respectively. Each press of an arrow button changes the address by 1. Setting the address may not be done via the GPIB interface.

ENCDG Calls up the 3rd-Level menu used to select between sending waveform data in ASCII, two's complement binary format, or positive-integer binary format code. The coding type is selectable via the GPIB using the DATA ENCDG command, and if switched via the GPIB, it is also switched in local and vice-versa. On power-on and INIT PANEL, the scope expects to receive waveform data in two's-complement format (RPBINary).

GPIB STATUS Indicators Provide the user with information concerning the GPIB interface activity. The indicators are located above the CRT bezel and are labeled LOCK, SRQ, and ADDR.

LOCK Indicates that the front-panel is in the local-lockout state when on. The user front-panel controls are not permitted to change the operation of the instrument. The condition exists as a result of the universal command group LLO sent when the controller needs uninterruptible control. The lockout condition is turned off at power-on, and the instrument defaults to user control. The lockout condition is also in effect during various other functions of the scope including PRINT, SENDPRGM, and SELF CAL.

SRQ Indicates the instrument is requesting service from the controller when on. It is turned off when the controller reads the status byte sent by the scope during a poll unless other pending events also require servicing.

ADDR Indicates the GPIB interface is in one of the addressed states: TACS (talker-active state), LACS (listener-active state), TADS (talker-addressed state), or LADS (listener-addressed state) when on. If the instrument is in either talk-only or listen-only mode, the ADDR LED is always lit.

HORIZONTAL CONTROLS

Refer to Figure 5-6 for locations of items 25 through 30.

(25) **A AND B SEC/DIV Switch** Selects 28 calibrated A or B SEC/DIV settings from 5 s per division to 5 ns per division. Sampling rate is controlled by the SEC/DIV switch setting to produce 50 data points per division (or 25 min-max data point pairs in ENVELOPE Mode) of waveform display up to the maximum sampling rate. Maximum sampling rate of 100 megasamples per second occurs at a SEC/DIV setting of 500 ns. Waveform sample points required to display signals at SEC/DIV switch settings faster than 500 ns are either interpolated (non-repetitive single event sampling) or acquired using random sampling (repetitive sampling) on periodic, reoccurring waveforms.

NOTE

Do not change Horizontal Display Mode after entering SAVE mode if the horizontal expansion feature is to be used.

Horizontal expansion of a waveform up to 100X is possible in SAVE mode. This is accomplished by turning the SEC/DIV knob to a faster setting after entering SAVE Storage Mode. The waveform is returned to its original SEC/DIV setting when the SEC/DIV setting is switched back to the position at which it was acquired. However, waveforms are not allowed to be horizontally scaled to a SEC/DIV setting slower than that at which they were acquired.

(26) **MODE Buttons** Select A, A INTEN, or B Delayed Horizontal Display Mode. In the A Horizontal Display Mode, the SEC/DIV control sets the A SEC/DIV setting. If either A INTEN or B Delayed mode is selected, the SEC/DIV control knob sets the B SEC/DIV setting. See Item 28, "DELAY by TIME," for assignment of delays to waveforms.

NOTE

Horizontal expansion of a SAVE waveform must be done in the Horizontal MODE with which it was acquired (either A or B). Do not change Horizontal Display Modes after entering SAVE Storage Mode.

A Button Selects the A Horizontal Display Mode. Waveforms are acquired at the A SEC/DIV setting.

A INTEN Button Selects the A Intensified Horizontal Display mode. Waveforms are acquired at the A SEC/DIV setting. Intensified zones displayed on the A waveform mark which portion or portions of the trace corresponds with the B Delayed SEC/DIV setting. For B TRIG AFTER (Delay) operation, the start of an intensified zone indicates the point on the A waveform where B triggering is enabled, not the point where the B record trigger will occur if the Horizontal Display Mode is switched to B Delayed.

B Button

Selects the B Delayed Horizontal Display mode and changes the acquisition rate to that required for the B SEC/DIV setting.

27 **HORIZONTAL POSITION Control Knob**

Sets the horizontal position of the waveforms displayed on the CRT in YT display mode. Clockwise rotation of the control positions the display to the right. The HORIZONTAL POSITION pot is a position-rate control. The center position area of the control produces linear positioning. Rotating the control into its spring-loaded region produces rate positioning of the display. The farther the knob is rotated toward the end-stop position the faster the positioning rate is. Releasing the knob returns it back to the linear positioning region of the pot.

The HORIZONTAL POSITION control knob does not affect the horizontal position of the XY display on the CRT, but it does select which 512 data points of the 1024 data points in the waveform record are displayed for the CH 1 vs. CH 2 live and SAVE displays and the XY:REF reference displays. In YT display mode, saved reference waveforms may be individually selected for horizontal positioning by using the HORIZ POS REF choice in the DISPLAY REF menu to call up the HORIZONTAL POSITION selection menu. REF HPOS is set to IND (independent) and the selected REF waveform is the only one that may be positioned.

The HORIZONTAL POSITION menu MUST be displayed and REF HPOS set to IND for the POSITION control to independently (of other reference waveforms and live waveforms) position reference waveforms. Setting REF POS to LOCK returns all independently positioned waveforms to their original position (their Trigger Point Indicators are locked in position). Adjusting the HORIZONTAL POSITION control while in LOCK adjusts all saved, REF, and live waveforms in unison. Also, REF1 and REF2 waveforms independently positioned in YT display mode are returned to their original position automatically if the scope is switched to XY display mode.

Delay Controls

The scope has two different delay modes—the conventional DELAY by TIME function used in B Delayed applications and a DELAY by EVENTS function used to delay the A acquisitions by a set number of B Trigger events. See Figure B-2 in Appendix B for an illustration of the delaying processes for the separate and combined delay features.

(28) **DELAY by TIME Button** Calls up the control menu used to set up the DELAY by TIME feature and displays the DELAY TIME readout used in conjunction with the A INTEN and B Delayed Horizontal Modes. Delay time is set using the shared CURSOR/DELAY control knob while the DELAY by TIME menu is being displayed.

Δ TIME ON:OFF Toggles between selection of a single delay time display (Δ TIME OFF) and a dual-delay time display. With Δ TIME ON, one delay time (the main delay) is referenced to the A record trigger, and the second (delta delay) is referenced to the first delay time. Pressing the DELAY TIME front-panel button, when the DELAY TIME menu is already displayed, switches the CURSOR/DELAY knob between setting DELAY TIME and Δ DELAY TIME. (The delay time selected to be set is underlined in the menu.)

Maximum delay is 2621.4 × B SEC/DIV setting at a resolution of 1/25 of the B SEC/DIV setting or 20 ns, whichever is greater. In Δ TIME mode, the combined delay-time settings cannot exceed the maximum allowable delay, and if the main delay is increased, the delta delay will be reduced (down to zero if necessary) when the delay limit has been reached. (See Table B-10 of Appendix B for a table of maximum delays and resolution for each SEC/DIV setting.)

NOTE

If the maximum delay time is reached by switching the B SEC/DIV to faster SEC/DIV settings, the delay time setting defaults to that maximum delay; switching back to a lower SEC/DIV setting does not return to the same delay-time setting that was previously in effect.

If only a single channel is displayed, both B Delayed displays (main delay and delta delay) will appear on that channel signal. A single channel display with two delay-time position settings is very useful in making measurements of pulse width and waveform period. When both CH 1 and CH 2 are displayed, the main delay occurs on CH 1 and the delta delay occurs on CH 2 for making propagation-delay measurements between two separate signals. An ADD or MULT waveform will be displayed with both delays in the Δ TIME Delay mode. With Δ TIME off, all B Delayed waveforms displayed are delayed by the main DELAY TIME setting.

NOTE

If AVERAGE Acquisition Mode is in effect, the Δ TIME delayed waveform will not be acquired or displayed. However, all the DELAY by TIME controls remain functional and may be used for setting the delta delay time that will be seen when AVG Acquisition Mode is turned off. If Δ TIME and AVG are both on, selecting A INTEN or B Horizontal Mode causes the message "NO Δ DELAY IN AVG" to appear in both the ACQUIRE Menu and the DELAY by TIME control menu.

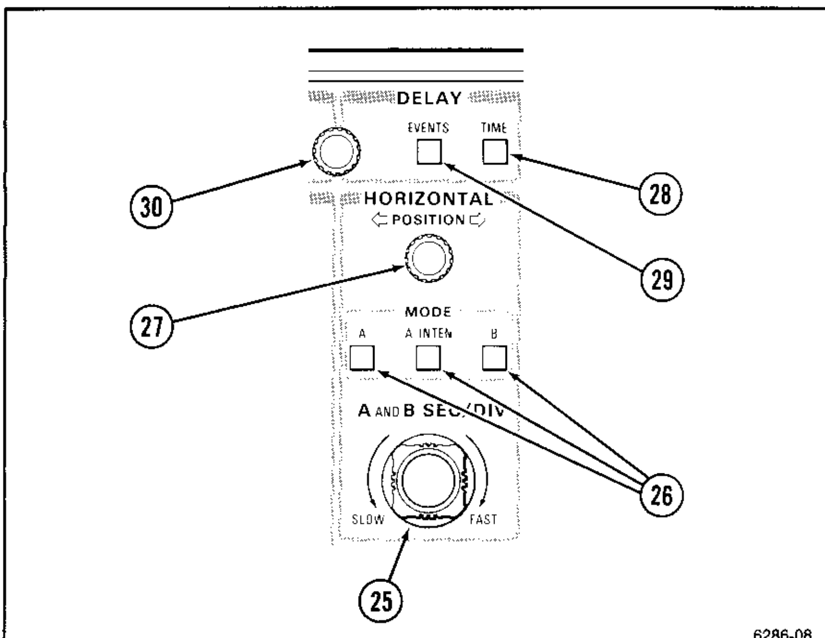


Figure 5-6. Horizontal and Delay Controls.

(29) **DELAY by EVENTS Button** Calls up a selection menu used to turn the DELAY by EVENTS function on and off and set the the EVENTS COUNT number. The DELAY by EVENTS function delays A Record Trigger (the waveform acquisition) from occurring for the specified number of B Trigger events after the normal A Trigger event occurs. The maximum events count setting is 65,536 events with a settability of 1 event. The B Trigger SOURCE, COUPLING, SLOPE, and LEVEL controls are used to condition the events trigger signal. The events count is set using the CURSOR/DELAY control knob while the DELAY by EVENTS menus is being displayed.

NOTE

If DELAY by EVENTS is on and no event triggers are occurring (B Trigger conditions not being met), A acquisitions appear to not be triggered properly. In this event, a check of the instrument STATUS display (see Figure 5-2) will show that the Trigger Status is "TRIG WAIT: EVENTS".

(30) **CURSOR/DELAY Control Knob** Used to set DELAY by Time, EVENTS COUNT, and MEASURE LEVEL depending on which function is active. The control is a position-rate potentiometer that provides linear response in the center positioning region. Rotating the control into its spring-loaded region produces fast positioning of the setting. The farther the knob is rotated toward the end-stop position the faster the positioning rate is. Releasing the knob returns it back to the linear region of the pot.

In DELAY by TIME mode, the CURSOR/DELAY control knob sets the main delay time. In Δ TIME mode, the control knob sets either the main delay or the delay between the main delay and the delta delay (pressing the DELAY by TIME button toggles the control knob between DELAY and Δ DELAY). For DELAY by EVENTS, the knob sets the events count—the number of B Trigger events that must occur after the A Trigger event, before an A Record Trigger (RTRIG) can occur. For cursor functions, the CURSOR/DELAY knob positions the active cursor (selected by pressing the SELECT button when a cursor function is active). If the LEVEL menu for the MEASURE feature is displayed, the knob sets the chosen level (PROXIMAL, MESIAL, or DISTAL) in percent or volts. The function of the knob defaults to CURSORS if neither the DELAY by TIME, the DELAY by EVENTS or, the MEASUREMENT LEVEL menu is displayed.

Trigger Controls

Refer to Figure 5-7 for location of Items 31 through 46.

(31) **A/B TRIG Button**

Selects either the A or the B Trigger system to be under control of the shared TRIGGER controls of MODE, SOURCE, CPLG, TRIG POSITION, SLOPE, and LEVEL. Each press of the A/B TRIG button toggles the displayed trigger control menu, effect of the SLOPE and LEVEL controls, and the SLOPE indicator LEDs between the A Trigger system and the B Trigger system.

(32) **SOURCE Button**

Displays either the A or the B TRIGGER SOURCE menu. The SOURCE control menu for A Trigger displays five selectable functions which are activated by pressing the appropriate menu button.

VERT

Selects the trigger signal source from the displayed waveforms. If CH 1 and CH 2 are both on, the selected source will be CH 1. When only CH 2 is on, that is the selected source for VERT. When MULT VERTICAL MODE is displayed, CH 1 again provides the trigger signal; for ADD VERTICAL MODE, the trigger signal is the algebraic sum of the CH 1 and CH 2 signals.

CHAN 1¦2

Selects either the Channel 1 or the Channel 2 input signal as the triggering source. When initially selected, CH 1 is the default source. Each subsequent push toggles the source between Channel 1 and Channel 2. While CHAN1¦2 is selected, pushing SOURCE also toggles the Source between Channel 1 and Channel 2.

EXT

Displays the A EXT SOURCE menu for selecting either the signal at the EXT TRIG 1 or at the EXT TRIG 2 connector as the triggering source for the A Trigger System. Also, the gain of EXT 1 and EXT TRIG 2 can be set in this menu. This menu can be toggled to B EXT SOURCE menu by pushing the A/B TRIG front-panel button.

Press the bezel button labeled A EXT SOURCE 1¦2 to toggle between EXT TRIG 1 and EXT TRIG 2 sources. (While this menu is displayed, pressing the Trigger SOURCE front-panel button also toggles the source selected between A EXT1 and A EXT2.) Each external trigger channel has a choice of either EXT (a gain of one) or EXT ÷ 5 (attenuation by a factor of five). Select EXT ÷ 5 when it is necessary to reduce the amplitude of large signals applied to the external trigger input connectors.

The attenuation choices for each source are mutually exclusive; selection of one turns off the other choice.

NOTE

The B EXT SOURCE menu has an identical menu section for setting A and B EXT GAIN. Changing a gain setting for either the A or B EXT SOURCE menu changes that setting for both menus. In other words, the gain set for the external trigger sources is always the same for both A and B Trigger Systems.

LINE Selects the ac power-source waveform as the source of the triggering signal. LINE source is useful when the displayed waveform frequency is time related to the ac power-source frequency.

A*B¦WORD Selects either both A and B or the 16-bit Word Recognizer Probe as the trigger source.

The A*B trigger source requires that the triggering conditions for both the A and the B Trigger Systems (SOURCE, COUPLING, LEVEL, etc.) be met before a trigger signal is valid. A*B is the default source when A*B¦WORD is initially selected. A subsequent push of the menu button toggles the trigger source to WORD (if the Word Recognizer Probe is attached). A third push of A*B¦WORD turns off A*B and WORD as trigger sources and returns to the source selected prior to the first push of A*B¦WORD. A*B¦WORD is not available as a trigger source if VIDEO is selected as the trigger coupling mode. Also, A*B is not an available choice as a B Trigger source.

WORD trigger source requires that an optional Word Recognizer probe be attached to the WORD RECOG INPUT connector on the rear panel of the scope. Attempting to select WORD as a source without the probe attached will ring the warning bell, display the message "WORD PROBE FAULT," and return the source to the previously selected trigger source. The error message will also appear if the Word Probe becomes disconnected after WORD has been selected.

Setup of the Word Recognizer Probe for selecting a trigger word is described in Section 7, "Options and Accessories."

(33) **CPLG Button** Calls up the control menu for selecting the trigger signal coupling to the A and B trigger circuits (as directed by the A/B TRIG switch).

DC Couples all frequency components of a triggering signal to the trigger circuitry. DC coupling is useful for most signals, but it is especially useful for providing a stable display of low-frequency or low-repetitive-rate signals.

AC Attenuates trigger signal frequency components below 60 Hz and blocks the dc component of the signal. AC coupling is useful for viewing ac waveforms having large dc offsets.

VIDEO (Video Option 05) Activates the Video Option triggering circuitry. See Section 7, "Options and Accessories" for operating the Video Option. With the Video Option installed, the A Trigger COUPLING menu has DC and AC Coupling combined over one of the menu buttons as DC¦AC. In that case, pressing the menu button toggles the choice between AC and DC trigger coupling. VIDEO is not a choice in the B Trigger Coupling menu.

NOISE REJECT Couples all frequency components of the input signal to the trigger circuitry, but increases the peak-to-peak signal amplitude required to produce a trigger event. NOISE REJECT coupling is useful for improving trigger stability on signals accompanied by low-level noise.

HF REJECT Attenuates high-frequency triggering signal components above 50 kHz. This coupling method is useful for providing a stable display of low-frequency components of complex waveforms and eliminates high-frequency interference from the trigger signal.

LF REJECT Attenuates low-frequency triggering signal components below 50 kHz and blocks the dc component of the signal. LF REJECT coupling is useful for producing stable triggering on the high-frequency components of complex waveforms and rejecting low-frequency interference or power supply hum from the trigger signal.

34 **TRIGGER MODE Button** Calls up either the A or the B Trigger Mode Menu as directed by the A/B TRIG switch.

A Trigger Modes

AUTO LEVEL Adjusts the Trigger LEVEL setting to within the peak-to-peak limits of the applied trigger signal. Loss of the trigger signal causes the scope to go through a trigger acquisition sequence to determine the peak-to-peak amplitude of the trigger signal and reset the trigger level to the midpoint level.

For SEC/DIV settings faster than 100 ms/div, if the trigger signal amplitude decreases to below the trigger level setting or if the Trigger LEVEL control is adjusted outside the peak levels on the trigger signal, the AUTO LEVEL trigger acquisition sequence is automatically performed to reset the trigger level. An AUTO LEVEL cycle can also be forced by selecting AUTO LEVEL again after it has already been selected or by pushing INIT @ 50% (see Item 36).

AUTO/ROLL Free runs the acquisition in the absence of a triggering signal. The triggering level changes only when the LEVEL control knob is adjusted to a new setting. At 100 ms or slower SEC/DIV switch settings, AUTO changes to a ROLL function.

In AUTO mode, loss of the trigger signal forces an auto-trigger to be generated. In ROLL, trigger signals are ignored although a Trigger Point Indicator ("T") is displayed. That point defines the waveform window that is captured for a SAVE ON Δ, and is the reference point used if absolute TIME cursors measurements are made. In ROLL mode, the display is updated a data point at a time in a scrolling manner (from right to left across the CRT).

NOTE

Since triggers are not looked at in ROLL mode, there will be no DELAY by EVENTS, and both A INTEN and B Horizontal Display Modes default to the A only operation. In ROLL mode, AVG Storage mode defaults to NORMAL and cumulative ENVELOPE acquisitions are not done. SAVE ON Δ is especially effective for monitoring changes in the dc level of a power supply voltage in ROLL mode.

NORMAL Permits an acquisition to occur either when triggered or when the input coupling of the selected trigger SOURCE channel's input coupling is set to GND (as when it is necessary to acquire a ground reference level). The scope auto-triggers for the GRD setting to allow the user to position the baseline trace vertically on screen while the normal trigger signal is shut off. Without this feature, the loss of the trigger signal when the input coupling is switched to GRD would stop the acquisition process and freezes the display and vertical positioning could not be done.

SINGLE SEQ (Single Sequence) Performs one complete storage sequence when triggered and enters SAVE mode. If SINGLE SEQ is not the desired Trigger MODE for the next acquisition to be made, select the new Trigger MODE before pressing ACQUIRE. To change the acquisition mode in SINGLE SEQ if a rapid sequence is occurring, SINGLE SEQ must be exited temporarily to gain access to the ACQUIRE menu; otherwise the acquisition is finished and SAVE mode is reentered before the user has time to make a change.

The number of single, triggered acquisitions required to complete the single sequence (a single acquisition is a single ARMED-READY-TRIG'D cycle, during which 1024 data points per channel are digitized; a sequence is a logical grouping of one or more acquisitions) depends on the STORE ACQUIRE mode selected and the requirements of that mode. For instance, if the scope is set to NORMAL ACQUIRE mode and the HORIZONTAL MODE is set to B, one acquisition completes the single sequence. However, if Δ DELAY TIME is now turned ON, the scope now makes two acquisitions—one for each delay specified—and two acquisitions now completes a single sequence. If the ACQUIRE MODE is now switched to envelope and the number or acquisitions set to 32, the scope must now make 64 acquisitions to satisfy the specified number of envelopes and delays (32 envelopes of 2 delayed acquisitions) to complete a single sequence.

NOTE

REPET mode also affects the number of acquisitions required to complete a single sequence. See "REPET ON/OFF" in this section for details.

When a single sequence is complete, the scope updates the display and enters the SAVE mode. After the initial single sequence performed when the SINGLE SEG TRIGGER MODE menu button is pressed, subsequent single-sequence acquisitions must be started by either pressing the ACQUIRE front-panel button or by command via the GPIB interface.

B Trigger Modes

RUNS AFTER Forces the B Record Trigger to occur immediately after the preset delay time from the Trigger event has elapsed. The B Trigger Mode of RUNS AFTER allows continuously smooth delay positioning of the display for making delay time measurements. The basic delay time (main delay) is set by the CURSOR/DELAY knob when the system is in the DELAY by TIME mode. If Δ TIME Mode is also on, two delays are set up (the main delay and the delta delay) for making time difference measurements, and the DELAY by TIME button is used to switch the CURSOR/DELAY knob between controlling the two delays. The B Trigger SOURCE, COUPLING, LEVEL, and SLOPE controls have no effect on B Triggering in RUNS AFTER Mode.

TRIG AFTER Permits the B Record Trigger to occur only when triggered after the preset delay time has elapsed. Since the B acquisitions are synchronized with the B Trigger signal, the delayed waveform display is stable even with jittering signals. In A INTEN displays, the start of the intensified zone is the point when B triggering is enabled, not the B Record Trigger point. All the B Trigger controls are functional for selecting and conditioning the signal used as the B Trigger signal in TRIG AFTER Mode.

EXT CLK ON!OFF Disables the internal time base (calibrated time) and uses an external signal as the sample clock when ON. The external clock signal is conditioned by the B Trigger circuitry and must meet the triggering requirements determined by the B Trigger controls before triggering can occur. The maximum usable external clock signal frequency is 100 MHz, and the minimum is 1 MHz.

When using the external clock, the A and B SEC/DIV switch (Item 25) has no effect on the time base setting, and, while both A and B acquisitions are possible, the ratio between A and B cannot be changed (the external clock frequency determines the acquisition rate for both). Also, the delay-time readouts are in terms of external clock events when either A INTEN or B Delayed Horizontal Mode is selected. If DELAY by EVENTS and external clocking are both on, the same signal is the trigger source for both functions.

(35) **TRIG POSITION Button**

Calls up the control menu used to select the Record Trigger position in the waveform display. The choices of 1/8, 1/4, 1/2, 3/4 and 7/8 determine the amount of pretrigger information that will be displayed prior to the Record Trigger in the next acquisition made (the Record Trigger position cannot be changed in a saved waveform). (See Table B-9 in Appendix B for the waveform data point number that corresponds to the fractional menu selections.)

The Record Trigger position may be set to any of 31 data point selections from 32 to 992 in the 1024 data point waveform record using commands via the GPIB interface. Trigger Position is the horizontal point on the waveform where the Record Trigger occurs (points counted from 0 to 1023). The Record Trigger point is marked with a "T" on the waveform display.

(36) **INIT @ 50% Button**

Forces the instrument to do a single AUTO LEVEL cycle (see Item 34) thus setting the trigger level at 50% of the peak-peak value of the signal. If the signal amplitude is too small to find a valid trigger, one will be forced to cause the current acquisition (not acquisition sequence) to complete when pressed. DELAY by EVENTS and DELAY by TIME requirements are ignored; therefore, any delay time readouts are meaningless when INIT @ 50% is used to generate the acquisition.

(37) **SET VIDEO Button (Video Option only)**

Calls up the control menu used to setup the Video Option operation. See "Video Option" in Section 7 of this manual for the operating instructions.

NOTE

When the CLAMP function is turned on in the SET VIDEO menu, it remains on even if the VIDEO Coupling selection is off (as indicated in the CRT readout display). If the scope is not being triggered by a composite-sync or composite-video signal, the circuit action of the back-porch clamp circuitry on the CH 2 waveform becomes unpredictable. In this event, press SET VIDEO and switch CLAMP off.

(38) **SLOPE Button (SLOPE/SYNC with Video Option)**

Selects the slope of the signal that triggers the A and/or B acquisition. An illuminated indicator (+ and −) shows the slope selected for triggering. A and B SLOPE selection are independent of each other. With the Video Option installed, the button is also used to select either sync-negative or sync-positive operation of the TV sync-separator.

(39) **Status Indicators (TRIG'D, READY, and ARM)**

Show the state of the instrument trigger system during an acquisition sequence. See Table B-11 in Appendix B for an interpretation of the trigger status shown by the Status Indicators.

(40) **HOLDOFF Control Knob**

Varies the amount of time from the A Trigger until the Trigger system will accept another A Trigger event. Use of this control often helps obtain stable triggering on aperiodic signals. Minimum and maximum holdoff values versus SEC/DIV settings are given in Table B-5 of Appendix B in this manual. The HOLDOFF setting between the maximum and minimum values is shown in percentage in the STATUS display, with 0% being minimum. A small HO symbol appears at the beginning of the A Trigger Level readout line whenever the HOLDOFF is set to anything other than 0%. HOLDOFF is reset to 0% whenever the A SEC/DIV is changed.

(41) **LEVEL Control Knob (LEVEL/FIELD LINE # with VIDEO OPTION**

Sets the amplitude level on the triggering signal at which A or B acquisitions are triggered (as directed by the A/B TRIG switch). The Level readout displayed on the CRT (see Figure 5-2 for the readout location) is the trigger signal voltage relative to ground at which triggering will occur. The trigger level readout is correctly scaled for the attenuator setting and probe coding that affect the trigger signal amplitude. A question mark will appear after the trigger level readout if the Trigger COUPLING is not DC or the vertical input SOURCE (CH 1 or CH 2) is either uncalibrated or not in DC Coupling.

NOTE

The trigger level is set in voltage units with no range limitation; however, the actual effective LEVEL control range is based on the attenuation factor of the current trigger source. The trigger LEVEL range is limited to ± 18 divisions for CH 1 or CH 2 source; for the EXT1 and EXT2 external trigger inputs, the maximum range is ±9 divisions.

When the A TRIG MODE is set to AUTO LEVEL, adjusting the trigger level setting past either peak of the current trigger signal causes the triggering level to be recalculated. The new trigger level recalculated is approximately the midpoint level of the applied trigger signal.

With the Video Option enabled, the LEVEL/FIELD LINE # control sets the specific line number that will trigger a video signal acquisition (FIELD1 or FIELD2 triggering). See the "Video Option" information in Section 7 for operation of this control with the Video Option.

(42) **TRIG STATUS Button**

Displays a readout of the present A and B Trigger control settings for SOURCE, CPLG, MODE, and TRIG POSITION. The Trigger System to which the trigger controls are presently directed (by the A/B TRIG switch) is indicated by an underline beneath the selected trigger system. Also, A*B is displayed if A*B is selected. Any trigger changes sent to the scope via the GPIB interface are immediately reflected in the TRIG STATUS display.

(43) **SET WORD Button**

Calls up the setup control menu used to program the optional Word Recognizer Probe to produce a trigger on a specified parallel TTL data word. (See "Word Recognizer Probe" in Section 7 of this manual for setting up the data word to be recognized.)

The output of the Word Recognizer Probe can be selected as the trigger source for the A Trigger and/or the B Trigger system. The Word Recognizer Probe output trigger is also routed to rear panel BNC connector labeled WORD TRIG OUT for use as a trigger signal to an external device. A trigger signal appears at this connector each time a word match occurs; however, the holdoff time of the scope may prevent each match from being accepted as a triggering signal by the scope if the selected trigger word occurs too often in a data stream.

Storage System

Refer to Figure 5-7 (page 5-53) for the location of Items 44 through 46.

(44) **ACQUIRE Button**

Calls up the control menu used to select the acquisition mode.

NOTE

When either ENVELOPE or AVERAGE acquisition mode is selected, the menu button under the selected mode is used to select the number of acquisitions to be included in the cumulative Envelope or Averaged waveform display. The (nnn) in the CRT menu display represents the present number of acquisitions selected. The number is changed by pressing the menu button. Each single press of the button doubles the number until the maximum limit selection is reached (CONT for ENVELOPE and 256 for AVG) then the number wraps around to the minimum limit (1 for ENVELOPE and 2 for AVG).

NORMAL

Selects a continuous acquisition and display mode that produces a live display similar to that of a conventional scope.

ENVELOPE Causes the instrument to execute fast peak detection of both channels. The data-point values of each min-max sample pair are compared to the previously acquired maximum and minimum data-point values that occurred during the previous two consecutive sampling intervals. The maximum and minimum peak values found are then transferred to the acquisition memory. The number of waveform acquisitions accumulated in an envelope display before resetting occurs can be set to 1, 2, 4, 8, 16, 32, 64, 128, 256, or CONT (continuous). If CONT is selected, the ENVELOPE acquisitions only restart as a result of a change to a control that affects the waveform data being acquired (except Vertical POSITION and DELAY TIME changes) or a press of the ACQUIRE Storage mode button.

NOTE

ADD and MULT Vertical Modes are not available with ENVELOPE acquisition mode. They will be turned off and removed from the Vertical MODE menu when ENVELOPE is selected. The SMOOTH ON/OFF function (see "SMOOTH" in this section) is ignored for ENVELOPE.

AVG (average) Causes the instrument to average the selected number of successive acquisitions. The averaged waveform displayed is updated with each new acquisition. The definition of noisy signals is improved with each average up to the selected number. The user selects the number of acquisitions to be averaged from a binary sequence from 2 to 256. A front-panel change that affects the acquisition erases the displayed waveform and restarts the averaged waveform acquisitions. Pressing the ACQUIRE Storage mode button also restarts the averaging. Information regarding signal-to-noise ratio improvement for the number of acquisitions averaged is found in Table B-3 in Appendix B of this manual.

While AVG mode is in effect, the extra vertical resolution obtained permits "live" vertical expansion to three additional VOLTS/DIV settings: 1 mV, 500 μV, and 200 μV (wit 1X attenuation of the input signal). When AVG mode is turned off, VOLTS/DIV settings in this range revert to 2 mV per division.

NOTE

When averaging with a weighting factor of 32 or greater, the finite-precision-fixed-point arithmetic used to compute the weighted difference between sampled data points truncates the answer. The loss of decimal places in the result biases it toward discrete digitizing levels. This phenomena can be seen in the averaged display under low-noise situations when vertically expanding small-amplitude waveforms (either "live" or in SAVE mode), especially when AVG is set to CONT and uses a weighting factor of 256.

REPET ON|OFF (Repetitive) Enables repetitive sampling for NORMAL, ENVELOPE, and AVG mode acquisitions when ON. At SEC/DIV settings of 500 ns/DIV and faster, the time base is sampling the incoming waveform at its maximum rate of 100 megasamples/second. With REPET OFF, data points between the actual digitized data points on a waveform are calculated by interpolation to obtain their displayed position. Interpolation allows expansion of the acquired data to a SEC/DIV setting of 5 ns on a single event acquisition up to a useful storage bandwidth of 40 MHz. From 200 ns/DIV to 5 ns/DIV, REPET ON turns on random-time sampling of the incoming signal to extend the bandwidth of the instrument to 150 MHz for repetitive signals.

NOTE

The interpolation that occurs with REPET OFF is different for ENVELOPE mode. For NORMAL and AVERAGE, the scope uses a sine-interpolation algorithm for calculation of data points between sample intervals. In ENVELOPE mode, the scope uses an algorithm that replicates the sampled data values a number of times determined by the expansion factor.

Each REPET acquisition cycle produces approximately 2 to 410 randomly-sampled display points. The user sees the waveform take shape as the newly acquired data points are successively added into the accumulating display.

NOTE

When REPET is used with ENVELOPE mode, the 2 to 410 sample points are stored as min-max pairs, each pair taken during two consecutive sample intervals. It is these pairs that are successively software-peak detected and form the envelope display on screen.

REPET ON affects the number of acquisitions needed to complete an ENVELOPE acquisition sequence. If the number of acquisitions specified is 1, the scope will make enough acquisitions to obtain 512 min/max pairs (1024 sample points) before erasing the waveform. The number of acquisitions required depends on the sample rate (at 5 ns/div, 10 samples are min-maxed into 10 min-max pairs with each acquisition; at 10 ns, 20 samples are min-maxed into 20 min-max pairs, etc.) If the number specified (N) is greater than 1 but less than CONTinuous, 50% of the 512 min-max pairs must have been enveloped N times and each pair enveloped at least once before the envelope sequence is complete. If N = CONT, the envelope sequence is never finished.

REPET ON also affects the number of acquisitions needed to complete a single sequence when SINGLE SEQ is the TRIGGER MODE selected. In NORMAL acquisition mode, the single sequence completes when a fixed number of acquisitions have occurred (see Table B-4, Appendix B). In AVG mode, the single sequence completes when 50% of the points have been averaged the user-specified number of times. The criteria for single-sequence completion for ENVELOPE is the same as for other ENVELOPE REPET acquisitions (see above). As was true for ENVELOPE REPET, if N = CONT, the envelope sequence is never finished; therefore, the single sequence never completes and the scope never enters SAVE mode. (See "SINGLE SEQ" under "A Trigger Mode" for more information on single sequence.)

SAVE ON Δ

Controls the Save-on-Delta mode. When ON, the scope compares each incoming waveform to a reference waveform and enters the SAVE mode if any part of the incoming waveform goes outside the limits set by the comparison envelope waveform. The comparison envelope reference is generated from the front-panel by selecting CONTinuous ENVELOPE and using the vertical POSITION and DELAY by TIME controls to set the comparisons limits. The reference is then saved in the correct REF memory. A more accurate comparison envelope can be generated by sending it into the desired REF memory via the GPIB interface. Both methods are described in Section 3, "Applications", of this manual.

After turning on SAVE ON Δ, waveforms acquired in NORMAL, AVG, or ENVELOPE mode are compared with the predefined displayed reference. (See Table B-14 in Appendix B to determine the comparison that will occur for the different modes of operation.) If no reference waveforms are being displayed for comparison, the SAVE ON Δ request is ignored. Upon entering SAVE mode, the number of acquisitions taken while waiting for a change is displayed in the readout.

When using REPET mode for acquiring the incoming waveform, only the data points acquired on each trigger event are compared to their corresponding data points in the reference waveform. In this way, the unfilled data points are ignored in the comparison.

The readout of scope's power-on time since the last cold start occurred is also displayed as HHHH:MM (Hours:Minutes). If the user wishes to determine the time required for the SAVE ON Δ to occur, the time before starting the acquisition may be recorded (from the SAVE storage mode). Subtract the starting time from the time displayed at SAVE ON Δ to determine the elapsed time.

Upon entering SAVE when a change occurs, SAVE ON Δ is turned off in the ACQUIRE menu to enable the user to return to the ACQUIRE mode menu without an immediate SAVE taking place.

SMOOTH ON|OFF The SMOOTH ON|OFF function is accessed via the menu displayed when the front-panel button BANDWIDTH is pushed. When SMOOTH is turned ON, a 5-sample point, moving averaging algorithm is applied to each sample point. Each new digitized sample is averaged with the 4 previous sample values before being displayed. The result is an overall smoothing of the waveform. The SMOOTH function only operates in AVG and NORMAL ACQUIRE modes; SMOOTH, if turned ON, is ignored in ENVELOPE mode.

45 **SAVE Button** Stops an acquisition in progress and freezes the display when pressed. SAVE Storage Mode is also entered as a result of a waveform change with SAVE ON Δ in effect and at the completion of a SINGLE SEQ acquisition. The number of acquisitions making up the SAVE display is shown in the CRT readout. Pressing the ACQUIRE Storage Mode button returns the acquisition mode in effect before SAVE Storage mode was entered (unless a front-panel control change was made). In the case of a front-panel control change during SAVE mode, the next acquisition made after ACQUIRE is pressed is made with the displayed control settings.

The SAVEREF SOURCE menu is called up when SAVE mode is entered. This menu is used to select waveforms from the save display for storage in the REF memories, as required.

The cursor functions can be used to make measurements on the saved waveforms, and the waveforms can be vertically and horizontally positioned using the normal POSITION controls. They can also be horizontally and vertically expanded in steps with the SEC/DIV and appropriate VOLTS/DIV control. The Channel 1 and Channel 2 SAVE displays can be added or multiplied with a recalculation of data taking place to obtain the additional trace. SMOOTHing can be turned on or off.

A waveform can be horizontally expanded up to 100X in SAVE mode. Expansion is done by turning the SEC/DIV knob to a faster setting after entering SAVE Storage Mode. The waveform is returned to its original SEC/DIV setting when the SEC/DIV setting is switched back to the position at which it was acquired. Waveforms are not allowed to be horizontally scaled to a SEC/DIV setting slower than that at which they were acquired. However, the SEC/DIV switch setting will continue to change to reflect the setting of the SEC/DIV switch at which the next waveform will be acquired when the ACQUIRE button is pressed.

SAVEREF SOURCE

A waveform to be stored in SAVEREF memory is selected from choices displayed in the SAVEREF SOURCE menu. If display sources (CH 1, CH 2, and either ADD or MULT) are turned on in the VERTICAL MODE menu, they appear as SAVE SOURCEs in the SAVEREF SOURCE menu. A display source must be on before it can be a SAVE SOURCE, unless the display source is REF. The REF selection displays a submenu for chosing any of the REF memories as a display source, regardless whether the REF is displayed or not. By providing REF1-REF4 as SAVE SOURCEs as well as DESTINATIONs, waveforms can be copied from one REF location to another.

When DELTA TIME mode is used with the B Horizontal Display Mode, two delayed waveforms are acquired. When the source displaying both delays is selected from the SAVE SOURCE menu, a sub-menu of DELAY1—DELAY2 is displayed so the desired delayed waveform can be specified for saving.

Reference memories can be used as a push-up stack. A press of the STACK REF menu button stores the displayed SAVE waveforms according to predefined rules. The VERTICAL MODES in effect when the SAVE mode is entered determine the REF memory written into. Previous reference waveforms get pushed into the next higher numbered reference memory and finally out the top (and lost) if the STACK REF button is repeatedly used. (See Appendix B, Table B-13 for the storage configuration when STACK REF is used for saving waveforms in reference memory.)

SAVEREF DESTINATION If a specific SOURCE is selected, the SAVEREF DESTINATION menu is then displayed to permit selection of the reference memory to be written to (REF1, REF2, REF3, or REF4). A press of the menu button under one of the displayed choices copies the previously selected SOURCE waveform into that reference memory and returns to the SAVEREF SOURCE menu to permit the user to make a new SOURCE and DESTINATION selection for storing additional reference waveforms.

Displaying a saved reference waveform is done using the DISPLAY REF menu (see Item 46 "DISPLAY REF").

46 **DISPLAY REF Button** Displays menu for selecting the reference waveform or waveforms for display (REF1, REF2, REF3, and/or REF4). Pressing the menu button below the appropriate menu label turns on and off the waveform display from that reference memory.

A reference memory may be empty, in which case a label of "EMPTY" is written above the menu choice and nothing is displayed from that location if it is selected for display. Once a memory space is filled, the EMPTY label is removed from that REF choice.

The HORIZ POS REF selection displays a menu used to select which reference waveform (REF1, REF2, REF3, and REF4) is to be positioned with the Horizontal POSITION control. Pressing the DISPLAY REF menu button returns the system back to the original DISPLAY REF control menu. IN XY mode, only one reference waveform (made up of REF1 against REF2) is displayed. Pressing the STACK REF button in the SAVE menu saves the XYREF waveform by storing CH 1 in REF1 and CH 2 in REF2 at the same time with a single button press. Storage in this manner produces an XY reference waveform with a defined phase relationship from the same trigger event. The XYREF can then be called up from memory by use of the DISPLAY REF menu button. The choices in XY are CH1 VS CH2 and XYREF. Pressing the XYREF menu button turns the XYREF display ON and OFF. If either REF1 or REF2 is EMPTY, the XYREF choice will be marked empty in XY mode.

Waveforms for the XYREF may be individually entered in the REF1 and REF2 memories using the menu choices in the SAVEREF SOURCE menu, and arbitrary waveforms for display may be transferred to these reference memories via the GPIB interface. In either of these cases, there can be no guarantee of the actual phase relationships between the waveforms being compared, and the XY phase difference seen in a display indicates only the phase difference of the displayed data, not that of the acquired data.

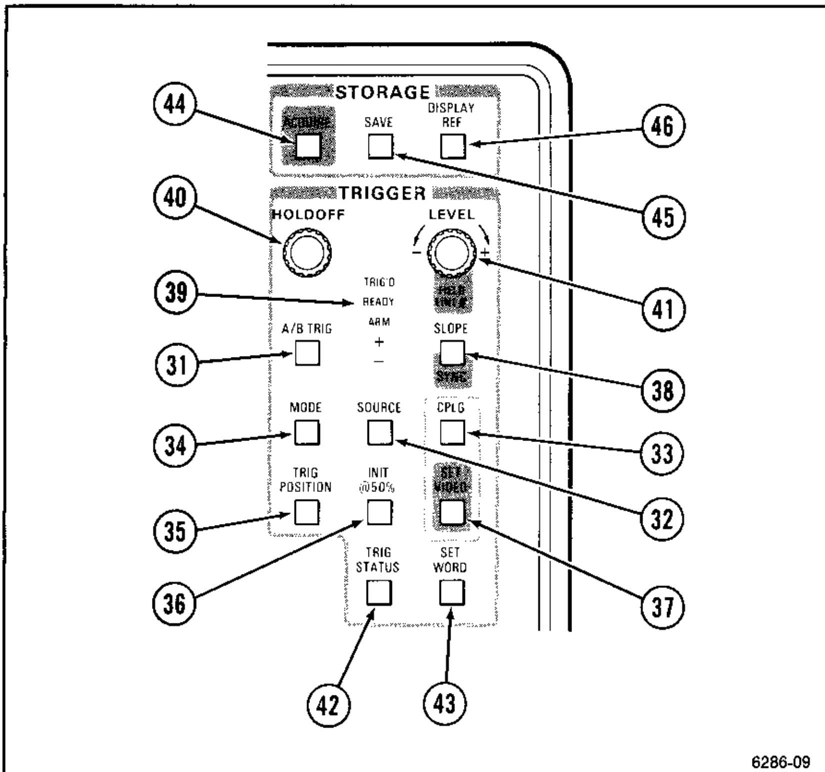


Figure 5-7. Storage and Trigger Controls.

Extended Features

HELP

"HELP" is a feature that provides readily-accessible operating information on-screen which describes the use of scope front-panel controls. To activate, first push the front panel button labeled STATUS/HELP (see button 4 in this section) to call up the STATUS menu. Next push the menu button labeled HELP to enter HELP mode.

In HELP mode, any waveforms, cursors and readouts displayed are temporarily shut off and replaced by an introduction to HELP mode. This introduction explains how further on-screen information is obtained for the front-panel controls:

> HELP MODE IS ON.
>
> PUSH THE THE FRONT PANEL BUTTONS OR TURN THE KNOBS TO CALL UP SCREENS OF INFORMATION ABOUT THE CONTROLS (THE SCOPE SETUP WILL NOT CHANGE WHILE IN HELP MODE).
>
> IF THE WORD -MORE- APPEARS ON THE BOTTOM LINE (AS IN THIS SCREEN), PUSH THE BEZEL BUTTON BELOW -MORE- TO DISPLAY FURTHER INFORMATION ABOUT THE CONTROL
>
> PUSH THE BEZEL BUTTON BELOW THE EXIT LABEL TO RETURN TO SCOPE OPERATION.
>
> -MORE- EXIT

As described by this introduction, information about each control is obtained by manipulating the desired control. Note also that additional introductory information is obtained by pushing the menu button labeled -MORE- and that EXIT must be pressed to return to normal operation from HELP mode. (Operating ANY other control or button, except for POWER, FOCUS, ASTIG, and TRACE ROTATION, displays operating information associated with that control and the function associated with the control is not implemented.)

Each HELP screen first describes the function/action corresponding to the button which the user selected. If operating the control normally calls up a menu, equivalent descriptions for each of those menus next appears. If more than 15 lines are required for the HELP screen, press the MORE menu button (bezel button 1) to display the HELP screen containing the remaining information.

This is the first HELP screen displayed when the STORAGE ACQUIRE button is pressed for HELP mode:

PUSH THIS BUTTON TO BEGIN ACQUIRING WAVEFORMS <SEE HELP FOR TRIGGER MODE> AND CALL UP THE ACQUISITION MODE MENU.

NORMAL: SELECT 'LIVE' ACQUISITION MODE.
ENVELOPE: CREATE WAVEFORM ENVELOPE BY SAVING MIN/MAX WAVEFORM POINTS DURING EACH SAMPLE INTERVAL FOR GLITCH CAPTURE AND ALIAS DETECTION. <REPET AFFECTS OPERATION AT SEC/DIVS OF 200ns/DIV AND FASTER; SEE MANUAL.> SUCCESSIVE PUSHES INCREMENT THE COUNT WHICH SET THE NUMBER OF ACQUISITIONS BETWEEN WAVEFORM RESETS. ADD AND MULT ARE TURNED OFF IN ENV MODE <SEE VERT MODE>.

-MORE- EXIT

(47) AUTO

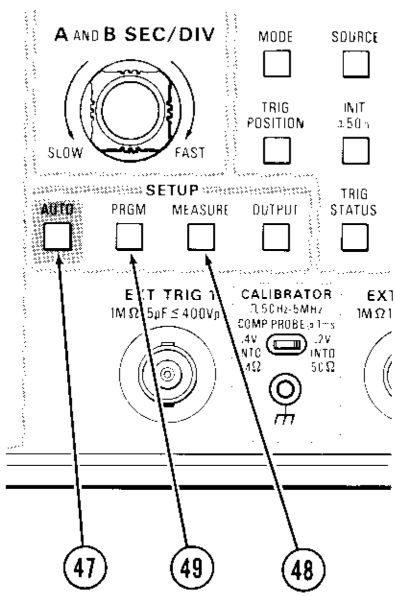
Displays the AUTOsetup menu and executes the AUTOsetup function. The AUTOsetup function causes the scope to automatically make a triggered acquisition and display it according to the modes selected in the AUTOsetup menu. If a new mode is selected from its menu, subsequent pressings of the AUTO button cause AUTOsetup to execute using the new mode.

AUTOsetup MENU

			EDGE	**RES**
VIEW	**PERIOD**	**PULSE**	_/‾ ¦ ‾_	**HI¦LO**

In AUTOsetup, the settings for VERT MODE, COUPLING, and menu for AUTOsetup all influence the scale for the scope display. See the descriptions for each AUTOsetup menu choice for information on how the vertical scale is chosen for various AUTOsetup settings. The horizontal scale setting (number of cycles of the signal displayed) is also detailed in the descriptions for each menu choice.

Regardless of the mode used, the scope must have a signal present in the channel selected that is triggerable in AUTOLEVEL setting for TRIGGER MODE (minimum frequency is 50 Hz and minimum scale is 5 mv). If no signal is present in the channel normally providing the horizontal scale, the scope sets the horizontal scale to 100 μs/DIV.



6286-12

Figure 5-8. AUTOsetup, AutoStep, and MEASURE Buttons.

VIEW

With VIEW mode selected, the user selections for VERT MODE and VERT COUPLING are retained and used to scale VOLTS/DIV and SEC/DIV. If one channel is selected, its ground reference is positioned to graticule center. The displayed acquisition is vertically scaled to fit within about 4 divisions (±2 divisions) around the ground reference (graticule center). Selection of two channels results in the CH1 ground reference being positioned +2 divisions and the CH2 ground reference being positioned −2 divisions with respect to graticule center. Both are vertically scaled to fit within about 2 divisions (±1 division) around their respective ground references.

If ADD or MULT is selected, it is displayed. However, the vertical scale and position of the ADD/MULT display is determined by the CH1 and CH2 scales and position.

In VIEW mode, waveforms are scaled for their total amplitude, ac component plus DC offset, with their ground references positioned as just described. See "DC Offset" later in this section for more information.

NOTE

The user selections for VERT COUPLING are retained for VIEW mode UNLESS GRD IS SELECTED. When ground is selected, the scope will switch the coupling setting to DC.

Horizontally, the VIEW mode displays the selected display source with 2 to 5 cycles on screen. The TRIGGER POSITION is CENTERED within the record and the TRIGGER SLOPE is positive (+).

NOTE

Although the rules for horizontally sizing the waveforms depend on the AUTOsetup mode executed, the rules for ascertaining which display source is used to determine the SEC/DIV setting are the same for all AUTOsetup modes. See "HORIZONTAL SOURCE" in this section for more information.

PERIOD

Scales the waveform for one period, triggered on the positive slope, according to the RES HI¦LO setting.

PULSE When PULSE mode is selected in the AUTOsetup menu, the waveform is horizontally scaled for the minimum pulse width, and TRIGGER SLOPE selected to display the leading edge of the selected pulse width. The minimum pulse width is the parameter scaled and positioned either on screen or within the 20 division horizontal record (see "RES HI¦LO").

EDGE (Rising) The base and top corners are located within the center 3 horizontal divisions for the RES LO setting and within the center 9 horizontal divisions for the RES HI setting. The TRIGGER SLOPE setting is (+) to display the rising edge.

EDGE (Falling) The top and base corners are located within the center 3 horizontal divisions for the RES LO setting and within the center 9 horizontal divisions for the RES HI setting. The TRIGGER SLOPE setting is (−) to display the falling edge.

RES HI¦LO Selects the type of scaling. In LO, the scaling is optimized for user viewing on screen; in HI, the scaling is optimized for maximum resolution for the MEASURE feature.

RES HI¦LO only affects PULSE, EDGE, and PERIOD modes. When any mode except VIEW is selected, the RES HI¦LO appears in the AUTOsetup menu. The influence of RES HI¦LO on the other modes is detailed in the description of those modes. In general, the RES LO setting affects the PULSE, EDGE, and PERIOD modes as follows:

Vertical Scaling

NOTE

Values (divisions) given when describing vertical sizing are target values only. The number of divisions to which the waveform is scaled depends on the available VOLTS/DIV settings and the amplitude of the waveform.

RES LO For one active channel displayed, it will be centered and scaled to about 5 divisions around graticule center.

For two active channels, both channels are scaled to about 3 divisions and centered vertically around graticule center.

For ADD displays, CH1 is scaled to about 3 divisions and vertically centered around graticule center. CH2 is scaled to the same scale as CH1 and also centered vertically around graticule center. The scale of the ADD display is the same as CH1 and CH2; the position of its ground reference baseline is the algebraic sum of the CH1 and CH2 baselines.

For MULT displays, CH1 and CH2 are scaled the same as described for two active channels, with the MULT display scaled to 5.12 $\times$ CH1 Vertical Scale Factor $\times$ CH2 Vertical Scale Factor = VOLT^2/DIV.

RES HI

For one active channel displayed, it will be centered and scaled to about 5 divisions around graticule center.

For two active channels, CH1 and CH2 are scaled to about 5 divisions and centered around the graticule center.

For ADD displays, CH1 is scaled to about 5 divisions and centered around the center graticule line. CH2 is scaled to the same scale as CH1 and and centered around the center graticule line. The scale of the ADD display is the same as CH1 and CH2; the position of its ground reference baseline is the algebraic sum of the CH1 and CH2 baselines.

For MULT displays, CH1 and CH2 are scaled the same as described for two active channels, with the MULT display scaled to 5.12 X CH1 Vertical Scale Factor X CH2 Vertical Scale Factor = VOLT^2/DIV.

NOTE

Waveforms with a large dc component relative to the ac component may be scaled mainly for DC. The vertical positioning rules described for the PERIOD, PULSE, and EDGE modes (see "Vertical Scaling" in this section) are suspended if any waveform displayed is scaled for the DC offset. Instead, AUTOsetup executes using the vertical positioning rules for VIEW. See "DC Offset" later in this section for more information.

Horizontal Scaling

RES LO The waveform parameter is scaled and displayed within the 10 horizontal divisions on screen.

RES HI The waveform parameter is scaled and displayed within the 20-division-length acquisition window.

See descriptions for the individual AUTOsetup modes for more information on how horizontal scaling is determined for a given mode.

NOTE

Values given for horizontally and vertically scaling waveform are target values only. The actual number of divisions to which a waveform or its parameter is sized depends on the available SEC/DIV settings and the time duration of the parameter.

DC Offset

The DC offset of the waveform is considered when AUTOsetup executes. In VIEW mode the waveforms are vertically scaled (as previously described) for both ac component and DC offset. For the other modes, since the scope can offset the position of a display ± 10 vertical divisions, waveforms are scaled using only their ac component if the resulting VOLT/DIV setting allows the DC offset to be compensated for within the ± 10 division position range. (Remember, the waveforms must be positioned on screen as previously described for single and dual channel displays.) However, if the ratio of the signal's total amplitude (again, peak plus offset) to the VOLTS/DIV setting necessary to display the ac component alone is greater than ten, the total amplitude of the waveform is used to determine the vertical scale.

When the scope determines that the DC offset must be used to vertically scale the waveform, it uses the VIEW mode rules for vertically scaling and positioning ALL waveforms displayed. (These rules are explained under "VIEW" earlier in this section.) After vertical scaling, the scope determines if it can trigger on the ac component. If it can trigger, it uses the criteria set in Table 5-1 to determine the horizontal scale for the display.

Whether or not DC offset of a signal affects vertical scaling depends somewhat on the VERTICAL mode and AUTOsetup mode chosen. If one or two channels are displayed, without ADD or MULT, the displayed channel(s) are affected by DC offset as just described. If ADD is displayed, it is not affected unless CH1 is, since the scale for ADD is determined by the CH1 scale.

Horizontal Source

As was indicated in the descriptions of the various AUTOsetup modes, this instrument uses different rules for determining vertical scale and position, depending on the AUTOsetup mode selected. Although the rules for horizontal scaling also are influenced by the AUTOsetup mode, the display source used to determine that scale is always determined the same way. The scope always uses the TRIGGER SOURCE setting "VERT" to determine the horizontal scale.

The setting for VERT TRIGGER SOURCE is determined by the VERT MODE setting. Therefore, the VERT MODE setting indirectly determines the source for horizontal scaling.

Table 5-1 indicates the TRIGGER SOURCE and the corresponding horizontal scale source used for various settings for VERT MODE. Note that if no signal sources are selected, CH1 will be turned ON. The scope also switches the TRIGGER SOURCE setting to VERT no matter what the previous selection might have been.

NOTE

The scope changes VERTICAL MODE, TRIGGER MODE, TRIGGER SOURCE, and TRIGGER CPLG settings required to determine the horizontal scale as described here and outlined in Table 5-1. The Trigger settings left after AUTOsetup executes are those assumed settings.

Table 5-1
Horizontal Scale Source vs. Vert Mode

Display Source	Sources[1] Switched On	Trigger[2] Source	Horizontal Scale Source
NONE	CH1	VERT CH1	CH1
CH1	NONE	VERT CH1	CH1
CH2	NONE	CH2	CH2
CH1 & CH2	NONE	VERT CH1	CH1
CH1 or CH2 & ADD/MULT	NONE	VERT ADD/CH1	ADD/CH1
ADD/MULT ONLY	NONE	VERT ADD/CH1	ADD/CH1

[1]The VERT MODE setting is changed to turn these sources on when AUTOsetup VIEW is executed.

[2]The Trigger Source is changed as listed. The scope always uses VERT for the trigger source; the source of VERT is also used to determine the horizontal scale. The scope also switches the TRIGGER MODE to AUTOLEVEL and TRIGGER CPLG to DC.

(48) **MEASURE**

Access the Waveform Parameter Extraction feature which allows the user to specify parametric waveform measurements from the scope Front Panel, Sequencer, or GPIB.

There are two modes for extraction of parameters available with the scope. The SNAPSHOT method extracts 20 different parameters, based on the last acquisition, and displays the result. The Continuous Measurement method is a dynamic method that extracts up to 4 different parameters. It continuously updates these parameters based on successive acquisition sequences, approximately every ⅓ second (except for extremely slow acquisition rates).

Pushing the front-panel button labeled MEASURE displays the 1st-Level menu. The SNAPSHOT parameter extraction function is accessed via the SNAPSHOT menu button; the continuous extraction function is accessed via the 2nd-Level menu displayed when the MEAS TYPE menu button is pressed.

MEASURE Menu (1st-Level)				
	SNAPSHOT	**MEAS TYPE**	**SETUP**	**DISPLAY ON:OFF**	**WINDOW ON:OFF**

WINDOW ON:OFF The TIME cursors can also be used to define a horizontal area on the display from which the specified parameter is extracted. When WINDOW is turned ON, the scope begins searching the waveform record, beginning at the left TIME cursor, to find adequate data to extract the user-specified parameter. The waveform record is searched until the right TIME cursor is reached. WINDOW ON is ignored until the user selects CURSOR FUNCTION and turns the TIME cursors on.

DISP ON:OFF When ON, the readout is continuously updated with the measurement results from successive acquisitions (or acquisition sequences). When OFF there is no readout for any parameters and no calculations of parameters occurs. This menu choice only affects the Continuous-Update mode for parametric measurements. (Turning a parameter on in the MEAS TYPE menu also turns DISP ON.)

SNAPSHOT To execute a SNAPSHOT parameter extraction, push the menu button labeled SNAPSHOT in the MEASURE Menu. If more than one signal source is selected for the VERTICAL MODE setting, the TARGET menu is displayed to allow user-selection of the signal source from which the parameter is to be extracted:

TARGET:

CH1 CH2 MULT/ADD REF

The TARGET menu is composed of any signal source (CH1, MULT or ADD, etc.) that is displayed. Selecting either CH1 or CH2 causes the "snapshot" of the parameters to be displayed for the selected channel (see "Snapshot Readout"). If Δ DELAY TIME is turned on and a MULT, ADD, or CH1 or CH2 signal source selected for the target, a 3rd-Level menu is displayed. This menu allows DELAY 1 OR DELAY 2 to be chosen for the parameter extraction (MULT and ADD sources display both the DELAY and Δ DELAY; CH1 or CH2 display both delays if only one channel is displayed; one or the other delay must be specified before the parameter can be extracted). If any REF waveforms are displayed and REF is selected from the TARGET menu, a different 3rd-Level menu is displayed, allowing the user to choose which REF waveform is the target. In both cases, selecting the target from the 3rd-Level menu causes the "snapshot" of the parameters to be displayed for the targeted signal source.

Snapshot Readout:

SNAPSHOT OF CHX USING MIN/MAX METHOD:

DIS= 4.35 V	TOP = 5.01 V	WID =20.3μS
MES= 2.12 V	BASE= 2.00mV	DUTY=50%
PRX=-1.23mV	MEAN= 2.32 V	FREQ=24.6kHz
MAX= 5.15 V	OVRS= 2.0%	PER =40.6μS
MID= 2.47 V	UNDS= 1.0%	RISE=28.4nS
MIN=-21.4mV	RMS= 2.65 V	FALL=18.3nS
P-P =5.36 V	AREA=47.5nVs	

DIST=90.0%	MES=50.0%	PROX=10.0%

AGAIN ↑

Pushing the AGAIN bezel button causes the scope to take another snapshot measurement. Pushing the ↑ button returns the scope to the MEASURE Menu.

SETUP

Pushing the menu button labeled SETUP in the MEASURE menu causes this 2nd-Level menu to be displayed:

--------------METHOD-------				MARK
MIN/MAX	**HIST**	**CURSOR**	**LEVEL**	**ON/OFF**

This SETUP menu is used to set up criteria for extraction of parameters, using both the Continuous-Update and SNAPSHOT features. The three buttons under the METHOD section of the menu allow the method used to determine the TOP and BASE of the targeted waveform to be selected. MARK ON|OFF allow indicators to appear on screen that mark the measurement points on the waveform when it's on. LEVEL calls up a 3rd-Level menu for user-specification of the PROXIMAL, MESIAL, DISTAL, and MESIAL2 points on the waveform.

MIN/MAX The absolute minimum (negative peak) of the targeted waveform is used as the BASE and the absolute maximum (positive peak) is used as the TOP.

CURSOR The level of the upper VOLTS Cursor (displayed or not) is used as the TOP and the level of the lower VOLTS Cursor is used as the base for the targeted waveform.

HIST Use a histogram of the vertical levels to determine the TOP and BASE for the targeted waveform:

1. Form the histogram of levels and find the mid-point of the level range.
2. Divide the histogram in two halves.
3. Use the value associated with the level bracket containing the most level points in the upper half as the TOP level; use the value associated with the level bracket containing the most level point in the lower half as the BASE.
4. In the case where two level brackets have equal level points, use the value that is most positive (largest) if determining the TOP and the most negative (smallest) if determining the BASE.

MARK ON¦OFF Allows "marks" to be turned ON or OFF for the targeted waveform. Marks indicate the points on the waveform at which time measurements take place. This menu choice affects only the Continuous-Update parametric measurements.

LEVEL Pushing the menu button labeled LEVEL displays a 3rd Level menu which allows the DISTAL, MESIAL, and PROXimal levels on the waveform to be specified:

PROXIMAL	10%
DISTAL	90%
MESIAL	50%
MESIAL2	50%

%¦VOLT Allows the user to select either the absolute level in VOLTS or percent of the total amplitude between the top and base of the waveform as the unit to express the level at the DISTAL, MESIAL, and PROXIMAL crossings. The unit can be different for the different crossings.

The percent level is changed in 1% steps, with a range of 0-100%. The voltage level is always expressed with three digits of resolution. The level is changed in one-unit steps of the least significant digit (i.e., if current setting is 1.80 V, the level is changed in 0.01-volt increments). The range for voltage level settings is ±999 V.

When INIT PANEL (PRGM menu) is executed, %¦VOLT is set to % and the levels are set as follows:

PROXIMAL	10%
DISTAL	90%
MESIAL	50%
MESIAL2	50%

Executing INIT PANEL also sets the levels for VOLT units. If INIT PANEL is executed and %/VOLT is set to VOLT for the MEASure SETUP LEVEL menu, the INIT levels are displayed as follows:

PROXIMAL	0.8 V
DISTAL	2.4 V
MESIAL	1.3 V
MESIAL2	1.3 V

DISTAL; MESIAL; PROXIMAL Selection of any of these three menu choices allows the user to set the level desired for the selected crossing type. The CURSOR/DELAY knob is used to adjust the level for the unit-type selected using %/VOLT.

MESIAL2 Selection of this menu choice allows the user to set the level desired for the second mesial crossing. This selection is only useful when DELAY is chosen as one of the parameters to be measured (continuous-type measurement only). Since DELAY is measured between mesial crossings for two waveforms and the two waveforms may have different amplitudes, MESIAL2 allows the mesial-crossing level of the delayed (non-targeted) waveform to be specified.

There are limit conditions for setting the crossing levels that must be observed. These levels must be set properly in relation to each other and must not be set outside the TOP and BASE of the target waveform. (See Appendix C for the limit conditions.) Crossing-level settings that violate these conditions cause:

- a string of "?" marks to be displayed in place of the measurement results if the mode used is SNAPSHOT.

- an error message, such as "LEVEL LIMIT?" or "LEVEL ORDER" (the message displayed depends on the criteria violated) to be displayed in place of the measurement results if the mode used is Continuous-Update.

Once the levels are set, pushing the MEASURE front-panel button displays the 1st-Level MEASURE menu. SETUP can be selected from that menu if it is desired to return to the SETUP menu.

MEAS TYPE

The Continuous-Update parameter extraction function is executed by selecting up to four parameters for display from a parameter matrix. Pushing the menu button labeled MEAS causes the Parameter Selection menu to be displayed:

DISTAL	**MESIAL**	**PROX**	**MAX**	**MID**
MIN	**PK-PK**	**TOP**	**BASE**	**MEAN**
OVRSHT	**UNDRSHT**	**RMS**	**AREA**	**WIDTH**
DUTY	**FREQ**	**PERIOD**	**RISE**	**FALL**
DELAY				

←	→	↓	**ON**	**OFF** V

This menu contains a matrix of the 21 parameters available for extraction and readout. The user selects the parameter by using the arrows to underline the parameter. The menu button labeled "→" moves the underline to the right in the row; the "←" button to the left. The downward arrow moves the underline down in any column (underline moves to the top of the column when the bottom of the column is encountered). When the end of a row is encountered, the underline jumps to the beginning of the row below if the "→" button is pushed and to the end of the row above if the "←" button is pushed (in other words, the underline "wraps around" the rows). Pushing the ON menu button turns the selected parameter on (the parameter name is bracketed with two underlined asterisks) while pushing the OFF button turns that parameter OFF (underlined asterisks are removed).

If more than one waveform is displayed (Vertical Mode or REF waveforms), turning on a parameter displays a 3rd-Level TARGET menu. This menu allows the selection of the signal source the parameter is to be extracted from:

TARGET:

CH1 CH2 MULT/ADD REF

The TARGET menu is composed of any signal source (CH1, MULT or ADD, etc.) that is displayed. Selecting either CH1 or CH2 causes the parameter to be immediately extracted, readout to be displayed, and the Parameter Selection menu to be returned for further parameter selection. If Δ DELAY TIME is turned on and a MULT, ADD, or CH1 or CH2 signal source selected for the target, a 4th-Level TARGET menu is displayed. This menu allows DELAY 1 OR DELAY 2 to be chosen for the parameter extraction (MULT and ADD displays have both the DELAY and Δ DELAY; CH1 or CH2 have both delays if only one channel is displayed; one or the other delay must be specified before the parameter can be extracted). If any REF waveforms are displayed and REF is selected from the TARGET menu, a different 4th-Level menu is displayed, allowing the user to choose which REF waveform is the target. In both cases, selecting the target from the 4th-Level menu causes the parameter extraction to occur.

NOTE

When the same parameter is being read out for more than one signal source, turning that parameter off (from the Parameter Selection menu) causes appropriate 3rd- (and 4th-, if required) Level menus to be displayed. These menus allow the user to specify for which signal source the parameter is to be turned off. Once the signal source is selected, the scope returns the Parameter Selection menu.

Selection of DELAY as the parameter to be extracted causes different 3rd- and 4th-Level Target menus to be displayed:

3rd-Level Menu:

DELAY FROM TARGET:

CH1 CH2 MULT/ADD REF

4th-Level Menu:

DELAY TO TARGET:

CH1 CH2 MULT/ADD REF

The menus are different because DELAY measurements require two signal sources. The delay FROM a mesial crossing on one source is measured TO the corresponding mesial crossing on another source. Turning DELAY on causes the 3rd-Level menu to be displayed and selecting the FROM source (target) from that menu causes the 4th-Level menu to be displayed. Selecting the TO source executes the extraction and returns the Parameter Selection menu.

Further information on measurements may be found in Appendix C.

49 PRGM

The PRGM (Program) front-panel button displays a menu choice INIT PANEL and the AUTOSTEP SEQUENCER menu. Pushing INIT PANEL sets almost all the front-panel functions to default settings. See Table B-15 in Appendix B for a list of those settings. With the AutoStep feature, users can save front-panel settings, chain them together into a sequence if desired, and perform various actions such as printing out selected parameter measurements or signaling an operator.

Basically, users label a sequence and store one or more front-panel setups under that label. For each step (each step is one front-panel setup) in a sequence, various self-test, measurement, flow-control, and I/O functions can be selected. The AutoStep Sequencer can be operated from the front panel, the GPIB, or from three BNC connectors on the back panel (these external connectors allow full 2-way handshaking for automatic handling equipment or remote semi-automatic control). Programmed sequences can be edited and stored in non-volatile memory. Over 200 program steps (front-panel setups) can be stored depending on the number of scope control-setting changes between steps.

General Description

Sequences of steps:

The Sequencer performs a preprogrammed sequence of steps. Each step consists of a scope instrument setup including selected parametric measurements and output functions, (if desired), and a set of actions for the step. Flow control to allow for an initialization routine (sequence of steps to be performed once at the beginning of the entire sequence) is provided by specifying a "REPEAT" step in the sequence. The last sequence step always transfers control to the last "REPEAT" step as shown below.

At the completion of each step an "Operation Complete" signal is generated which can be detected by the GPIB or through the special External Step Complete output. Stepping can be initiated from the front panel, the GPIB, or the external input. An additional Operation Complete is generated at the end of the sequence and is detectable via the GPIB or through the Sequence Complete output.

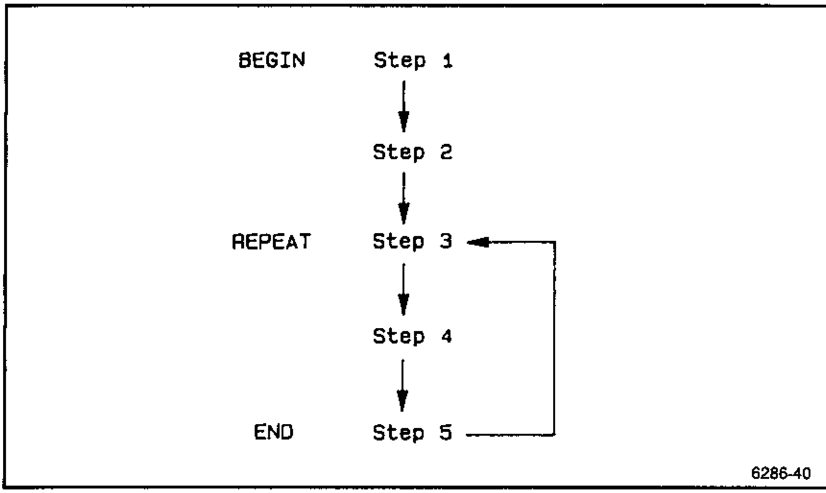


Figure 5-9. Event Order for Sequences.

Step Options (Actions):

In addition to the instrument setup and parametric measurement selection, each step can be programmed to execute one or more of the following functions:

- — REPEAT
- — SELF CALIBRATION
- — SELF TEST
- — AUTO-SETS
- — PRINT OR PLOT SELECTED WAVEFORMS AND/OR MEASUREMENTS
- — RING BELL ON COMPLETION
- — GENERATE SRQ ON COMPLETION
- — PAUSE AND WAIT FOR STEP COMMAND
- — PROTECT SEQUENCE FROM DELETION

Typical Application:

A typical application might look like this:

STEP NO.		Attributes Included	Front-Panel Action
1	(START)	SELF CAL SELF TEST	Set to Init Panel.
2		REPEAT AUTOsetup PRINT/PLOT	Set up for display and printing of waveform.
3		AUTOsetup PRINT/PLOT	Change AUTOsetup to allow triggering on the rising edge. Set RISE on for the Continuous MEASURE feature to extract the rise time parameter.
4	(DONE)	AUTOsetup BELL SRQ PAUSE	Change AUTOsetup to allow triggering on the falling edge. Set Fall on for the Continuous MEASURE feature to extract the fall time parameter.

When started at step 1, this sequence first performs a SELF CAL and SELF TEST, and then initializes the front-panel to INIT PANEL. It then repeatedly executes the REPEAT through DONE block, comprised of steps 2 through 4, printing the waveform, the rise time, and the fall time. AUTOsetup is done at each step to optimize the acquired data for the measurements. The program halts at the last step each time, rings the bell, and waits for the operator to install another test device and give it a step command to begin testing.

NOTE

When including the AUTOsetup or PRINT/PLOT actions in a step, the modes for AUTOsetup and OUTPUT should be set prior to entering the ACTIONS menu just as for any other front panel control. The instrument uses the setups in effect at the time the step is stored when the sequence is run. See button 47, "AUTO" and 24, "OUTPUT" for information on setting modes.

Operation

Selecting the Sequencer:

As indicated earlier, pressing the front-panel button "SETUP PRGM" accesses the SEQUENCE menu. The following 1st-Level menu is displayed:

				MEMORY nn%
————————SEQUENCE————————				**INIT**
SAVE	**RECALL**	**DELETE**	**EDIT**	**PANEL**

Now users can select any of four operations (as well as initialize the front panel via the INIT PANEL bezel button). The percent of sequencer memory available for new sequences is shown in this menu.

SAVE Option:

Press the SAVE bezel button to generate a new sequence of steps. This requires the three submenus discussed below.

2nd-Level Menu

The first menu to appear after the SAVE option is selected is the sequence name menu shown below:

USE ARROW KEYS TO CHANGE NAME: nn

————————————————————————

ROLL-CHARS		**CURSOR**		
↑	↓	<>	**SAVE**	**EXIT**

This menu allows the sequence to be labeled with a six-character alphanumeric name. The two-digit number at the end of the first line is a default name selected when this menu was entered. The user can save the sequence under the two-character default name or create another name. The CURSOR bezel button moves the cursor left and right in the name field (the cursor and the name field are displayed immediately after "NAME:"), and the two bezel buttons under ROLL-CHARS select a character. Pressing the ↓ steps forward through the alphabet first, and then through the digits 0-9. The ↑ steps from 9-0 and then from Z-A.

When the name selection is complete, press the SAVE button. This creates a new sequence with the selected name. If a name is not entered by the user, the sequence is given the specified two-character default name. Pushing the EXIT button aborts the sequence creation and returns to the 1st-Level AUTOSTEP SEQUENCER menu.

NOTE

Labels (names) can be created with as few as one character and any character position (1-6) can be left blank. Simply press SAVE when the label has the number of characters wanted in the positions desired.

Front Panel Setup Message

When the bezel button labeled SAVE is pressed, the scope displays this message:

SETUP CONTROLS, PUSH PRGM TO CONTINUE
SEQUENCE<name> STEP<num> MEMORY<%>

At this point, adjust the front-panel controls to set up the scope for the desired measurement. Here, any AUTOsetup or OUTPUT modes and any parameters to be measured (parameter selection is made via the MEASURE menu—see "48-MEASURE" in this section for more information) are specified for that sequence step. While this message is displayed, all scope controls except the PRGM button function normally. Hence, the instrument can be set up in any operating mode and any available parameter can be specified for the step number displayed. When the setup is complete and the parameter to be measured specified, press the PRGM front-panel button to proceed to the SET STEP ACTIONS menu.

SET STEP ACTIONS Menu.

This 3rd-Level menu appears after the hardware setup menu is exited with a PRGM button push:

```
SEQUENCE <name> STEP <num> MEMORY<%>

      BEGIN STEP               .....................
      REPEAT          <N> :                 :
      SELF-CAL        <N> :     PRINT/PLOT <N>
      SELF-TEST       <N> :     BELL       <N>
      LOAD PANEL          :     SRQ        <N>
      AUTOSETUP       <N> :     PAUSE      <N>
      MEASUREMENTS        :     PROTECT    <N>
            :             :     END STEP
            :.............:

SET STEP ACTIONS
NEXT       SAVE
↑     ↓    Y!N      STEP      SEQ
```

This menu allows one or more actions to be associated with the step just setup. By using the arrow-labeled bezel buttons, the user can move to any selectable action in the menu and turn it on or off (include it or not include it in the step) using the Y!N (yes!no) menu button.

Selectable actions are as follows:

REPEAT Selects the current step as the start of an infinite loop between the current step and the last step. Sequences can be aborted during execution by pressing the PRGM button.

SELF-CAL Performs the SELF-CALibration routine prior to loading the instrument setup. Failure to pass the routine terminates the sequence and displays the EXTENDED DIAGNOSTICS menu.

SELF-TEST	Performs self-diagnostics prior to loading the instrument setup. Failure to pass the diagnostics terminates the sequence and displays the EXTENDED DIAGNOSTICS menu.
AUTOSETUP	Performs an automatic setup of the instrument front-panel after loading the user-specified front panel setup and prior to any measurements.
PRINT/PLOT	Outputs acquired waveforms and other data via the GPIB for the step associated with this action. The user must set the OUTPUT menu up to configure the scope properly for the type of communication desired. The communications can be either controller-directed, or prints or plots can be output directly to certain devices. See button "24 OUTPUT" for more information.
BELL	Rings the instrument's bell at the steps completion to signal operator. The bell must be enabled via the EXTENDED FUNCTIONS menu.
SRQ	Generates STEP COMPLETE and/or SEQUENCE COMPLETE "Operation Complete's" on the GPIB at step completion.
PAUSE	Stops at the end of the step and waits for operator command to advance, either by pressing PRGM or providing a GPIB STEP command or rear panel SEQ INPUT. Paused sequences can be terminated by pressing the EXIT button in the menu displayed at the pause, or by a GPIB HALT command.

PROTECT If this action is selected on the first step of a sequence, the sequence cannot be accidentally deleted. PROTECT can be defeated by deleting the first step or editing that step to turn the PROTECT action off (set to "N").

NOTE

The ACTIONS displayed for selection are shown in the order in which they occur when a step in a sequence executes. BEGIN and END are not actions but merely mark the beginning and end of the step. LOAD PANEL and MEASUREMENTS are actions which are not user selectable. The location of these actions in the list indicates where the front-panel setup (LOAD PANEL) and the parameter specification (MEASUREMENTS) (both stipulated before PRGM was pushed) are implemented during execution of the step.

The process of specifying steps and actions for steps can continue by pressing the menu button NEXT STEP. This causes the display to return to the setup message displayed previously. The user can then specify the setup and the parameter for the next step in the sequence and follow with the action specification for that step. Once all the steps have been specified, the user can return from the SET STEPS ACTIONS menu by pressing the SAVE SEQ menu button. The sequence creation is then complete and the scope is returned to the 1st-Level AUTOSTEP SEQUENCE menu (the message "SEQUENCE SAVED" is displayed in the menu). RECALL Option:

If the RECALL option is selected from the 1st-Level AUTOSTEP SEQUENCE menu, the sequence selection menu shown below is displayed:

—SELECT —

↑ ↓ **RECALL** **EXIT**

Above the menu all current sequence names are displayed in columns with the one currently selected underlined. The arrow-labeled menu buttons are used to move the underline to any sequence name desired (underlining the name selects that sequence). Pushing the RECALL menu button executes the sequence. The sequence can also be started via the GPIB or through the external Sequencer input. Pushing EXIT returns to the 1st-Level menu without executing the sequence. (Also, sequences can be terminated during execution by pressing the PRGM button or by a GPIB HALT command.)

DELETE Option

If the DELETE option is selected from the main Sequencer menu, the sequence selection menu shown below is displayed:

—SELECT—
↑ ↓ **DELETE** **EXIT**

Above the menu all current sequence names are displayed and the one currently selected is underlined. Using the arrow keys selects a different sequence. Pushing the DELETE bezel button deletes the selected sequence from memory. EXIT returns to the 1st-Level SEQuencer menu.

NOTE

While a sequence is being deleted the message "RECLAIMING FREED MEMORY..." is displayed on the screen and front panel controls are locked. Turning off the instrument while it is reclaiming memory can result in the loss of stored sequences.

EDIT

If the EDIT function is selected from the 1st-Level menu, the 2nd-Level Sequence Selection menu shown below is displayed:

—SELECT SEQ—
↑ ↓ **EDIT** **COPY** **EXIT**

Above the menu all current sequence names are displayed with the one currently selected underlined. Using the arrow keys selects a different sequence. Pushing the EDIT bezel button causes the Step Edit menu to be displayed. EXIT returns to the 1st-Level SEQuencer menu.

STEP EDIT MENU

The 3rd-Level menu is displayed when EDIT is pushed:

SETUP CONTROLS AND PUSH PRGM TO CONTINUE
SEQUENCE<name> STEP<num> MEMORY<%>
SELECT STEP DELETE
↑ ↓ TO BUF ADD EXIT

This menu contains the message displayed when the sequence steps were created using the previously described method. With the Step Edit menu, however, any step in the selected sequence can be chosen for editing using the arrow-labeled menu buttons under the SELECT STEP menu label. The user changes the front-panel settings and parameter specification as desired and pushes the front-panel button "PRGM" to display the SET STEP ACTIONS menu. The actions are then changed as desired. Pushing the menu button labeled NEXT STEP returns to the Step Edit menu and selects the next step (the user can change the step selected as desired).

Steps can also be added and existing steps deleted while in the Step Edit menu. Pressing DELETE TO BUFfer eliminates the currently selected step from the sequence and stores it in a buffer where it can be recovered later. Pressing ADD causes the Add Step menu to be displayed.

Add Step Menu

The Add Step menu allows steps to be added to a sequence. Steps can be added either by modifying the setup from the previous step using the scope front-panel controls, or by using or modifying any step previously deleted into the step buffer. On entering the add step menu, the front-panel setup and the actions are set to those of the previous step and the following menu is displayed:

SETUP CONTROLS AND PUSH PRGM TO CONTINUE
SEQUENCE<name> STEP<num> MEMORY<%>

LOAD
BUFFER **EXIT**

Pressing the LOAD BUFFER button replaces the current front-panel setup and step actions with those currently in the step buffer. Any front panel changes can be made before it is added by using the front-panel controls. When complete, pushing the PRGM button adds the hardware setup to the sequence and places the scope in the action selection menu (see above) so the added step's actions can be selected. The EXIT button returns to the main AUTOSTEP SEQUENCER menu without adding a new step.

Rear Panel

Refer to Figure 5-10 for location of Items 50 through 60.

(50) **GPIB Connector** Provides a data output port with the IEEE-488 data bus. The electrical and physical arrangement of the 24-pin connector conforms to the IEEE General Purpose Interface Bus Standard. Refer to Figure 5-11 for an illustration of the connector and pin assignments.

(51) **Detachable-Power-Cord Receptacle** — Provides the instrument connection point to the appropriate ac voltage.

(52) **LINE VOLTAGE SELECTOR Switch** — Selects the nominal operating voltage for the instrument. When set to 115 V, the instrument operates from a power source range of 90 V to 132 Vac. When set to 230 V, the instrument operates from an input voltage range of 180 V to 250 Vac.

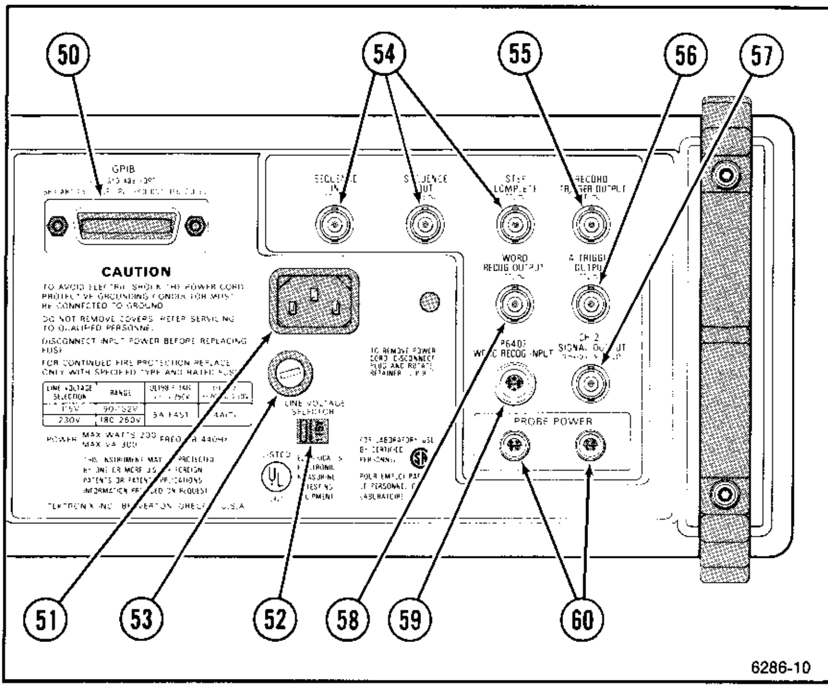


Figure 5-10. Rear Panel Controls and Connectors.

53	**Fuse Holder**	Contains the primary ac power-source fuse.
54	**SEQUENCE IN, SEQUENCE OUT, and STEP COMPLETE**	These TTL-compatible outputs are used with the sequencer for the following purposes: SEQUENCE IN: This input restarts the sequence after a pause. SEQUENCE OUT: A HI to LO transition on this output signals the end of a sequence. While a sequence is in progress this output is high. STEP COMPLETE: A HI to LO transition on this output signals the end of a step in a sequence. While a step is in progress this output is high. See "PRGM" in this section for more information on the Sequencer.
55	**RECORD TRIGGER OUTPUT Connector**	Provides a negative-true TTL-compatible record trigger signal for use as a trigger with external instrument systems (see Figure B-2 in Appendix B of this manual).
56	**A TRIGGER OUTPUT Connector**	Provides a negative-true TTL-compatible A Trigger signal for application to external instrument systems.
57	**CH 2 SIGNAL OUTPUT Connector**	Provides an output signal that is representative of the Channel 2 input signal. The output amplitude into a 50-Ω load is approximately 10 mV per division of input signal.

(58)	**WORD RECOG OUTPUT Connector**	Provides a negative-true, TTL-compatible Word Trigger signal for use with external test equipment (see Section 7, "Options").
(59)	**P6407 WORD RECOG INPUT Connector**	Provides a dedicated control signal port for programming the optional Word Recognizer Probe and obtaining the word trigger output for use as the A and/or B trigger signal source (see Item 32 "SOURCE" and Item 43 "SET WORD" in this section).
(60)	**PROBE POWER Connectors (Option 11)**	Provides output power for optional Tektronix active probes.

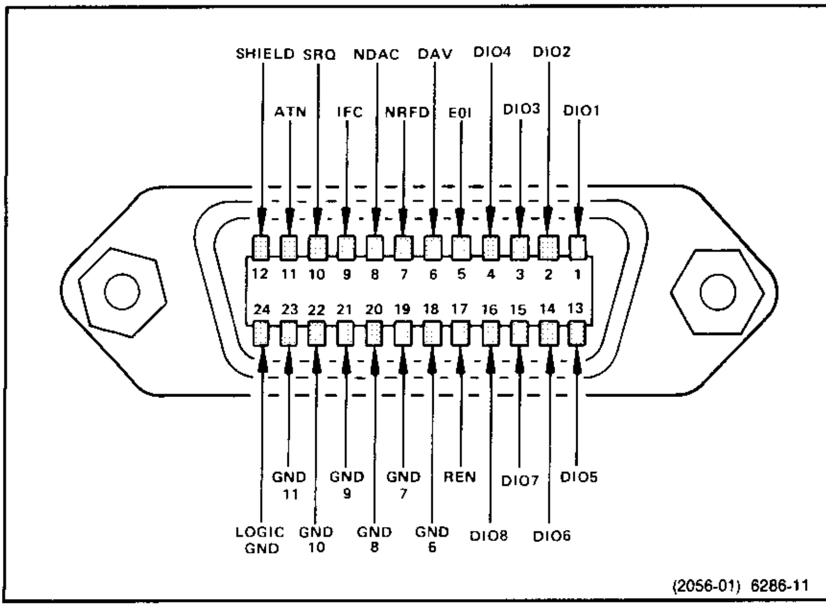


Figure 5-11. GPIB Connector pin arrangement.

System Menus

The following information is an annotated list of the menus used to control operation of the scope from the front panel. Each menu is an extension of the front-panel control button that calls it up. The menus replace multi-position front-panel switches by providing the same functions using the firmware-defined buttons mounted in the CRT bezel. Most of the menus are only one level deep, and the choices displayed by a press of the front-panel button are self-explanatory. Table 5-2 is a reference listing of each 1st-Level menu and any sub-level menus called up from the 1st-Level menu where applicable.

The listing corresponds with the labeled front-panel buttons which call up the menu on the CRT. The table menus are grouped by major system functions in the following order: CRT Display, Vertical, Cursor, Delay, Storage, A and B Trigger, Word Recognizer, Output, and SETUP.

Table 5-2
Control Menus and Displays

CRT Display Menus

SELECT

INTENSITY READOUT	DISP	INTENS	GRAT	VECTORS ON¦OFF

STATUS/HELP

Presents an instrument status display and increases the readout intensity to 65% to ensure visibility (see Figure 5-2). The HELP function can also be enabled from this menu.

MENU OFF/EXTENDED FUNCTIONS

Turns off any menu being displayed or, if none is one, calls up the EXTENDED FUNCTIONS menus. See Appendix A for the Extended Functions Calibration and Diagnostics menus.

EXT FUNCT

		SYSTEM	SPECIAL	CAL/DIAG

Second-level menu for SYSTEM.

PANEL	MISC	PREFLT ON¦OFF		VIDEO OPT

Third-level menu for PANEL.

PWR ON LAST¦INIT				↑

Third-level menu for MISC.

BELL ON¦OFF	TRIG T ON¦OFF			↑

Third-level menu for VIDEO OPT

TV SYS M¦NON/N	CNT RST BOTH¦F1			↑

Second-level menu for SPECIAL. (Use of these functions by the operator will cause the instrument to need a complete calibration to return it to normal operation. The selections may be internally disabled.)

WARNING: SERVICE ONLY—SEE MANUAL (if enabled)
DISABLED—SEE MANUAL (if disabled)

COLD START			CAL PATH ON¦OFF	FORCE DAC

Table 5-2 (cont)

VERTICAL Control Menus				
VERTICAL MODE				
In YT Mode				
VERTICAL MODE				
CH1	CH2	ADD	MULT	YT¦XY
In XY Mode				
VERTICAL MODE				
CH1 vs CH2				YT¦XY
VARIABLE				
CH1 VARIABLE				
CAL	↓	↑		
CH3 VARIABLE				
CAL	↓	↑		
COUPLING/INVERT				
CH1 COUPLING			50 Ω	INVERT
AC	DC	GND	ON¦OFF	ON¦OFF
CH2 COUPLING			50 Ω	INVERT
AC	DC	GND	ON¦OFF	ON¦OFF
BANDWIDTH				
USB=xxxxHz		USR=xxxx s		
--------------BANDWIDTH------------------			SMOOTH	
20 MHz	50 MHz	FULL	ON¦OFF	

The number xxxx depends on the Acquisition Mode, the SEC/DIV setting, and the bandwidth selected.

Table 5-2 (cont)

CURSOR Control Menus

FUNCTION

CURSOR FUNCTION

VOLTS TIME V@T SLOPE 1/TIME

Second-level ATTACH CURSORS menu.

In YT Mode.

ATTACH CURSORS TO:

No Δ delay

CH1 CH2 (func) (func)Δ REF n

Δ delay—CH1 on

CH1 CH1Δ (func) (func)Δ REF n

Δ delay—CH1 and CH2 on

CH1 CH2Δ (func) (func)Δ REF n

Function is either ADD or MULT; they are mutually exclusive. Pressing REF rolls through the displayed reference waveforms. Only waveforms called up for display are included in the ATTACH CURSORS menu.

In XY Mode.

ATTACH CURSORS TO:

CH1 vs CH2 XYREF

UNITS in VOLTS or V@T

UNITS VOLTS CURS REF=xxxxxx
VOLTS % dB NEW REF Δ¦ABS

In SLOPE

UNITS SLOPE CURS REF=xxxxxx
SLOPE % dB NEW REF

---

in 1/TIME

UNITS 1/TIME CURS REF=xxxxxx
Hz % DEGREES NEW REF Δ¦ABS

---

in TIME

UNITS TIME CURS REF=xxxxxx
SEC % DEGREES NEW REF Δ¦ABS

Table 5-2 (cont)

DELAY Control Menus

DELAY by TIME (with ΔTIME OFF)

DELAY TIME = xxxxxx s	ΔTIME ON¦OFF

(with ΔTIME ON)

DELAY TIME = xxxxxx s ΔDELAY TIME = xxxxxx s	ΔTIME ON¦OFF

DELAY by TIME button is pressed to switch the effect of the CURSOR/DELAY position knob between the Main DELAY TIME and the Δ (delta) DELAY TIME.

DELAY by EVENTS

EVENTS START AT A TRIG EVENTS COUNT = xxxxx B TRIGS	EVENTS ON¦OFF

Events count may be changed using the Cursor Delay position.

STORAGE Control Menus

ACQUIRE

ACQUIRE NORMAL	nnn ENVELOPE	nnn AVG	REPET ON¦OFF	SAVE ON Δ ON¦OFF

nnn selections:
ENVELOPE—1,2,4,8,16,32,64,128,256,CONT
AVG—2,4,8,16,32,64,128,256

SAVE

----------SAVEREF SOURCE----------

CH1	CH2	(function)	REF	STACK REF

Second-level menu displayed after SAFEREF SOURCE (except SAVEREF) is selected.

-------SAVEREF DESTINATION------

REF1	REF2	REF3	REF4	SAVEREF SOURCE

Second-level menu if in Δ (delta) DELAY by TIME.

SAVEREF SOURCE - (channel)
DELAY 1 DELAY 2

Second-level menu if REF is selected.

SAVEREF SOURCE - REF

REF1	REF2	REF3	REF4	SAVEREF SOURCE

Table 5-2 (cont)

DISPLAY REF In YT Mode.

DISPLAY REF				HORIZ POS
REF1	REF2	REF3	REF4	REF

In XY Mode

	HORIZ
XYREF	POS REF

Second-level menu displayed when HORIZ POS REF is called.

---------HORIZONTAL POSITION -------				REF HPOS
REF1P	REF2P	REF3P	REF4P	IND¦LOCK

A TRIGGER Control Menus

TRIGGER MODE

A TRIGGER MODE

AUTO			SINGLE
LEVEL	AUTO	NORMAL	SEQ

AUTO switches to ROLL at 100 ms/div and slower.

TRIGGER SOURCE

A TRIG SOURCE

VERT	CHAN			
CH1	1¦2	EXT	LINE	A*B¦WORD
CH2				
ADD				

Second-Level menu for EXT.

A EXT				
SOURCE	--------A and B EXT GAIN----------			
1¦	EXT 1	EXT 1/5	EXT 2	EXT 2/5

TRIGGER CPLG

Without the Video option.

A COUPLING		-----------------REJECT --------------------		
DC	AC	NOISE	HF	LF

With the Video option installed.

A COUPLING		-------------- REJECT ----------------------		
DC¦AC	VIDEO	NOISE	HF	LF

Table 5-2 (cont)

A TRIGGER Control Menus (cont)				
SET VIDEO (Video Option only)				
A VIDEO COUPLING				CLAMP
FIELD1	FIELD2	ALT	TV LINE	ON¦OFF
FIELD2 and ALT are displayed only when the Video Option has an interlaced video signal applied. CLAMP remains ON even if TV COUPLING is not selected.				
TRIG POSITION				
A TRIGGER POSITION				
1/8	1/4	1/2	3/4	7/8

B TRIGGER Control Menus				
TRIGGER MODE				
B TRIG	RUNS AFTER	TRIG AFTER		EXT CLK ON¦OFF
TRIGGER SOURCE In B TRIG AFTER Delay Mode.				
B TRIG SOURCE				
b, EXT CLOCK SOURCE			(with EXT CLOCK)	
B, EVENTS SOURCE			(with DELAY by EVENTS)	
B, EXT CLK, EVNT SOURCE			(with both)	
SOURCE				
VERT	CHAN	EXT		
CH1	1¦2		WORD	
CH2				
ADD				
In B RUNS AFTER Delay Mode.				
B TRIG SOURCE				
EXT CLK SOURCE				
EVENTS SOURCE				
EVENTS, EXT CLK SOURCE				
SOURCE				
VERT	CHAN	EXT		
CH1	1¦		WORD	
CH2				
ADD				
Second-Level menu for for EXT.				
A EXT SOURCE	----------A and B EXT GAIN ----------			
1¦2	EXT 1	EXT 1/5	EXT 2	EXT 2/5

Table 5-2 (cont)

TRIGGER CPLG In B TRIG AFTER Delay Mode.

B COUPLING
B, EXT CLK CPLG (with EXT CLOCK)
B, EVENTS CPLG (with DELAY by EVENTS)
B, CLK, EVENTS (with both

			------REJECT----	
DC	AC	NOISE	HF	LF

In B RUNS AFTER Delay Mode.

B COUPLING
EXT CLK CPLG (with EXT CLOCK)
EVENTS CPLG (with DELAY by EVENTS)
CLK, EVENTS (with both)

			--------REJECT------	
DC	AC	NOISE	HF	LF

TRIG POSITION

B TRIGGER POSITION

1/8	1/4	1/2	3/4	7/8

EXTERNAL Trigger and Trigger Status Menus

TRIG STATUS

TRIG STATUS

A*B MODE	SOURCE	CPLG	TRIG POS

A (Setup conditions for the A Trigger controls.)
B (Setup conditions for the B Trigger controls.)

WORD RECOGNIZER Control Menus

SET WORD

RADIX	----------- CLOCK ----------			SET
OCT:HEX	_/‾	‾_	ASYNC	BITS

SET BITS 2nd-Level menu.

In Hexadecimal:

TRIG WORD:
CLK= _/‾ ???? x x xxxx xxxx xxxx xxxx
1 0 X ← →

In Octal:

TRIG WORD:
CLK= ‾_ ?????? x x xxx xxx xxx xxx xxx
1 0 X ← →

Table 5-2 (cont)

SETUP MENUS

AUTOSETUP

			EDGE	RES
VIEW	PERIOD	PULSE		HILO

MEASURE

	MEAS	SETUP	DISPLAY	WINDOW
SNAPSHOT	TYPE		ONOFF	ONOFF

2nd-Level menu for SNAPSHOT when more than one display source is displayed.

TARGET:

CH1	CH2	MULT/ADD	REF

Resulting display when either SNAPSHOT is pressed and only one display source is on screen or when the TARGET waveform is selected.

SNAPSHOT READOUT:

SNAPSHOT OF CHx USING MIN/MAX METHOD:

DIS= 4.35 V	TOP = 5.01 V	WID =20.3μS
MES= 2.12 V	BASE= 2.00mV	DUTY=50%
PRX=−1.23mV	MEAN=2.32 V	FREQ=24.6kH
MAX= 5.15 V	OVRS= 2.0%	PER =40.6μS
MID= 2.47 V	UNDS= 1.0%	RISE=28.4nS
MIN=−21.4mV	RMS= 2.65 V	FALL=18.3nS
P-P =5.36 V	AREA=47.5nVs	
DIST=90.0%	MES=50.0%	PROX=10.0%
AGAIN		

EXIT: Returns the scope to the MEASURE Menu.

2nd-Level menu for SETUP.

---------METHOD-----------		MARK
MIN/MAX HIST CURSOR	LEVEL	ON/OFF

This menu is used to set up criteria for extraction of LEVEL: Pushing the menu button labeled LEVEL displays a 3rd Level menu which allows the DISTAL, MESIAL, and PROXimal levels on the waveform to be specified:

3rd-Level menu for LEVEL

ADJUST LEVELS WITH CURSOR/DELAY KNOB

nn%	nn%	n.nV	nn%	
DISTAL	MESIAL	PROXIMAL	MESIAL2	%/VOLT

Table 5-2 (cont)

SETUP MENUS (cont)

2nd-Level menu for MEAS TYPE.

MEAS TYPE: The continuous parameter extraction function is executed by selecting up to four parameters for display from a parameter matrix. Pushing the menu button labeled MEAS causes the Parameter Selection menu to be displayed:

DISTAL	MESIAL	PROX	MAX	MID
MIN	PK-PK	TOP	BASE	MEAN
OVRSHT	UNDRSHT	RMS	AREA	WIDTH
DUTY	FREQ	PERIOD	RISE	FALL
DELAY				
←	→		ON	OFF

3rd-Level menu for SNAPSHOT when more than one display source is displayed and DELAY is not selected in the parameter matrix.

TARGET:
CH1 CH2 MULT/ADD REF

Selection of DELAY as the parameter to be extracted causes different 3rd- and 4th-Level Target menus to be displayed:

3rd-Level menu for SNAPSHOT when more than one display source is displayed and DELAY is selected in the parameter matrix.

DELAY FROM
TARGET:
CH1 CH2 MUL/ADD REF

4th-Level menu for SNAPSHOT when more than one display source is displayed and DELAY is selected in the parameter matrix.

DELAY TO
TARGET:
CH1 CH2 MUL/ADD REF

Table 5-2 (cont)

SETUP MENUS (cont)

OUTPUT

STATUS	SETUP	DEBUG	TRANSMIT/(PRINT)	

STATUS calls up an on-screen display of most GPIB parameters that might interest a system user.

TRANSMIT/(PRINT) switches to ABORT when the function is active. TRANSMIT/(PRINT) is off in OFF BUS mode.

GPIB SETUP 2nd-Level menu.

MODE	TERM	ADDR	ENCDG	

GPIB MODE 3rd-Level menu.

T/ONLY	L/ONLY	T/L	DEVICES	OFF BUS

Selecting DEVICES changes TRANSMIT to PRINT in the OUTPUT control menu. Selecting OFF BUS turns off the TRANSMIT/PRINT choice.

DEVICES 4th-Level menu.

HPGL PLOTTER	THINKJET PRINTER		SETUP	

SETUP 5th Level menu.

SETTINGS ONOFF	TEXT ONOFF	GRAT ONOFF	WFM ONOFF	PGSIZE USA4

GPIB T/ONLY 4th-Level menu.

--------SEND CURVE----------- ONLY	WFMPRE/CURVE	SEND PRGM		

GPIB TERM 3rd-Level menu.

EOI	LF/EOI			

GPIB ADDR 3rd-Level menu.

GPIB ADDRESS		= ↑		nn ↓

Table 5-2 (cont)

GPIB ENCDG 3rd-Level menu.

---------WHOLE WFMS---------			PARTIAL WFMS	
ASCII	RP	RI	RP	RI

RI encoding is two's-complement format. RP is positive-integer format. At power-on the scope assumes that the data is formatted RI. The user must select RP or send ENCDG RP to get positive-integer formats interpreted correctly.

GPIB DEBUG 2nd-Level menu.

DEBUG	-----MONITOR-----		-SCREEN UPDATE-	
ONOFF	BUSSCOPE	INOUT	SLOW	PAUSE

PRGM (AutoStep Sequencer)

				MEMORY nn%
------------SEQUENCE--------------				INIT
SAVE	RECALL	DELETE	EDIT	PANEL

Level 2 menu for SAVE.

USE ARROW KEYS TO CHANGE NAME:

ROLL-CHARS		CURSOR		
↑	↓	<>	SAVE	EXIT

Instruction message displayed after pushing SAVE. (This message is displayed any time the user is expected to setup the Front-panel controls).

SETUP CONTROLS, PUSH PRGM TO CONTINUE
SEQUENCE <name> STEP <num> MEMORY <%>

3rd-Level menu for SAVE. This menu is displayed after pushing PRGM as instructed in in the instruction message.

SEQUENCE <name> STEP <num> MEMORY<%>

BEGIN STEP	....		
REPEAT	<N> :	:	
SELF-CAL	<N> :	PRINT/PLOT	<N>
SELF-TEST	<N> :	BELL	<N>
LOAD PANEL	:	SRQ	<N>
AUTOSETUP	<N> :	PAUSE	<N>
MEASUREMENTS	:	PROTECT	<N>
:	:	END STEP	
:..............................:			

SET STEP ATTRIBUTES

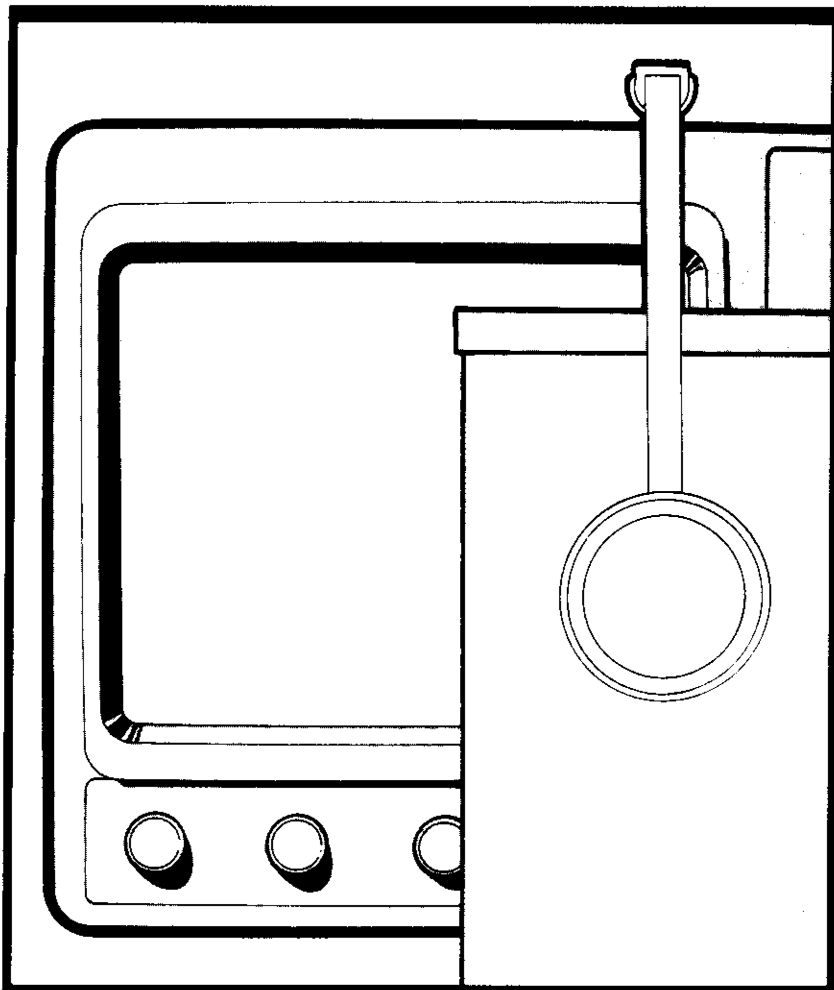
			NEXT	SAVE
↑	↓	YN	STEP	SEQ

Table 5-2 (cont)

SETUP MENUS (cont)
2nd-Level menu for RECALL. 1st Labeled Sequence 2nd Labeled Sequence nth Labeled Sequence --SELECT-- ↑ ↓ RECALL EXIT
2nd-Level menu for DELET. 1st Labeled Sequence 2nd Labeled Sequence nth Labeled Sequence --SELECT-- ↑ ↓ DELETE EXIT
2nd-Level menu for EDIT. 1st Labeled Sequence 2nd Labeled Sequence nth Labeled Sequence --SELECT SEQ-- ↑ ↓ EDIT COPY EXIT
3rd-Level menu for EDIT. SELECT STEP DELETE ↑ ↓ TO BUF ADD EXIT
4th-Level menu displayed for COPY. USE ARROW KEYS TO CHANGE NAME: ROLL-CHARS CURSOR ↑ ↓ <> SAVE EXIT
4th-Level menu for ADD. LOAD BUFFER EXIT

SECTION 6

Performance Characteristics



Performance Characteristics

Introduction

The TEKTRONIX 2430A Digital Oscilloscope is a portable, dual-channel instrument with a maximum digitizing rate of 100 Megasamples per second. The scope is capable of simultaneous acquisition of Channel 1 and Channel 2 input signals. It has a real-time useful storage bandwidth of 40 MHz for single-event acquisitions, with an equivalent-time bandwidth of 150 MHz when repetitive acquisitions are acquired. Since both channels are acquired simultaneously, the XY display is available to full bandwidth. Options include a Word Recognition Probe, Video signal triggering, Probe Power, and Rackmounting.

The instrument is microprocessor-controlled and menu-driven, displaying at the top of the screen alphanumeric CRT readouts of the vertical and horizontal scale factors, trigger levels, trigger source, and cursor measurements. Menus, displayed at the bottom of the CRT display, are used by the operator to select the operating mode.

A user makes decisions as to what operation and mode setup the instrument must have to make the measurement wanted and then selects the proper functions using a combination of front-panel buttons and the displayed menu.

Five menu buttons mounted on the CRT bezel are used to make selections from the entry choices displayed. The top line of the menu display usually contains the menu title, and the bottom line labels the buttons with the control functions they select. The selection is made (indicated by an underscoring of the menu label in the display) when the bezel button below the selected function is pressed. The menus, system operating modes, and auxiliary functions are described in Section 5, "Controls, Connectors, and Indicators", and the "Getting Acquainted" procedure in Section 1 familiarizes the user with menu operation.

Vertical System

The two vertical channels have calibrated deflection factors from 2 mV to 5 V per division in a 1-2-5 sequence of 14 steps. Use of coded probes having attenuation factors of 1X, 10X, 100X, and 1000X extends the minimum sensitivity to 5,000 V per division (with the 1000X probe) and the maximum sensitivity to 200 μV per division (using a 1X probe in SAVE or AVERAGE expanded mode).

VOLTS/DIV readouts are automatically switched to display a correct scale factor when properly coded probes are attached. Each channel can be separately inverted. ADD and MULT are display functions provided by the processor system.

In SAVE mode, the waveforms may be both horizontally and vertically repositioned, expanded horizontally and vertically, added to each other, or multiplied together for either XY or YT displays.

Horizontal System

Horizontal display modes of A, A INTEN, and B Delayed are available. The time base has 28 calibrated SEC/DIV settings in a 1-2-5 sequence from 5 ns per division to 5 s per division. An External Clock mode is provided that accepts clocking signals from 1 MHz to 100 MHz.

The B Trace and the intensified zone on the A INTEN Trace may be delayed by time with respect to the A trigger, and a DELAY by EVENTS function permits the A display to be delayed by a selected number of B Trigger events. In the case of DELAY by EVENTS, the B Trigger SOURCE, COUPLING, SLOPE, and LEVEL controls define the nature of the signal needed to produce events triggering. The number of events required to satisfy the delay may be set from 1 to 65,536, with a resolution of one event. The DELTA DELAY feature produces two independently settable delayed B Traces in DELAY by TIME.

Trigger System

The trigger system of the scope provides many features for selecting and processing a signal used in triggering the acquisition system. The conventional features of SOURCE selection, Trigger LEVEL control, Trigger SLOPE, Trigger MODE, and CPLG (coupling) include enhancements not normally found in a conventional oscilloscope.

The choices of VERT, CH1 or CH2, EXT1 or EXT2, LINE, and A*B or WORD (16-bit data word recognition) are available as SOURCE selections for triggering A Horizontal Mode acquisitions. These sources for trigger signals provide a wide range of applications involving specialized triggering requirements. Except for A*B (A AND B) and LINE (power-source frequency), the same Trigger SOURCE selections are available for triggering B acquisitions. The selected trigger signal is conditioned by the choice of input CPLG (coupling). These coupling selections are AC, DC, HF REF, LF REJ, and NOISE REJ. LEVEL control provides a settable amplitude (with CRT readout) at which triggering will occur, and SLOPE control determines on which slope of the triggering signal (plus or minus) the acquisition is triggered.

Trigger MODE choices are AUTO LEVEL, AUTO, NORM, and SINGLE SEQ (single sequence), for the A and A INTENSIFIED Modes, and Triggerable After Delay and Runs After Delay, for the B Mode. AUTO LEVEL provides for automatic leveling on the applied trigger signal. AUTO MODE produces an auto trigger in the event a trigger signal is either not received or not within the limits needed to produce a triggering event. When triggering conditions are met, a normal triggered display results. At SEC/DIV settings of 100 ms per division and longer, the AUTO MODE switches to ROLL. In ROLL MODE, the display is continually updated and trigger signals are disregarded.

NORM (normal) trigger MODE requires that all triggering requirements are met before an acquisition will take place. SINGLE SEQ (single sequence) MODE is a variation of the conventional single-shot displays found on many previous oscilloscopes. In SINGLE SEQ, a single complete acquisition is done on all called-up VERTICAL MODES. Since an acquisition depends on the acquisition mode in effect, many of the scope operating features are altered in SINGLE SEQ. A complete description of this mode is discussed in "Controls, Connectors, and Indicators" in Section 5 of this manual.

The user has a choice of trigger points within the acquired waveform record by selecting the amount of pretrigger data displayed. The trigger location in the record is selectable from a choice of five pretrigger lengths beginning at one-eighth of the record length and increasing to seven-eighths of the record length. A record trigger position is independently selectable for both A and B acquisitions. Additional trigger positions in the record are selectable via the GPIB interface commands.

Cursor Measurements

Time and Voltage cursors are provided for making parametric measurements on the displayed waveforms. Time may be measured either between the cursor positions (DELTA TIME) or between a selected cursor and the trigger point of an acquired waveform (ABSOLUTE). Time cursor readouts are scaled in seconds, degrees, or percentage values. The 1/TIME cursors may be scaled in hertz (Hz), degrees, or percentage.

Voltage cursor measurements on a waveform display can be selected to read either the voltage difference between the cursor positions or the absolute voltage position of a selected cursor with respect to ground. The volts measurement readouts may be scaled in units of volts, decibels (dB), or percent. The Voltage cursors and Time cursors may also be coupled to track together (V@T and SLOPE) and assigned to a particular waveform for ease in making peak-to-peak and slope waveform measurements. The units for V@T may be volts, percent, or dB; SLOPE may have units of slope (VOLTS/SEC), percent (VOLTS/VOLT), or dB.

Waveform Acquisition

Waveforms may be acquired in different modes, depending on the measurement requirements. The acquisition modes of NORMAL, ENVELOPE, and AVG (averaging) provide the user with a wide range of measurement adaptability. NORMAL mode provides a continuous acquisition producing a "live" waveform display similar to that seen with an analog oscilloscope. AVG (averaging) mode is especially useful for improving the signal-to-noise ratio of the displayed waveform. Small amplitude signals masked by noise become easily visible for making measurements and analysis by averaging from 2 to 256 acquisitions for removing uncorrelated noise.

Equivalent-time sampling, used for NORMAL and AVG acquisition of recurring periodic signals, extends the useful storage bandwidth to 150 MHz when the REPETITIVE mode is on. Randomly acquired data points taken from a periodic signal are used to fill the complete record of the signal waveform display. Depending on the SEC/DIV setting, as few as 10 samples (at 5 ns/DIV) or as many as 409 (at 200 ns/DIV) samples may be obtained on each trigger event. The user sees the waveform display build up as dots until the entire 1024 data point record is filled.

ENVELOPE mode saves the maximum and minimum data-point values over a selected number of acquisitions from 1 to 256 plus CONT (continuous). The display presents a visual image of the amount of change (envelope) that occurs to a waveshape during the accumulated acquisitions. Frequency, phase, amplitude, and position changes are easily identified when acquiring in ENVELOPE mode. The glitch-catching capability of ENVELOPE mode can capture single-event pulses as narrow as 2 ns at the slowest SEC/DIV setting of 5 seconds per division.

Horizontally, the record length of acquired waveforms is 1024 data points (512 max/min pairs in ENVELOPE mode), of which 500 make up a one-screen display (50 data points per division for 10 divisions). The entire record may be viewed by using the Horizontal POSITION control to position any portion of the record within the viewing area.

Storage and I/O

Acquired waveforms may be saved in any of four REF waveform nonvolatile memories. Any or all of the saved reference waveforms may be displayed for comparison with the waveforms being currently acquired. The source and destination of waveforms to be saved may be user designated. Assignment can be made to save either channel 1 or channel 2 (or the results of an addition or multiplication of the two channels) to any REF memory or to move a stored reference from one REF memory to another. Reference waveforms may also be written into a REF memory location via the GPIB interface.

The scope is fully controllable and capable of sending and receiving waveforms via the standard equipped GPIB interface. This feature makes the instrument ideal for making automated measurements in a production or research and development environment that calls for repetitive data taking. Self- calibration and self-diagnostic features built into the scope to aid in fault detection and servicing are also accessible via commands sent from the GPIB controller.

Another standard feature is the "DEVICES" setting for GPIB Interface control. This feature allows the user to output waveforms (and other on-screen information) to either a HP® Graphics Printer or Plotter from the scope front-panel, providing a way to obtain hard copies of acquired waveforms without putting the scope into a system controller environment.

Extended Features

There are several other features incorporated into this instrument designed to make it more usable, namely, the HELP, AUTOsetup, MEASURE, and AutoStep Sequencer features.

HELP: The HELP function can be used to display operational information about any front-panel control. When HELP mode is in effect, manipulating almost any front-panel control causes the scope to display information about that control. When HELP is first invoked, an introduction to HELP is displayed on screen.

AUTOsetup: The AUTOsetup function is used to automatically setup the scope for a viewable display based on the input signal. The user can specify the waveform characteristic the display is optimized for (front-edge, period, etc.) from a menu displayed upon executing AUTOsetup.

MEASURE: MEASURE automatically extracts parameters from signal input to the scope. In the "SNAPSHOT" mode, 20 different waveform parameters are extracted and displayed for a single acquisition. In the continuous extraction mode, up to four parameters are extracted continuously as the instrument continues to acquire.

AutoStep Sequencer (PRGM): With AutoStep, the user can save single front-panel setups or sequences of setups and associated flow control and Input/Output actions for later recall. If MEASURE and/or OUTPUT are saved as part of these setups they can be used for automatic parameter extraction and data printout. 100 to 800 front-panel setups (depending on complexity) can be stored in one or more sequences.

The complete descriptions of these four features are found in Section 5 "Controls, Connectors, and Indicators". See Section 3 "Basic Applications" for examples of applications for AUTOsetup, MEASURE, and AutoStep.

The following items are standard accessories shipped with the scope instrument:

2	Probe packages
1	Snap-lock accessories pouch
1	Zip-lock accessories pouch
1	Operators manual
1	Programmer's Reference Guide
1	Users Reference Guide
1	Fuse
1	Power cord (installed)
1	Blue plastic CRT filter (installed)
1	Clear plastic CRT filter
1	Front-panel cover

For part numbers and further information about standard accessories and a list of the optional accessories, refer to "Options and Accessories" (Section 7) in this manual. For additional information on accessories and ordering assistance, contact your Tektronix representative or local Tektronix Field Office.

Performance Conditions

The following electrical characteristics (Table 6-1) apply when the scope has been calibrated at an ambient temperature between +20°C and +30°C, has had a warmup period of at least 20 minutes and is operating at an ambient temperature between −15°C and +55°C (unless otherwise noted).

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

Environmental characteristics are given in Table 6-2. The scope meets the environmental requirements of MIL-T-28800C for Type III, Class 3, Style D equipment, with the humidity and temperature requirements defined in paragraphs 3.9.2.2, 3.9.2.3, and 3.9.2.4. The rackmounted scope meets the vibration and shock requirements of MIL-T-28800C for Type III, Class 5, Style D equipment when mounted using the rackmount rear-support kit supplied with both the 1R Option and the Rackmount Conversion kit.

Mechanical characteristics of the scope are listed in Table 6-3.

Video Option characteristics are given in Table 6-4.

Recommended Adjustments Schedule

For optimum performance to specification, the internal SELF CAL should be done:

1. if the operating temperature is changed by more than 5°C since the last SELF CAL was performed, and
2. immediately before making measurements requiring the highest degree of accuracy.

Table 6-1
Electrical Characteristics

Characteristics	Performance Requirements
ACQUISITION SYSTEM—CHANNEL 1 AND CHANNEL 2	
Resolution	8 bits. Displayed vertically with 25 digitization levels (DL)[a] per div, 10.24 divisions dynamic range.
Record Length	1024 samples. Displayed horizontally with 50 samples/per division, 20.48-division trace length.
Sample Rate	10 samples/sec to 100 megasamples per second (5 sec/DIV to 500 ns/DIV).
Sensitivity Range	 80 μV per DL to 0.2 Volts per DL in a 1-2-5 sequence of 11 steps (2 mV/DIV to 5 V/DIV).
Accuracy Normal and Average Modes	 Within ±(2% + 1 DL) at any VOLTS/DIV setting for a signal 1 kHz or less contained within ±75 DLs (±3 divisions) of center when a SELF CAL has been performed within ±15°C of the operating temperature. Measured on a 4 or 5 division signal with VOLTS or V@T cursors; UNITS set to delta volts.
Envelope Mode	Add 1% to Normal Mode specifications.
Variable Range	Continuously variable between VOLTS/DIV settings. Extends sensitivity to 0.5 V per DL or greater, 12.5 V per division or greater.

[a] "DL" is the abbreviation for "digitization level". A DL is the smallest voltage level change that can be resolved by the internal 8-bit A-D Converter, with the input scaled to the VOLTS/DIV setting of the channel used. Expressed as a voltage, a DL is equal to 1/25 of a division times the VOLTS/DIV setting.

Table 6-1 (cont)

Characteristics	Performance Requirements
ACQUISITION SYSTEM—CHANNEL 1 AND CHANNEL 2 (cont)	
Bandwidth	
Normal and Average Mode, Repet OFF, SEC/DIV at 0.5 μs/DIV or Faster, and SMOOTH OFF bandwidth—USB).	DC to 40 MHz (calculated useful storage). $USB = \frac{F_{(\text{sample freq max}^{a})}}{2.5}$
Normal and Average Modes with Repet On or Continuous Envelope Mode; SEC/DIV at 0.2 μs/DIV or Faster (−3 dB bandwidth).	DC-150 MHz. Bandwidth with a P6133 probe is checked using the obtainable reference signal (six divisions or less) from a terminated 50-Ω system via probe-tip-to-BNC adapter. Bandwidth with external termination is checked using a six-division reference signal from terminated 50-Ω system. Bandwidth with internal termination is checked using a six-division reference signal from a 50-Ω system.
AC Coupled Lower −3 dB Point	
1X Probe	10 Hz or less.
10X Probe	1 Hz or less.

[a]**Sample frequency max. is 100 MHz.**

Table 6-1 (cont)

Characteristics	Performance Requirements
ACQUISITION SYSTEM—CHANNEL 1 AND CHANNEL 2 (cont)	
Step Response; Repet and Average ON; Average Set to 16 Rise Time	 2.3 ns or less (calculated) $T_r(\text{in ns}) = \frac{350}{\text{BW in MHz)}}$
Envelope Mode Pulse Response Minimum Single Pulse Width for 50% or Greater Amplitude Capture at 85% or Greater Confidence	 2 ns.
Minimum Single Pulse Width for Guaranteed 50% or Greater Amplitude Capture.	4 ns.
Minimum Single Pulse Width for Guaranteed 80% or Greater Amplitude Capture.	8 ns.
Channel Isolation	100:1 or greater attenuation of the deselected channel at 100 MHz; 50:1 or greater attenuation at 150 MHz, for a 10-division input signal from 2 mV/DIV to 500 mV/DIV; with equal VOLTS/DIV setting on both channels.
Acquired Channel 2 Signal Delay with Respect to Channel 1 Signal at Full Bandwidth	±250 ps.

Table 6-1 (cont)

Characteristics	Performance Requirements
ACQUISITION SYSTEM—CHANNEL 1 AND CHANNEL 2 (cont)	
Input R and C (1 MΩ)	
Resistance	1 MΩ ± 0.5%. In each attenuator, the input resistance of all VOLTS/DIV positions is matched to within 0.5%.
Capacitance	15 pF ±2 pF. In each attenuator, the input capacitance of all VOLTS/DIV positions is matched to within 0.5 pF.
Input R (50 Ω)	
Resistance	50 Ω ±1%.
VSWR (DC to 150 MHz)	1.3:1 or better.
Maximum Input Voltage	5 V rms; 0.5 W sec for any one-second interval for instantaneous voltages from 5 V to 50 V.
Maximum Input Voltages	
Input Coupling set to DC, AC, or GND	400 V (dc + peak ac); 800 V p-p ac at 10 kHz or less.
Common Mode Rejection Ratio (CMRR); ADD Mode With Either Channel Inverted	At least 10:1 at 50 MHz for common-mode signals of 10 divisions or less with VARIABLE VOLTS/DIV adjusted for best CMRR at 50 kHz.
POSITION	
Range	±(9.3 to 10.4) divisions, at 50 mV per division with INVERT off and when SELF CAL has been done within ±5°C of the operating temperature.
Gain Match Between NORMAL and SAVE	±3 DLs for positions within ±5 divisions from center.
Low-Frequency Linearity	3 DLs or less compression or expansion of a two-division, center- screen signal when positioned anywhere within the acquisition window.

Table 6-1 (cont)

Characteristics	Performance Requirements
ACQUISITION SYSTEM—CHANNEL 1 AND CHANNEL 2 (cont)	
20 MHz Bandwidth Limiter −3 dB Bandwidth	13 MHz to 24 MHz.
50 MHz Bandwidth Limiter −3 dB Bandwidth	40 MHz to 55 MHz.
Rise Time	6.3 ns to 8.7 ns. With a five-division, fast-rise step (rise time of 300 ps or less) using 50 Ω DC input coupling and VOLTS/DIV setting of 10 mV.
TRIGGERING—A and B	
Minimum Amplitude and frequency for AUTO LEVEL Trigger and for triggering an AUTOsetup	≥ 5 mv at ≥ 50 Hz.
Minimum P-P Signal Amplitude for Stable Triggering from Channel 1, Channel 2, or ADD A Trigger DC Coupled	0.35 division from DC to 50 MHz, increasing to 1.0 division at 150 MHz; 1.5 divisions at 150 MHz in ADD mode.
NOISE REJ Coupled	1.2 divisions or less from DC to 50 MHz, increasing to 3 divisions at 150MHz; 4.5 divisions at 150 MHz in ADD mode.
AC Coupled	0.35 division from 60 Hz to 50 MHz; increasing to 1.0 division at 150 MHz, 1.5 divisions at 150 MHz in ADD mode. Attenuates signals below 60 Hz.
HF REJ Coupled	0.50 division from DC to 30 kHz. Attenuates signals above 30 kHz.
LF REJ Coupled	0.50 division from 80 kHz to 50 MHz increasing to 1.0 division at 150 MHz; 1.5 divisions at 150 MHz in ADD mode. Attenuates signal below 80 kHz.
B Trigger	Multiply all A Trigger specifications by 2.
A*B Selected	Multiply all A Trigger specifications by 2.

Table 6-1 (cont)

Characteristics	Performance Requirements
TRIGGERING—A AND B (cont)	
Minimum P-P Signal Amplitude for Stable Triggering from EXT TRIG 1 or EXT TRIG 2 Source	
A Trigger	
Ext Gain = 1	
DC Coupled	17.5 mV from DC to 50 MHz, increasing to 50 mV at 150 MHz.
NOISE REJ Coupled	60 mV or less from DC to 50 MHz; increasing to 150 mV at 150 MHz .
AC Coupled	17.5 mV from 60 Hz to 50 MHz, increasing to 50 mV at 150 MHz. Attenuates signals below 60 Hz.
HF REJ Coupled	25 mV from DC to 30 kHz.
LF REJ Coupled	25 mV from 80 kHz to 50 MHz; increasing to 50 mV at 150 MHz.
Ext Gain = ÷5	Amplitudes are five times those specified for Ext Gain = 1.
B Trigger	Multiply all A Trigger amplitude specifications by two.
A*B Selected	Multiply all A Trigger amplitude specifications by two.

Table 6-1 (cont)

Characteristics	Performance Requirements
TRIGGERING A and B (cont)	
Maximum P-P Signal Rejected by NOISE REJ Coupling within the Vertical Bandwidth	
Channel 1 or Channel 2 Source	0.4 division or greater for VOLTS/DIV settings of 10 mV and higher.
EXT TRIG 1 or EXT TRIG 2 Source	20 mV or greater when Ext Trig Gain = 1. 100 mV or greater when Ext Trig Gain = ÷5.
EXT TRIG 1 and EXT TRIG 2 Inputs	
Resistance	1 MΩ ±1%.
Capacitance	15 pF ±3 pF.
Maximum Input Voltage	400 V (dc + peak ac); 800 V p-p ac at 10 kHz or less.
LEVEL Control Range	
Channel 1 or Channel 2 Source	±18 divs x VOLTS/DIV setting.
EXT TRIG 1 or EXT TRIG 2 Source	
EXT GAIN = 1	±0.9 volts.
EXT GAIN = ÷5	±4.5 volts.

Table 6-1 (cont)

Characteristics	Performance Requirements
TRIGGERING A and B (cont)	
LEVEL Readout Accuracy (for triggering signals with transition times greater than 20 ns)	
Channel 1 or Channel 2 Source	
DC Coupled	
+15°C to +35°C	Within ±[3% of setting + 3% of p-p signal + (0.2 division × VOLTS/DIV setting) + 0.5 mV + (0.5 mV × probe attenuation factor)].
−15°C to +55°C (excluding +15°C to +35°C)	Add (1.5 mV × probe attenuation) to +15°C to +35°C specification.
NOISE REJ Coupled	Add ±(0.6 division × VOLTS/DIV setting) to DC Coupled specifications.
EXT TRIG 1 or EXT TRIG 2 Source	
EXT GAIN = 1	
DC Coupled	Within ±[3% of setting + 4% of p-p signal + 10 mV + (0.5 mV × probe attenuation factor)].
NOISE REJ Coupled	Add ±30 mV to DC Coupled specifications.
EXT GAIN = ÷5	
DC Coupled	Within ±[3% of setting + 4% of p-p signal + 50 mV + (0.5 mV × probe attenuation factor)].
NOISE REJ Coupled	Add ±150 mV to DC Coupled specifications.

Table 6-1 (cont)

Characteristics	Performance Requirements		
TRIGGERING—A AND B (cont)			
Variable A Trigger Holdoff	**A SEC/DIV**	**MIN HO**	**MAX HO**
	5 ns	2-4 μs	
	10 ns		
	20 ns		9-15 μs
	50 ns		
	100 ns		
	200 ns		
	500 ns	5-10 μs	
	1 μs	10-20 μs	
	2 μs	20-40 μs	100-150 μs
	5 μs	50-100 μs	
	10 μs	0.1-0.2 ms	
	20 μs	0.2-0.4 ms	1-1.5 ms
	50 μs	0.5-1.0 ms	
	100 μs	1-2 ms	
	200 μs	2-4 ms	10-15 ms
	500 μs	5-10 ms	
	1 ms	10-20 ms	
	2 ms	20-40 ms	90-150 ms
	5 ms	50-100 ms	
	10 ms	0.1-0.2 s	
	20 ms	0.2-0.4 s	0.9-1.5 s
	50 ms	.5-1.0 s	
	100 ms	1-2 s	
	200 ms	2-4 s	
	500 ms		9-15 s
	1 s		
	2 s	5-10 s	
	5 s		

Table 6-1 (cont)

Characteristics	Performance Requirements
TRIGGERING—A AND B (cont)	
SLOPE Selection	Conforms to trigger-source waveform and ac-power source waveform.
Trigger Position Jitter (p-p)	
SEC/DIV 0.5 μs per Division or Greater	
A and B Triggered Sweeps	0.04 $\times$ SEC/DIV setting.
B RUNS AFTER Delay	0.08 $\times$ SEC/DIV setting.
SEC/DIV 0.2 μs per Division or Less	(0.02 $\times$ SEC/DIV setting) + 500 ps. Checked at 5 ns/DIV in ENVELOPE ACQUIRE mode with REPET ON using a 5-division step having less or equal to 1 ns rise time.
TIME BASE	
Sample Rate Accuracy	
Average Over 100 or More Samples	$\pm$0.001%.
External Clock	
Repetition Rate	
Minimum	1 MHz.
Maximum	100 MHz.
Events Count	1 to 65,536.
Events Maximum Repetition Rate	100 MHz.

Table 6-1 (cont)

Characteristics	Performance Requirements
TIME BASE (cont)	
Signal Levels Required for EXT Clock or EVENTS	
Channel 1 or Channel 2 SOURCE	
DC Coupled	0.7 division from DC to 20 MHz; increasing to 2.0 division at 100 MHz; 3.0 divisions at 100 MHz in ADD mode.
NOISE REJ Coupled	2.4 divisions or less from DC to 20 MHz; increasing to 6.0 divisions at 100 MHz; 9.0 divisions at 100 MHz in ADD mode.
AC Coupled	0.7 division from 60 Hz to 20 MHz; increasing to 2.0 division at 100 MHz; 3.0 divisions at 100 MHz in ADD mode. Attenuates signals below 60 Hz.
HF REJ Coupled	1.0 divisions from DC to 30 KHz. Attenuates signals above 30 kHz.
LF REJ Coupled	1.0 division from 80 kHz to 20 MHz; increasing to 4.0 division at 100 MHz; 3.0 divisions at 100 MHz in ADD mode. Attenuates signals below 80 kHz.
EXT TRIG 1 or EXT TRIG 2 Source	
Ext Gain = 1	
DC Coupled	35 mV from DC to 20 MHz; increasing to 100 mV at 100 MHz.
NOISE REJ Coupled	120 mV or less from DC to 20 MHz; increasing to 300 mV at 100 MHz.
AC Coupled	35 mV from 60 Hz to 20 MHz; increasing to 100 mV at 100 MHz. Attenuates signals below 60 Hz.
HF REJ Coupled	50 mV from DC to 30 kHz.
LF REJ Coupled	50 mV from 80 kHz to 20 MHz; increasing to 100 mV at 100 MHz.
Ext Gain = ÷5	Amplitudes are five times those specified for Ext Gain = 1.

Table 6-1 (cont)

Characteristics	Performance Requirements
TIME BASE (Cont)	
Delay Time Range	(0.04 × B SEC/DIV) to (65,536 × 0.04 × B SEC/DIV).
Delay Time Accuracy	Same as the sample rate accuracy.
Delay Time Resolution	The greater of (0.04 × B SEC/DIV) or 20 ns.
NONVOLATILE MEMORY	
Front-Panel Setting, Waveform Data, Sequencer, and Calibration Data Retention Time	Greater than 3 years.
Battery	3.6 Volt, 1.6 Amp Hour, Lithium Thionyl Chloride; Manufacturer EAGLE PICHER, Type LTC16P/P, TEK Part Number 146-0062-00; UL Listed. (See Warning below.) *WARNING* *To avoid personal injury, observe proper procedures for handling and disposal of lithium batteries. Improper handling may cause fire, explosion, or severe burns. Don't recharge, crush, disassemble, heat the battery above 212°F (100°C), incinerate, or expose contents of the battery to water. Dispose of battery in accordance with local, state, and national regulations. Typically, small quantities (less than 20) can be safely disposed of with ordinary garbage in a sanitary landfill. Larger quantities must be sent by surface transport to a hazardous waste disposal facility. The batteries should be individually packaged to prevent shorting and packed in a sturdy container that is clearly labeled "Lithium Batteries—DO NOT OPEN."*

Table 6-1 (cont)

Characteristics	Performance Requirements
SIGNAL OUTPUTS	
CALIBRATOR	CALIBRATOR output amplitudes at 5 MHz are at least 50% of output amplitudes at 1 ms SEC/DIV setting.
Voltage (with A SEC/DIV switch set to 1 ms)	
1 MΩ Load	0.4 V ±1%.
50 Ω Load	0.2 V ±1.5%.
Current (short circuit load with A SEC/DIV switch set to 1 ms)	8 mA ±1.5%.
Accuracy	±0.001%.
Symmetry	Duration of high portion of output cycle is 50% of output period ±(lesser of 500 ns or 25% of period).
CH 2 SIGNAL OUTPUT	
Output Voltage	20 mV per division ±10% into 1 MΩ. 10 mV/DIVision ±10% into 50 Ω.

Table 6-1 (cont)

Characteristics	Performance Requirements
SIGNAL OUTPUTS (cont)	
CH 2 SIGNAL OUTPUT (cont)	
Offset	±10 mV into 50 Ω, when dc balance has been performed within ±5°C of the operating temperature.
−3 dB Bandwidth	DC to greater than 50 MHz.
A TRIGGER, RECORD TRIGGER, and WORD RECOGNIZER Output	
Logic Polarity	Negative true. HI to LO transition indicates the trigger occurred.
Output Voltage HI	
Load of 400 μA or less	2.5 V to 3.5 V.
50-Ω Load to Ground	0.45 V or greater.
Output Voltage LO	
Load of 4 mA or less	0.5 V or less.
50-Ω Load to Ground	0.15 V or less.
SEQUENCE OUT, SEQUENCE COMPLETE Outputs	
Logic Polarity	Negative true. HI to LO transition indicates the event occurred.
Output Voltage HI	
Load of 400 μA or less	2.5 V to 3.5 V.
50-Ω Load to Ground	0.45 V or greater.
Output Voltage LO	
Load of 4 mA or less	40.5 V or less.
50-Ω Load to Ground	0.15 V or less.

Table 6-1 (cont)

Characteristics	Performance Requirements
SIGNAL OUTPUTS (cont)	
SEQUENCE IN Input	
Logic Polarity	Negative true. HI to LO transition restarts a paused sequence.
High-Level Input Current	20 μA maximum at Vin = 2.7 V.
Low-Level Input Current	−0.4 mA maximum at Vin = 0.4 V.
High-Level Input Voltage	2.0 V minimum.
Low-level Input Voltage	0.8 V maximum.
Absolute Maximum Ratings	
Vin max	+7.0 V.
Vin min	−0.5 V.

Table 6-1 (cont)

Characteristics	Performance Requirements
	DISPLAY
Graticule	80 mm X 100 mm (8 x 10 div).
Phosphor	P31.
Nominal Accelerating Potential	16 kV.
Waveform and Cursor Display, Vertical	
Resolution, Electrical	One part in 1024 (10 bit). Calibrated for 100 points per division.
Gain Accuracy	Graticule indication of voltage cursor difference is within 1% of CRT cursor readout value, measured over center six divisions.
Centering; Vectors OFF	Within ±0.1 division.
Offset with Vectors ON	Less than 0.05 division.
Linearity	Less than 0.1 division difference between graticule indication and CRT cursor readout when active VOLTS cursor is positioned anywhere on screen and inactive cursor is at center screen.
Vector Response	
NORMAL Mode	
Step Aberration	+4%, −4%, 4% p-p.
Fill	Edges of filled regions match reference lines within ±0.1 division.
ENVELOPE Mode	
Fill	Less than 1% change in p-p amplitude of a 6-division, filled ENVELOPE waveform when switching vectors ON and OFF.

Table 6-1 (cont)

Characteristics	Performance Requirements
DISPLAY (cont)	
Waveform and Cursor Display, Horizontal	
Resolution, Electrical	One part in 1024 (10 bit). Calibrated for 100 points per division.
Gain Accuracy	Graticule indication at time cursor difference is within 1% of CRT cursor readout value, measured over center 6 divisions.
Centering, Vectors OFF	Within ± 0.1 division.
Offset with Vectors ON	Less than 0.05 division.
Linearity	Less than 0.1 division difference between graticule indication and CRT cursor readout when active time cursor is positioned anywhere along center horizontal graticule line and inactive cursor is at center screen.
AC POWER SOURCE	
Source Voltage	
Nominal Ranges	
115 V	90 V to 132 V.
230 V	180 V to 250 V.
Source Frequency	48 Hz to 440 Hz.
Fuse Rating	5 A, 250 V, AGC/3AG, Fast Blow; or 4 A, 250 V, 5 $\times$ 20 mm Time-Lag (T). Each fuse type requires a different fuse cap.
Power Consumption	
Typical (standard instrument)	160 watts (250 VA).
Maximum (fully-optioned instrument)	200 watts (300 VA).
Primary Grounding[a]	Type test 0.1 Ω maximum. Routine test to check grounding continuity between chassis ground and protective earth ground.[a]

[a]Routine test is with ROD-L/EPA Electronic Model 100AV Hi-Pot Tester. This tests both the Primary Circuit Dielectric Withstand and Primary Grounding in one operation. Contact Tektronix Product Safety prior to using any other piece of equipment to perform these tests.

Table 6-2
Environmental Characteristics

Characteristics	Performance Requirements
STANDARD INSTRUMENT	
	The Oscilloscope meets the environmental requirements of MIL-T- 28800C for Type III, Class 3, Style D equipment, with the humidity and temperature requirements defined in paragraphs 3.9.2.2, 3.9.2.3, and 3.9.2.4.
Temperature Operating	−15°C to +55°C.
Nonoperating (storage)	−62°C to +85°C.
Altitude Operating	To 15,000 feet (4500 meters). Maximum operating temperature decreased 1°C for each 1000 feet (300 meters) above 5000 feet (1500 meters).
Nonoperating (storage)	To 50,000 feet (15,000 meters).
Humidity Operating and Storage	Stored at 95% relative humidity for five cycles (120 hours) from 30°C to 60°C, with operation performance checks at 30°C and 55°C.
Vibration Operating	15 minutes along each of three axes at a total displacement of 0.025 inch (0.64 mm) p-p (4 g at 55 Hz), with frequency varied from 10 Hz to 55 Hz in one-minute sweeps. Hold 10 minutes at each major resonance, or if none exist, hold 10 minutes at 55 Hz (75 minutes total test time).
Shock Operating and Nonoperating	50-g, half-sine, 11-ms duration, three shocks on each face, for a total of 18 shocks.

Table 6-2 (cont)

Characteristics	Performance Requirements
STANDARD INSTRUMENT (cont)	
Transit Drop (not in shipping package)	12-inch (300-mm) drop on each corner and each face (exceeds MIL-T-28800C, paragraphs 3.9.5.2 and 4.5.5.4.2).
Bench Handling	
Cabinet On and Cabinet Off	MIL-STD-810C, Method 516.2, Procedure V (MIL-T-28800C, paragraph 4.5.5.4.3).
Topple (Cabinet Installed)	
Operating	Set on rear feet and allow to topple over onto each of four adjacent faces (Tektronix Standard 062-2858-00).
Packaged Transportation	
Drop	Meets the limits of the National Safe Transit Assn., test procedure 1A-B-2; 10 drops of 36 inches (914 mm) (Tektronix Standard 062-2858-00).
Vibration	Meets the limits of the National Safe Transit Assn., test procedure 1A-B-1; excursion of 1 inch (25.4 mm) p-p at 4.63 Hz (1.1 g) for 30 minutes (Tektronix Standard 062-2858-00).
EMI (Electromagnetic Interference)	Meets MIL-T-28800C; MIL-STD-461B, part 4 (CE-03 and CS-02), part 5 (CS-06 and RS-02), and part 7 (CS-01, RE-02, and RS-03—limited to 1 GHz); VDE 0871, Category B; Part 15 of FCC Rules and Regulations, Subpart J, Class A; and Tektronix Standard 062-2866-00.
Electrostatic Discharge Susceptibility	Meets Tektronix Standard 062-2862-00. The instrument will not change control states with discharges of less than 10 kV.
X-Ray Radiation	Meets requirements of Tektronix Standard 062-1860-00.

Table 6-2 (cont)

Characteristics	Performance Requirements
RACKMOUNTED INSTRUMENT	
Environmental Requirements (cont)	Listed characteristics for vibration and shock indicate those environments in which the rackmounted instrument meets or exceeds the requirements of MIL-T-28800C with respect to Type III, Class 5, Style D equipment with the rackmounting rear-support kit installed. Refer to the Standard Instrument Environmental Specification for the remaining performance requirements. Instruments will be capable of meeting or exceeding the requirements of Tektronix Standard 062-2853-00, class 5.
Temperature (operating)	−15°C to +55°C, ambient temperature measured at the instrument's air inlet. Fan exhaust temperature should not exceed +65°C.
Vibration	15 minutes along each of three major axes at a total displacement of 0.015 inch (0.38 mm) p-p (2.3 g at 55 Hz), with frequency varied from 10 Hz to 55 Hz to 10 Hz in one-minute sweeps. Hold 10 minutes at each major resonance, or if no major resonance is present, hold 10 minutes at 55 Hz (75 minutes total test time).
Shock (operating and nonoperating)	30-g, half-sine, 11-ms duration, three shocks per axis in each direction, for a total of 18 shocks.

Table 6-3
Mechanical Characteristics

Characteristics	Description
STANDARD INSTRUMENT	
Weight With Front Cover, Accessories, and Accessories Pouch	12.8 kg (28.1 lbs).
Without Front Cover, Accessories, and Accessories Pouch	10.9 kg (23.9 lbs).
Domestic Shipping Weight	16.4 kg (36 lbs).
Overall Dimensions	See Figure 6-1 for a dimensional drawing.
Height With Feet and Accessories Pouch	190 mm (7.48 in).
Without Accessories Pouch	160 mm (6.3 in).
Width (with handle)	330 mm (130.0 in).
Depth With Front Cover	479 mm (18.86 in).
With Handle Extended	550 mm (21.65 in).
Cooling	Forced air circulation; no air filter.
Finish	Tek Blue vinyl-clad material on aluminum cabinet.
Construction	Aluminum-alloy/plastic composite chassis (spot-molded). Plastic-laminate front panel. Glass-laminate circuit boards.

Table 6-3 (cont)

Characteristics	Performance Requirements
RACKMOUNTING	
Rackmounting Conversion Kit	
Weight	4.0 kg (8.8 lbs).
Domestic Shipping Weight	6.3 kg (13.8 lbs).
Height	178 mm (7 in).
Width	483 mm (19 in).
Depth	419 mm (16.5 in).
Rear Support Kit	
Weight	0.68 kg (1.5 lbs).
OPTION 1R	
Rackmounted Instrument (Option 1R)	
Weight	15.8 kg (34.9 lbs).
Domestic Shipping Weight	18.1 kg (39.9 lbs).
Height	178 mm (7 in).
Width	483 mm (l9 in).
Depth	419 mm (l6.5 in).

Table 6-4
Video Option 05 (TV Trigger) Electrical Characteristics

Characteristics	Performance Requirements
VERTICAL—CHANNEL 1 AND CHANNEL 2	
Frequency Response	
Full Bandwidth	
50 kHz to 5 MHz	Within ±1%.
Greater than 5 MHz to 10 MHz	Within +1%, −2%.
Greater than 10 MHz to 30 MHz	Within +2%, −3%. For VOLTS/DIV switch settings between 5 mV and 0.2 V per division with VARIABLE VOLTS/DIV set to CAL. Five-division, 50-kHz reference signals from a 50-Ω system. With external 50-Ω termination on a 1-MΩ input.
20 MHz Bandwidth Limit	
50 kHz to 5 kHz	Within +1%, −4%.
Square Wave Flatness	
Field Rate	
5 mV/DIV to 20 mV/DIV	±1%, 1% p-p at 60 Hz with input signal of 0.1 V.
50 mV/DIV	±1%, 1% p-p at 60 Hz with input signal of 1.0 V. With fast-rise step (rise time 1 ns or less), 1-MΩ dc input coupling, an external 50-Ω termination, and VARIABLE VOLTS/DIV set to CAL. Exclude the first 20 ns following the step transition and exclude the first 30 ns when 20 MHz BW LIMIT is set.
Line Rate	
5 mV/DIV to 20 mV/DIV	±1%, 1% p-p at 15 kHz with input signal of 0.1 V.
50 mV/DIV	±1%, 1% p-p at 15 kHz with input signal of 1.0 V.

Table 6-4 (cont)
Video Option 05 (TV Trigger) Electrical Characteristics

Characteristics	Performance Requirements
VERTICAL—CHANNEL 1 AND CHANNEL 2 (cont)	
TV (Back-Porch) Clamp (CH 2 only)	
60 Hz Attenuation	18 dB or greater. For VOLTS/DIV switch settings between 5 mV and 0.2 V with VARIABLE VOLTS/DIV set to CAL. Six-division reference signal.
Back-Porch Reference	Within ±1.0 div of ground reference.
TRIGGERING	
Sync Separation	Stable video rejection and sync separation from sync-positive or sync- negative composite video, 525 to 1280 lines, 50 Hz or 60 Hz, interlaced or noninterlaced systems.
Trigger Modes A Horizontal Mode	All Lines: Field 1, selected line (1 to n), Field 2, selected line (1 to n), Alt fields, selected line (1 to n). n is equal to or less than the number of lines in the frame and less than or equal to 1280.
B Horizontal Mode	Delayed by time.

Table 6-4 (cont)

Characteristics	Performance Requirements
TRIGGERING (cont)	
Minimum Input Signal Amplitude for Stable Triggering	
Channel 1 and Channel 2	
Composite Video	2 divisions.
Composite Sync	0.6 division. Peak signal amplitude within 18 divisions of input ground reference.
EXT TRIG 1 or EXT TRIG 2	
EXT GAIN = 1	
Composite Video	60 mV
Composite Sync	30 mV Peak signal amplitude within ±0.9 V from input ground reference.
Channel 1 and Channel 2	
Composite Video	2 divisions.
Composite Sync	0.6 division. Peak signal amplitude within 18 divisions of input ground reference.
EXT TRIG 1 or EXT TRIG 2	
EXT GAIN = 1	
Composite Video	60 mV
Composite Sync	30 mV Peak signal amplitude within ±0.9 V from input ground reference.
EXT GAIN = ÷5	
Composite Video	300 mV
Composite Sync	150 mV Peak signal amplitude within ±4.9 V from input ground reference.

Table 6-5
Video Option 05 (TV Trigger) Environmental Characteristics

Characteristics	Performance Requirements
Environmental Requirements	Same as the standard scope Digital Oscilloscope.

Table 6-6
Video Option 05 (TV Trigger) Mechanical Characteristics

Characteristics	Performance Requirements
Weight	Same as the standard scope Digital Oscilloscope.

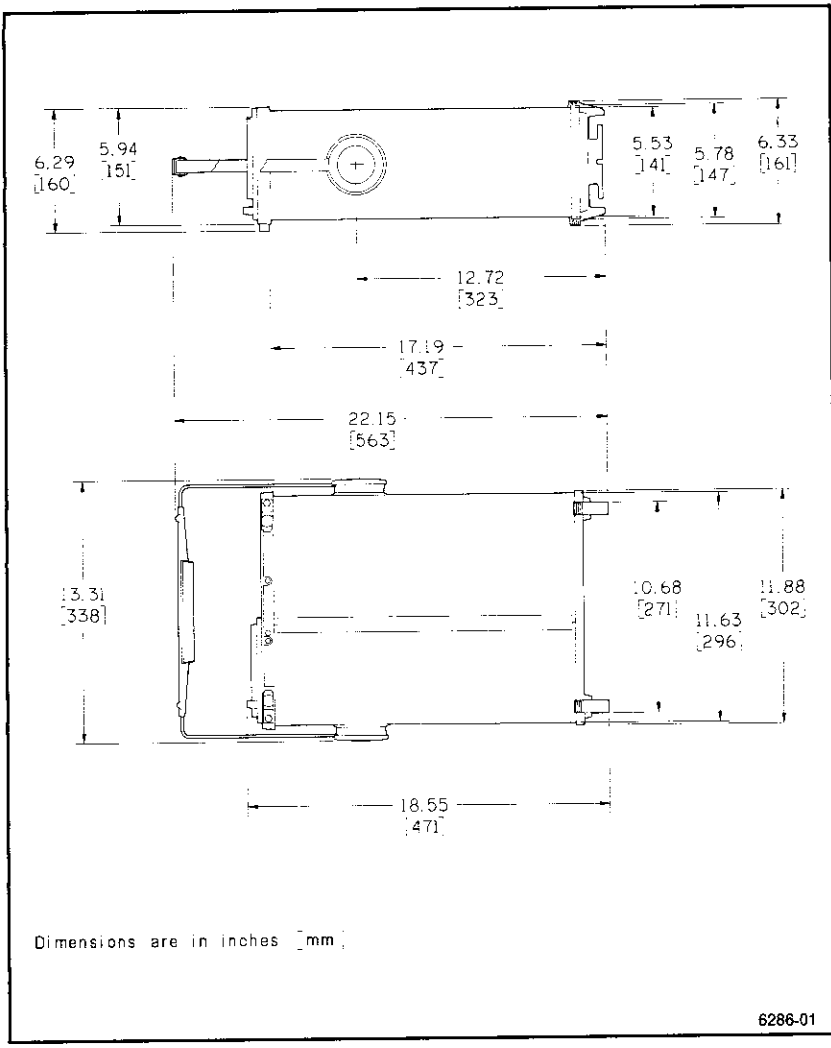
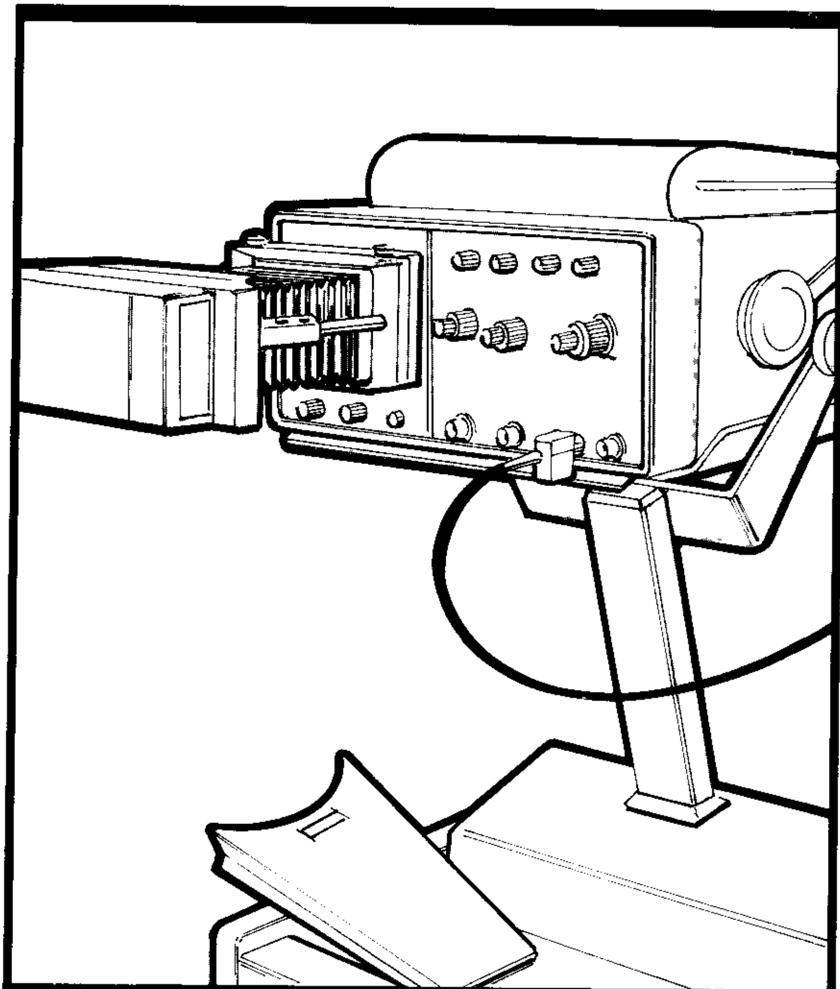


Figure 6-1. Dimensional drawing.

SECTION 7

Options and Accessories



Options and Accessories

Options Descriptions

This section contains a general description of available options for the 2430A Digital Storage Oscilloscope at time of manual publication. The options are:

Options A1-A5	International Power Cords
Option 1R	Rackmounting
Option 03	Word Recognizer Probe
Option 05	Video Option
Option 11	Probe Power

Operating instructions for the Video Option and the Word Recognizer Probe Option/Optional accessory follow the general descriptions. A complete list of standard accessories supplied with the instrument and a list of suggested optional accessories, each identified by part number, is included at the rear of this section.

Additional information about instrument options, option availability, and other accessories can be obtained from the current Tektronix Products Catalog or by contacting your local Tektronix Field Office or representative.

Options A1-A5 International Power Cords

Instruments are shipped with the detachable power-cord configuration ordered by the customer. Descriptive 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.

Option A1 (Universal Euro)

Power cord (2.5 m)	161-0104-06
Option A2 (UK)	
Power cord (2.5 m)	161-0104-07
Option A3 (Australian)	
Power cord (2.5 m)	161-0104-05
Option A4 (North American)	
Power cord (2.5 m)	161-0104-08
Option A5 (Switzerland)	
Power cord (2.5 m)	161-0154-00

Option 1R Rackmounted 2430A

When this instrument is is ordered with Option 1R, it is shipped in a configuration that permits easy installation into a 19-inch-wide equipment rack. An optional rackmounting kit may be ordered to convert the standard instrument to a rackmounted instrument. Installation instructions for rackmounting are provided in the documentation supplied with the rackmounting kit and the 1R Option.

The rear-support kit also is supplied for use when rackmounting the scope. Using this rear-support kit enables the rackmounted instrument to meet all electrical and environmental specifications of the standard instrument.

Connector-mounting holes are provided in the front panel of the rackmounted instrument. These holes enable convenient accessing of the rear panel BNC connectors and directing the Vertical Channel and External Trigger input connectors to rear access in an electronics equipment rack. The choice of which signals are routed through the rackmounting front panel is left to user discretion. Additional cabling and connectors required to implement any through-panel access must be user supplied; however, the necessary items may be separately ordered from Tektronix, Inc.

Option 03—Word Recognizer Probe

The Word Recognizer (*WR*) Probe is available as an option or can be ordered as an optional accessory. In either case, it is used to trigger the instrument on user-selected parallel TTL data word. The *WR* recognizes a 16-bit word, plus a 17th qualifier bit. Each bit is selectable as 0, 1, X (don't care). Recognition can be either synchronous with an external clock signal (rising or falling edge) or asynchronous.

For instruments purchased either with or without Option—03, the required hardware and firmware for using the Word Recognizer Probe is included in the standard 2430A Digital Oscilloscope; it is only necessary to purchase the Word Recognizer Probe optional accessory. Instruments purchased with Option—03 include the *WR* Probe.

Option 05—Video Option

Option 05 provides an aid in examining composite video signals. With the Video Option installed, all basic instrument functions remain the same. Changes to any of the control menus by the installation of Option 05 are detailed in the description of the affected menus in Section 3, Controls, Connectors, and Indicators. Features of this option include a sync separator, back-porch clamp circuitry, TV trigger coupling modes, and adjustment for closer tolerance on the 20-MHz BANDWIDTH LIMIT. This option permits the user to trigger on a specific line number within a TV field and provides sync-polarity switching for either sync-negative or sync-positive composite video signals.

Option 11—Probe Power

Option 11 provides two probe-power connectors on the rear panel of the instrument. Voltages supplied at the PROBE POWER connectors meet the power requirements of standard Tektronix active oscilloscope probes.

Option Operating Information

Video Options

Introduction

This instrument, with the Video Trigger (Option 05) installed, contains additional hardware and software components to simplify the triggering and viewing of video signals. All standard instrument operating controls and features remain unchanged; and, as with those features, the Video Option is fully controllable via the GPIB interface. GPIB control commands for the Video Option are given in the Programmers Reference Guide.

Features of this option include a sync separator, back-porch clamp circuitry, TV trigger coupling modes, and adjustment for closer tolerance on the 20-MHz bandwidth. This option permits the user to trigger on a specific line number within a TV field and provides sync polarity switching for either sync-negative or sync-positive composite video signals.

Both system-M and nonsystem-M operation are available, providing compatibility with most U.S. television signal line-numbering formats. Stable video rejection and sync separation is obtained from the sync-positive or sync-negative, interlaced or non-interlaced scan, composite video signals having 525 to 1280 horizontal lines per frame and 50- or 60-Hz field rates.

Video Option Accessories

In addition to the standard accessories supplied with the 2430A, the following accessories are provided when Option 05 is installed in the instrument:

1 CCIR Graticule, Tektronix Part Number 378-0199-04

1 NTSC Graticule, Tektronix Part Number 378-0199-05

Video Option Specifications

The electrical characteristics of the Video Option are listed in Table 6-4 of Section 6 in this manual. All other electrical, environmental, and mechanical characteristics remain as for the standard instrument.

General Operation

Selecting VIDEO in the A TRIGGER COUPLING menu enables the sync separator circuitry of the Video Option. Pressing the front-panel button labeled SET VIDEO calls up the control menu for setting up the operating mode of the Video Option.

CLAMP (CHANNEL 2 ONLY). The Channel 2 back-porch clamp circuit is used to stabilize TV waveform displays by removing unwanted hum or tilt from displayed waveforms. With the CLAMP function on, the back-porch level of the video signal displayed on CH 2 will be held at near ground level. Clamp circuit operation will be unpredictable if the Channel 2 signal is not a composite video or composite sync signal or if the scope is not being triggered with video sync signals.

If the back-porch clamp is enabled without a video sync signal applied to the sync separator, the CH 2 trace may drift vertically, which is normal. When the back-porch clamp is turned off, regular operation is again restored.

When any front-panel change is made while back-porch clamp is enabled, the display may jump vertically. However, the back-porch clamp circuit will return the back-porch level to its previous position.

FIELD TRIGGERING. Either FIELD 1 or FIELD 2 in interlaced video signals may be selected for triggering. ALT (alternate field triggering) causes the triggering to alternate between the two fields.

With field triggering selected (Field 1 only for noninterlaced video signals), the A TRIGGER LEVEL/FIELD LINE # control knob is used to select a specific line within the field on which to trigger. Line numbers may be selected from 1 to the maximum number of lines per frame in the video signal being viewed. The acquisition will trigger on the chosen horizontal line sync pulse after all holdoffs have been satisfied. In an interlaced TV signal, Field 1 has one more line than Field 2; however, the last line in Field 1 is not accessible when alternate (ALT) field triggering is selected because the line counter counts only to the highest common line number.

SYSTEM SELECTION. Selecting system-M or nonsystem-M operation is accomplished using the EXTENDED FUNCTIONS SYSTEM menu. In system-M operation, line counting begins three lines before the field sync; but in nonsystem-M operation, line counting starts just after the field sync.

SYNC POLARITY. Sync polarity is selected with the A Trigger SLOPE/SYNC front-panel button. When VIDEO Coupling is selected, the SLOPE/SYNC selector button controls the signal polarity applied to the sync separator and operates independently of the SLOPE selection for the A and B Trigger signals. SYNC polarity for correct sync separator operation is chosen as follows.

For composite-video signal inputs (at the input BNC) with positive-going sync and negative-going picture information, the SLOPE/SYNC is set to + (plus). For composite-video signal input with negative-going sync, the SLOPE is set to − (minus). The INVERT feature of the Vertical inputs has no effect on the polarity of the trigger signal to the Video Option sync separator.

Setting Up the Video Option

Pressing the SET VIDEO front-panel button calls up the following menu (see Section 3, Item 38).

A VIDEO COUPLING **CLAMP**
FIELD1 **FIELD2** **ALT** **TV LINE ON!OFF**

FIELD1: Acquisition is triggered on a selected line during Field 1 of the input video signal. The line number and field indicator (TVF1) are displayed in place of the normal A Trigger level and source indicators.

FIELD2: Acquisition is triggered on a selected line in Field 2 of the input video signal. When Field 2 is the selected field, TVF2 is the displayed indicator in front of the line number readout. An input signal must be interlaced to activate and display FIELD 2 in the SET TV menu.

NOTE

The Video Option circuitry does not detect the color-burst phase or Bruch Sequence color burst blanking information. In a four-field Pal Sequence with Bruch Sequence color burst blanking, Fields 1 and 3 will be displayed when Field 1 is selected (odd fields), and Fields 2 and 4 will be displayed when Field 2 is selected (even fields). On noninterlaced scan systems the TV circuitry detects the start of field information only.

ALT: Acquisition is alternately triggered on a selected line during both fields of an interlaced video signal. With alternate field triggering selected, the indicator in front of the line number readout is TVFLD.

When B Delayed Horizontal Mode is selected with Δ TIME mode on, one field of a single channel video signal will be displayed at the main delay and the other field will be displayed at the main delay plus the delta delay. If CH 1 and CH 2 are both on, the CH 1 signal will be one field at the main delay and the CH 2 signal will be the other field at the main delay plus the delta delay. If the delta delay is adjusted for zero delay time, a line-by-line comparison between the two fields may be done using the FIELD LINE # control knob to move through the two fields in unison.

TV LINE: Selects any line within either field for triggering the oscilloscope when the Video Option is enabled (TV CPLG on). An acquisition will be triggered by the first line-sync pulse encountered after all holdoffs have been satisfied. The indication for TV LINE triggering selected is TVLN without a line number readout being displayed.

CLAMP ON/OFF: Controls the Channel 2 back-porch clamp feature. The clamp circuit holds the video signal back-porch level to a constant dc level (the vertical position of the ground indicator) and eliminates vertical drift, hum, and tilt from the display. A stable display is provided despite changes in signal amplitude and luminance levels. When the Video Option CLAMP feature is on, the message *CLAMP appears on the CRT screen, and the clamp circuitry continues to function for the Channel 2 display until CLAMP is set to OFF.

Setting a Line Number

When the Video Option is on, the A TRIGGER LEVEL/FIELD LINE # control knob is used for selecting a specific horizontal line within a field. For line number selection within a specific field, the field and line numbers are displayed in the upper-right corner of the CRT screen in place of the normal A Trigger Level readout.

Rotating the LEVEL/FIELD LINE # control knob clockwise increases the selected line number in a field; rotating it counterclockwise decreases the line number. (The LEVEL/FIELD LINE # control still sets the B Trigger Level when the A/B TRIG button is pressed to select B Trigger operation.)

When the user attempts to select lines beyond the maximum or minimum line-number available in the field selected, the action taken depends on the user selection for CNT RST BOTH¦F1 (Count Reset Both or F1). If set to BOTH, and ALT (alternate field coupling) is not selected in the A VIDEO COUPLING menu, attempting to turn the control past the first or last line number in the field selects the last or first number (respectively) of the opposite field. In these cases, the underscored FIELD choice in the SET VIDEO control menu and the field-number (TVF1 or TVF2) readout preceding the line number readout also switch to reflect the correct field.

If CNT RST is set to F1 (again, ALT not selected), the instrument treats the two fields as one large field, with the maximum line number available equaling the sum of field 1 and field 2. When the maximum line number of field 1 is encountered, the line-readout will increment that number by 1 when line 1 of field 2 is selected. "Wrap-around" occurs at both ends in both directions (for example, for CCIR System B usage, attempting to select one count less than line one selects 625; one more than 625, line 1). Again, the menu and field-number readout indicate the field selected.

If ALT is selected, the selection for CNT RST doesn't matter. The instrument alternates between fields for triggering successive acquisitions using the same line count for both fields. Further rotation of the control past the maximum or minimum line number only resets the line count to the beginning (line 1) or the end (the end is the maximum line count common to both fields—for CCIR System M, 262 in field 2).

The user selects the setting for CNT RST via the EXTENDED FUNCTION menu. Steps 1 and 2 of the procedure "System-M/Nonsystem-M Protocol Selection" describes how to access this menu selection.

System-M/Nonsystem-M Selection

The following procedure is used to select a particular protocol using the EXTENDED FUNCTIONS menu.

1. Press the MENU OFF/EXTENDED FUNCTIONS front-panel button (see Figure 5-1 and item 8 in "Controls, Connectors, and Indicators") once to turn off any menus being displayed and again to call up the EXTENDED FUNCTIONS menu.

2. Press SYSTEM to call up the selection menu for the system extended functions. Push VIDEO OPT to select that menu.

3. Under TV SYS, use the menu button to toggle between M and NON-M as desired (the selected protocol is underlined).

Selecting an incorrect protocol for a given TV signal will not affect the ability to trigger on that signal. It will, however, cause the specific line number within the field to be inaccurate. When system-M is selected, the line count begins three lines before the field-sync pulse is encountered. When nonsystem-M is selected, the line count begins coincident with the field-sync pulse.

Special Measurements

OVERSCANNED DISPLAYS. For various video measurements, it may be desirable to expand the video waveform vertically beyond the limits of the screen. Under these circumstances, the trigger amplifiers or the sync separator circuitry may be overloaded, blocking out sync pulses in the vicinity of large signal transitions or losing sync pulses altogether. Therefore, to avoid overload problems, use the other vertical channel or one of the external trigger inputs (EXT1 or EXT2) to supply a constant amplitude trigger signal to the Video Option while the observations are being made on the expanded waveform.

RF INTERFERENCE. Operation in the vicinity of some FM and TV transmitters may impress objectionable amounts of rf signal energy on the input signal, even when coaxial cables are used to make the signal connections. Using the 20-MHz BANDWIDTH limit feature will usually eliminate such interference from the display, but it does not limit the signal reaching the Video Option circuitry. Where the rf energy interferes with the TV triggering operation, external filters will be required to limit the bandwidth of the trigger signal. In such cases, it is recommended that one of the external trigger inputs (EXT1 or EXT2) be used to supply the trigger signal, using the required external bandwidth limiters and attenuators to obtain the necessary trigger amplitudes.

Identifying Fields, Frames, and Lines in 525/60 and 625/50 TV Systems

NTSC (CCIR SYSTEM M). Field 1 is defined as the field whose first equalizing pulse is one full H interval (63.5 μs) from the preceding horizontal sync pulse. The Field 1 picture starts with a full line of video, and its lines are numbered 1 through 263, starting with the leading edge of the first equalizing pulse. The first regular horizontal sync pulse after the second equalizing interval is the start of line 10.

Field 2 starts with an equalizing pulse a half-line interval from the preceding horizontal sync pulse. The Field 2 picture starts with a half line of video and its lines are numbered 1 through 262, starting with the leading edge of the second equalizing pulse. After the second equalizing interval, the first full line is line 9.

CCIR SYSTEM B AND SIMILAR 625/50 SYSTEMS. Except for PAL systems, identification of parts of the picture in most 625-line, 50-Hz field-rate systems relies primarily on continuous line numbering rather than on field-and-line identification.

The CCIR frame starts with the first (wide) vertical sync pulse following a field which ends with a half-line of video. The first line after the second equalizing interval is line 6; the first picture line is line 23 (half-line of video). The first field of the frame contains lines 1 through the first half of line 313, and the picture ends with a full line of video (line 310).

The second field of the frame commences with the leading edge of the first (wide) vertical sync pulse (middle of line 313) and runs through line 625 (end of equalizing interval). The first full line after the equalizing interval is line 318; the picture starts on line 336 (full line).

The first field is referred to as "odd," and the second field as "even." Note that the identification systems for System-M and System-B are reversed.

In the four-field PAL sequence with Bruch Sequence color-burst blanking, the fields are identified as follows:

Field 1: Field that follows a field ending in a half-line of video, when preceding field has color burst on the last full line. Field 1 lines are 1 through 312 and half of line 313. Color burst starts on line 7 of Field 1; a half-line of video appears on line 23.

Field 2: Field that follows a field ending in a full line which does not carry color burst. Field 2 lines are the last half of line 313 through line 625. Color burst starts on line 319 (one line without burst following the last equalizing pulse); a full line of video appears at line 336.

Field 3: Field that follows a field ending in a half line when preceding field has no color burst on its last full line. Field 3 lines are 1 through the first half of line 313. Burst starts on line 6 (immediately following the last equalizing pulse); a half-line of video appears on line 23.

Field 4: Field that follows a field ending in a full line carrying color burst. Field 4 lines are the second half of line 313 through line 625. Color burst for Field 4 starts on line 320 (two full lines without burst follow the last equalizing pulse); video starts with a full line on line 336.

Basic Applications

This instrument, with the TV Option installed, is an accurate and flexible measurement system for displaying and analyzing video information. After becoming familiar with the controls, indicators, operating considerations, and capabilities of the instrument, perform the following procedures to become familiar with the functions for making TV-related measurements.

Verify that the POWER switch is OFF (push button out); then plug the power cord into the power outlet.

Initial Setup

a. Press in the POWER switch button (ON).

b. Set the instrument controls to obtain a baseline trace as follows:

Trigger

TRIG POS (A and B)	½
MODE	AUTO
SOURCE	CH 2
COUPLING	TV
SET TV	
FIELD 1	Selected
CLAMP	ON
LEVEL/FIELD LINE #	1
SLOPE/SYNC	– (minus)
HOLDOFF	Off (no Holdoff indicator displayed)

Storage Mode

ACQUIRE	ENVELOPE (1 sweep)

Horizontal

MODE	A
SEC/DIV	2 ms
POSITION	Center trigger-point indicator

Vertical

CH 2 POSITION	Center baseline trace
MODE	CH 2
CH 2 VOLTS/DIV	500 mV
CH 2 COUPLING	GND

Extended Functions System

TV SYS	M

c. Adjust the DISPLAY and READOUT intensity for the desired trace and readout brightness.

d. Apply a composite video signal (with color-burst signal and negative-going sync) to the CH 2 input connector using a coaxial cable with the proper terminations for impedance matching.

e. Set CH 2 input coupling to DC; observe the field-rate signal envelope.

f. Press SET TV to display the Video Option control menu.

g. Rotate the LEVEL/FIELD LINE # knob counterclockwise into the end region of Field 2. Observe that the field number indicator switches to TVF2 and that FIELD2 becomes the underscored field choice in the control menu.

h. Rotate the FIELD LINE # knob clockwise through the entire Field 1 display and set the line number for line one of Field 2.

i. Switch the A SEC/DIV setting to 50 μs and set the Storage ACQUIRE mode to NORMAL.

j. Observe that line number 1 is in the vertical blanking region prior to the vertical sync pulse.

k. Set the line number for line 263 of Field 1 and set the A SEC/DIV to 2 μs for a close examination of the waveform around the horizontal sync pulse.

l. Supply a trigger signal to external trigger input EXT1.

m. Set the following controls:

B TRIGGER MODE	RUNS AFTER
B SEC/DIV	500 ns
A TRIGGER SOURCE	EXT1
EXT GAIN	EXT1/5
CH 2 VOLTS/DIV	100 mV
Horizontal MODE	B
DELAY by TIME	ON
DELTA TIME	OFF
DELAY TIME	Minimum

n. Adjust the DELAY TIME to observe the color-burst signal (approximately 4 to 5 μs delay from RTRIG).

o. Press CURSOR FUNCTION and select VOLTS cursors. Measure the peak-to-peak voltage of the color-burst reference signal.

p. Press SAVE Storage Mode.

q. Save the color-burst signal in REF4.

r. Expand the SAVE display by switching the B SEC/DIV setting to 100 ns.

s. Press CURSOR FUNCTION and select 1/TIME cursors. Measure the frequency of one cycle of the color-burst signal. V@T cursors may be selected first to overlap the VOLTS cursors for 0 V with the TIME cursors set one period apart to set the exact time; then press 1/TIME to measure the frequency.

t. Set the Horizontal MODE to A and press the ACQUIRE button.

u. Press DISPLAY REF and press REF4 to recall the previously saved waveform.

v. Set the SEC/DIV control back to 500 ns and compare the SAVE waveform with the REF4 waveform display.

w. Switch the Horizontal Mode to A and press the ACQUIRE button to restart the waveform acquisition.

Signal Input Coupling

The CH 2 back-porch clamp stabilizes video waveform displays by removing unwanted hum and tilt from the Channel 2 display. For the clamp circuit to be functional, the instrument must be triggered on a composite video or composite sync signal.

The following procedure demonstrates the appearance of a video signal with CLAMP on and off.

NOTE

When enabling the back-porch clamp (CLAMP ON), leave the rear-panel CH 2 SIG OUT connector unterminated (open) to preserve waveform fidelity of video signals applied to the CH 2 Vertical Input connector.

a. Connect a composite video signal (negative-going sync) along with an overriding ac signal of 60 or 120 Hz (simulating power-supply hum) to CH 2 input connector.

b. Set the A SEC/DIV to 5 ms.

c. Set VOLTS/DIV to obtain a display amplitude of at least 2 divisions.

d. Press the front-panel Trigger CPLG (coupling) button and select TV from the A TRIGGER COUPLING menu.

e. Press SET TV panel button, and select FIELD 1 or FIELD 2 triggering; then press the CLAMP OFF menu button.

f. Select the ENVELOPE Acquisition Mode and observe the presence of AC tilt or hum on the displayed trace.

g. Press SET TV again and turn the CLAMP ON.

h. With the CH 2 back-porch CLAMP enabled, observe that the ac hum on the waveform has been eliminated (see Figure 7-1).

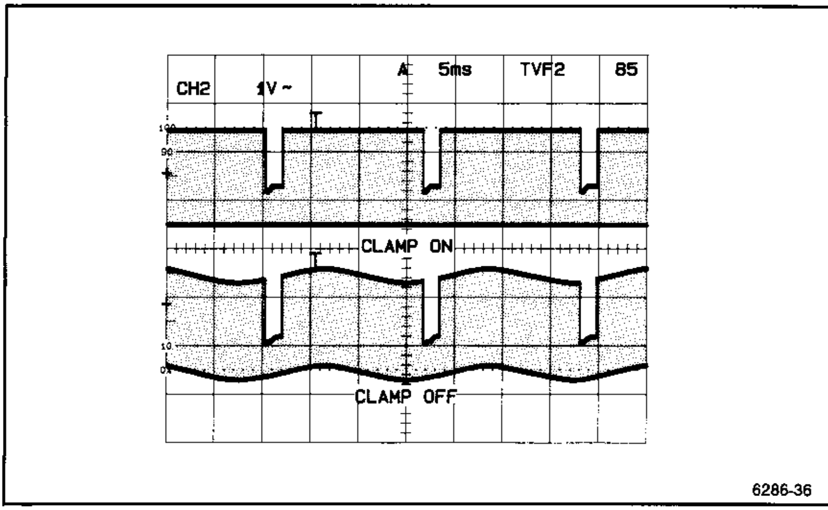


Figure 7-1. Composite Video Signal with and without TV clamping.

Word Recognizer Probe Options

The Word Recognizer Probe is used to trigger on a selected parallel TTL data word. The following text is general operating information:

Electrical connection from the Word Recognizer Probe to the scope is via the rear-panel connector labeled "P6407 WORD RECOG INPUT". The instrument has one Word Recognizer Probe connector, but the trigger output from the probe can be selected as the source for the A Trigger signal or the B Trigger signal, or for both using the A and B TRIG SOURCE menus. The system indicates whether the WORD trigger is the selected trigger Source for A or B Trigger, or both, in the TRIG WORD menu (displayed when the SET WORD front-panel button is pressed).

Attempting to select WORD as a trigger source or to program the probe operation without a Word Recognizer Probe connected will ring the warning bell, displays the error message "WORD PROBE FAULT". The trigger source remains as previously selected in that case. If the Word Recognizer Probe is disconnected after WORD is selected, the same error message will appear if the scope is acquiring. Disconnecting the probe will not be detected while the scope is in SAVE mode; however, any attempt to change the programmed word with the probe removed will result in a WORD PROBE FAULT.

A word length of 16-bits, plus a 17th qualifier bit, is recognizable with each bit selectable to 0, 1, or X (don't care). Word recognition may be either synchronous with an external clock signal (rising or falling edge) or asynchronous (ignoring clock signals).

The word-recognizer trigger signal is routed to the rear-panel BNC connector labeled WORD TRIG OUT for use as a trigger signal to external devices. A trigger signal will appear at the WORD TRIG OUT connector each time a word match occurs; however, the holdoff time of the scope may prevent it from accepting each trigger if the selected word appears too often in the data stream.

Word Probe Setup

The front-panel button labeled SET WORD calls up the control menu for setting up the Word Recognizer Probe operation. The RADIX choice lets you display the selected word in either octal or hexadecimal. Under the CLOCK in the menu, you can select either the rising-edge of clock, falling-edge of clock, or ASYNChronous (ignore clock) for determining when a data match will produce an output trigger.

Pressing the SET BITS menu button calls up the TRIG WORD control menu for setting the word to be recognized. The trigger word is displayed in binary form (for ease in setting the individual bits) and in either octal (six digits) or hexadecimal (four digits) as selected under the RADIX choice (for ease in user identification of the trigger word). Digits containing don't care bits (X) in the binary word display are shown in the octal or hex word representation as a question mark (?).

The binary trigger word bits are selected for setting using the direction arrow menu buttons to position the cursor, represented by an underline beneath the bit to be set. Once the cursor is positioned to the desired word bit or to the qualifier bit, that bit may be set by pressing a 1, 0, or X menu button. After a bit is set, the cursor automatically advances to the next bit in the direction last selected by an arrow button. The bit selection and arrow buttons are repeating; they continue their function and rotate through the bits as long as they are held down. Using the repeating feature, all the word bits (or any portion of the bits) may be set to one, zero, or X. The specific bits for change may then be selected by pressing the arrow keys for one step at a time as necessary to align the cursor and then pressing the correct bit button once.

Basic Application

Use the following procedure as a general guide to *WR* operation:

1. Connect the *WR* probe to the instrument and the system under test. Note that bits 0-7 and the clock appear on one side of the probe and bits 8-15 and the qualifier bit appear on the other. Be sure to connect at least one of the GND terminals to a good signal ground in the system, as close to the trigger source as possible.
2. Use A/B TRIG front-panel button to select the desired Triggering System.
3. Push TRIGGER SOURCE to display that menu.
4. Set A*BWORD to WORD in the displayed menu (if the *WR* probe is not connected, the message "WORD PROBE FAULT" is displayed and the coupling is switched to VERT.
5. Push SET WORD front-panel button to display the WORD RECOGNIZER setup menu. Set the menu as desired to select OCTal or HEX RADIX, rising edge (_/‾) symbol, falling edge (‾_) symbol), or ASYNCHRONOUS (or no clock) as desired.
6. Push SET BITS in the menu to display the TRIG WORD menu (pushing SET WORD also toggles between the SETUP and the TRIG WORD menus).
7. Use the menu buttons to set the Word Trigger:
   a. Use the arrow-labeled buttons in the menu to move the underline to a bit in the word you want to change.
   b. Select 0, 1, or X (don't care) for the bit as required. (The underline automatically steps 1 bit to the left in the word for convenience in setting).
   c. Repeat a and b until all bits are set as desired. Note that the word set is also displayed in OCT or HEX (depending on the RADIX previously selected) in the menu.
8. The instrument will now recognize any specified word for triggering purposes.

Accessories

Standard Accessories

The following standard accessories are provided with each instrument.

2 Probes, 10X, 1.3 Meter, with Accessories	P6133, PROBE OPT. 01
1 Accessory Pouch, Snap	016-0692-00
1 Accessory Pouch, Ziploc	016-0537-00
1 Operators Manual	070-6286-00
1 Programmers Reference Guide	070-6338-00
1 Users Reference Guide	070-6339-00
1 Fuse, 5 A, 250 V, AGC/3AG	159-0014-00
1 CRT Filter, Blue Plastic (installed)	378-0199-03
1 CRT Filter, Clear Plastic	378-0208-00
1 Front Cover	200-2742-00

Rackmounting Accessories

The following accessories are available to rackmount the instrument not purchased as a 1R option.

	PART NUMBER
Rackmounting conversion kit	016-0825-00
Rackmounting rear-support kit (for use with the rackmounted instruments)	016-0096-00

Optional Accessories

The following optional accessories are recommended for use with the 2430A Digital Oscilloscope.

	PART NUMBER
Service manual	070-6330-00
Word Recognizer probe	010-6407-01
Oscilloscope cameras	
C-5C Option 01	016-0357-01
C7 Option 03 with Option 30	016-0799-01
SCOPE-MOBILE cart	K212
Carrying strap	346-0058-00

Extended Functions

Introduction

The information in this section describes and defines the performance of the EXTENDED FUNCTIONS. There are two types of EXTENDED FUNCTIONS available for use by operators: SYSTEM and CAL/DIAG. The third type, SPECIAL, is used for special servicing only and performs no user functions. The control menus found under SYSTEM are seldom used and, once set for the system operation wanted, are not normally accessed. Control menus for the internal calibration and diagnostics are accessed using the CAL/DIAG menu selection. The instrument system supports three levels of internal diagnostics; SELF DIAG, EXT DIAG, and service routines. Calibration is in two levels; Self Calibration and Extended Calibration.

Special

The menu choices under SPECIAL are normally disabled, and if the SPECIAL button is pressed, the message "DISABLED—SEE MANUAL" is displayed. If the functions are enabled, pressing the SPECIAL choice of EXTENDED FUNCTIONS calls up the display "WARNING: SERVICE ONLY—SEE MANUAL" with the choice of COLD START, CAL PATH ON¦OFF and FORCE DAC. All three choices are special diagnostics functions that should not be called up by operators/users. COLD START eliminates all the previous calibration constants. After a COLD START, a partial re-calibration is required to return the instrument to its previous state. CAL PATH ON¦OFF and FORCE DAC is a special diagnostic tool which service technicians can use to change the value of selected constants when troubleshooting the internal circuitry.

System Controls

Pushing SYSTEM displays the SYSTEM menu. This menu allows the user to specify settings for certain seldom-changed functions.

In this menu, one button, PREFLT ON¦OFF, turns a function on and off while the other three buttons, PANEL MISC and VIDEO OPT, call up submenus for controlling functions.

PREFLT ON¦OFF

When on, it operates on interpolated data points only. It reduces the filter overshoot in the sinx/x interpolator which occurs when viewing very narrow pulses. Generally, PREFLT is set to on for normal operation; if viewing very narrow pulses, the user might prefer to turn off the prefilter.

PANEL

Calls up a submenu for specifying how the front-panel controls are set up at power-on. The only menu choice in this menu is POWER ON LAST¦INIT. When the button is toggled to set to LAST, the control settings in effect at power-off are reestablished at power-on. When toggled to INIT, a factory setup of initialized front-panel settings is established at power-on.

In general, powering up in INIT produces a simple setup with CH 1 only displayed and all special functions (such as Delay by Events, Cursors, and Envelope or Average acquisition) OFF. (The complete list of controls and states of the INIT feature is found in Table B-15 of Appendix B). The button labeled INIT PANEL in the AutoStep Sequencer menu (push PRGM to display) produces exactly the same front-panel setup as when the instrument is powered on with POWER ON set to INIT.

MISC.

Calls up a submenu for selecting miscellaneous function settings. The menu choices are BELL ON¦OFF and TRIG T ON¦OFF. The up-arrow labeled button returns the scope to the SYSTEM menu.

When BELL ON¦OFF is set to ON, any warnings to the user regarding system operating errors (especially with the GPIB interface) can be signaled by an audible tone. BELL must be on for it to sound when running sequences containing steps that require the BELL to sound.

TRIG T, when set ON, indicates the point where the Record Trigger occurred on displayed acquisitions. It is a small "T", riding on the waveform.

VIDEO OPT.

Calls up a submenu for setting up Video Option operation.

The scope is set up to use either System-M protocol or nonsystem- M protocol for sync operation via the TV SYS M¦NON-M menu button. Choosing the wrong protocol does not prevent TV Triggering; however, the line counter will not count the lines correctly. When System-M is selected, the line count begins three lines before the field-sync pulse is encountered. When nonsystem-M is selected, the line count begins coincident with the field-sync pulse. See "Video Option" in Section 7 for more information.

CNT RST BOTH¦F1 (Count Reset, Both or F1) controls how the scope treats Field 1 and Field 2 when lines are selected beyond the maximum or minimum line number available in those fields. The way the fields are treated depends on settings used in the A VIDEO COUPLING menu. See "Video Option" in Section 7 for more information.

Calibration/Diagnostics Description

Selecting the bezel menu button under CAL/DIAG menu label displays four choices: SELF CAL, EXT CAL, SELF DIAG, and EXT DIAG.

Internal Diagnostic Routines

The SELF DIAG and EXT DIAG routines are layered into three levels for detecting and isolating system operation faults. Fault detection is based on starting at the lowest system level, the kernel, and then testing each additional subsystem with the knowledge that previously tested subsystems were good. When a subsystem fault is detected by one of the diagnostics, it is isolated at that subsystem level. Additional testing then proceeds downward through the remaining tests of that subsystem to the lowest testable level.

Self Diagnostics

These are menu-driven tests, automatically executed at power-on. The Self Diagnostics test the functionality of all components that may be controlled or accessed by the internal System uP. The Self Diagnostics routines may also be accessed from the instrument front-panel or by means of the GPIB interface. If all tests pass, the system invokes the SCOPE MODE.

Power-on/Self Diagnostics Test Failure

If the Self Diagnostics tests fail, either at power-on or when called by the user from the front panel, the "EXTENDED DIAGNOSTICS" mode will be entered. The menu displayed in Extended Diagnostics permits the user to determine which test(s) failed as a start in isolating the fault to the problem area (see Table A-1). Failure of a test number from 7000 through 9300 does not necessarily indicate a fatal instrument fault. An abnormal power-off or transient power condition may have prevented the orderly shutdown that normally saves the data needed to return the scope to the operating state present at power-off. A failure of the SELF DIAGNOSTICS will also occur if the present temperature of the scope is very different from the temperature during the last SELF CAL. In the last case, the stored calibration constants may not permit accurate measurements to be made.

NOTE

If the extended diagnostics fails upon power on, and if this failure is due to loss of power to the instrument, the scope will display the message "RUN SELF CAL WHEN WARMED UP". At that point, the user should press the up arrow in the displayed menu to get to the SELF CAL menu (instrument remains locked in the DIAGNOSTICS menu until the button is pushed). Once in the SELF CAL menu, run the SELF CAL as soon as the "NOT WARMED UP" message disappears from the menu (the instrument remains locked in the SELF CAL menu until SELF CAL is run).

At power-on, the instrument checks the self-calibration constants, waveform data, waveform scaling factors, and power-off front-panel control settings stored in the instrument. Failure of a 6000 subset diagnostic test indicates a checksum failure of the stored data in the nonvolatile RAM. If test 6100 fails, tests 6200 and 6300 in the subset are not done. The causes of a failure in this area may be non-fatal to continued instrument operation, and normal (or near-normal) operation may be recovered by the user.

Loss of calibration constants (failure of CAL-CONSTANTS test 6100) causes the instrument to do a "COLD START" with the resulting replacement of all calibration constants by predetermined nominal values. After a COLD START, all previously stored waveforms are invalid (SAVEREF memories will be marked "EMPTY" and the VERTICAL MODE menu will contain an "invalid waveform" message). An INIT PANEL is also done to set all the front-panel controls and GPIB states to their INIT values (see Table B-15 in Appendix B for a complete list of INIT settings).

Continued scope operation after a COLD START is obtained by first performing the SELF CAL procedure to restore the automatic calibration constants. (Pressing the up-arrow menu button shown in the EXTENDED DIAGNOSTICS menu returns to the main CAL/DIAG menu with the SELF CAL choice.) SELF CAL takes a little more time to complete than normal after a COLD START. This is because the nominal starting point values for the calculations are farther from the correct results than the previously calculated SELF CAL constants.

NOTE

DO NOT TURN THE SCOPE OFF WHILE THE SELF CAL ROUTINE IS RUNNING. Turning off the power prior to completion of SELF CAL will again invalidate the instrument calibration constants.

After SELF CAL has been done, the REPET calibration in the EXT CAL menu must also be done if the scope is to be operated in the REPET mode. The ATTEN and TRIGGER choices (normally disabled to the user) in the EXTENDED CAL menu are labeled "UNCALD" after the COLD START. Pressing the MENU OFF/EXTENDED FUNCTIONS button returns the scope to the operating mode for near-normal operation. The COLD START nominal calibration values supplied for the ATTEN and TRIGGER calibration permit normal measurements to be made, but with slightly reduced vertical gain and trigger level readout accuracy.

Replacement of the calculated ATTEN and TRIGGER calibration constants by a COLD START causes the scope to enter the EXTENDED DIAGNOSTICS mode with the "RUN SELF CAL, THEN RUN EXT CAL " message displayed for each following power-on. The ATTEN and TRIGGER choices in the EXTENDED CAL menu will be labeled UNCALD. These messages are there to remind the user that the scope must be referred to a qualified service person to replace the nominal COLD START calibration constants with actual calculated values. External test equipment and access to the inside of the scope is required to perform the EXTENDED CAL procedures needed.

Loss of the stored power-off front-panel settings (failure of FP-LAST test 6200) causes the scope to do an INIT PANEL on power-up (see Table B-15 in Appendix B for the INIT settings). Recovery of normal operation is done by pressing MENU OFF/EXTENDED FUNCTIONS to exit EXTENDED DIAGNOSTICS and resetting the front-panel controls to the required settings for the measurement to be made. The "FAIL" condition for test 6200 will be reset to PASS and the scope will not enter EXTENDED DIAGNOSTICS on the next power-up if permanent failure of the memory has not occurred.

Loss of waveform scaling factors (failure of WFM-HEADERS test 6300) causes all waveforms to be invalid. At power-on, invalid waveforms may be displayed, but an "invalid waveform" message will be displayed in the VERTICAL MODE menu for invalid vertical mode waveforms and SAVEREF memorys containing invalid waveforms will be labeled "empty" in the DISPLAY REF menu. Pressing the MENU/OFF EXTENDED FUNCTIONS button to exit EXTENDED DIAGNOSTICS, followed by pressing STORAGE ACQUIRE to resume acquiring waveform data, restores normal operation of the scope.

Loss of individual waveforms from the SAVE memory will not cause a power-up test failure. Such a loss can occur if the scope is in the middle of acquiring when the power is turned off. The user is notified of this loss by replacing the invalid waveform(s) with a horizontal line broken by full-screen fill areas (broken line of dots with vectors off).

Failure of diagnostic tests numbered 7000 through 9300 may indicate that instrument calibration is invalid at the present temperature. If that condition occurs, the instrument will enter the EXTENDED DIAGNOSTICS mode, and the "RUN SELF CAL WHEN WARMED UP" message will then be displayed. Such a non-fatal condition might exist if the last SELF CAL was done at an operating temperature that is very different than the present temperature of the scope. In this case, the power-on self diagnostics detect that the stored calibration constants may not permit accurate measurements to be made. Recovery is made by allowing the instrument to warm up ("NOT WARMED UP" message not displayed in the main CAL/DIAG menu) and running the SELF CAL procedure to recalculate the calibration constants.

A diagnostic test number of 7000-9300 that continues to fail diagnostics after SELF CAL is done indicates that some condition exists that prevents correct operation. The scope may still be operational for limited use, depending on the nature of the failure. For example, if the failure is in the CH 2 side only, CH 1 may still be used for making measurements with confidence that the required vertical accuracy is available. Exit the Extended Diagnostics mode by pressing the MENU OFF/EXTENDED FUNCTIONS button to operate the scope.

When Self Diagnostics is called via the GPIB, completion and/or failure will cause an SRQ to be issued by the instrument. The status bytes returned on a poll indicate a successful completion or failure of the Self Diagnostics sequence. Errors can then be queried via the GPIB and traced to the lowest level of the Extended Diagnostics in the same manner as from the front-panel. Failure of Self Diagnostics when run from the GPIB does not put the instrument into the Extended Diagnostics menu.

Extended Diagnostics

Any of the Self Diagnostics tests may be accessed either individually or in selected groups using the EXT DIAG control menu. The tests use internal feedback and the digitizing capabilities of the instrument to minimize the need for applying external signals or using external test equipment to troubleshoot. Testing of a failed area down to the lowest functional level possible (in some cases to the failed component) provides direction for further troubleshooting with service routines and/or conventional methods. Troubleshooting a failure of the instrument may be based on assumptions made possible by running selected tests to verify good circuit blocks, thereby eliminating those blocks from consideration as a failed area.

Service Routines

The Service Routines are menu, GPIB interface, or jumper-initiated routines for exercising the hardware, usually in a looping test, that allow a service technician to troubleshoot an internal fault using external testing and measuring equipment. Where possible, the Extended Diagnostics routines are used for looping to permit access to them from both the front-panel EXTENDED FUNCTIONS menu and the GPIB interface.

Use of these routines provide service personnel with signals and procedures to enable fault isolation and for restoring an instrument to a functional level that is supported by the Extended Diagnostics and/or other Service Routines.

Programmed routines that systematically exercise specific firmware or hardware functions may be implemented via the GPIB interface. This enhances troubleshooting performance by providing a comprehensive tool for instrument troubleshooting using controller programming.

Internal Calibration Routines

The instrument system supports two levels of Internal Calibration routines: SELF CAL and EXT CAL. These routines calibrate the analog subsystems of the scope to meet specified performance requirements. Any detected faults in the control system and/or in the self-calibrating hardware are reported by a "FAIL" message displayed with the label of the failed area.

Self Calibration

Self Calibration may be started from the front-panel using the EXTENDED FUNCTIONS menu or by the GPIB routines for automatically calibrating the analog systems within the instrument. Self Calibration routines calibrate the major portion of the scope's analog system in about 10 seconds. A Self Calibration may be performed by the user at any time. Important times are after the instrument has warmed up, if the ambient operating temperature changes by a significant amount since the last Self Calibration, and just prior to making a measurement that requires the highest possible level of accuracy.

NOTE

The Extended calibration feature is normally disabled, and the scope must be referred to a qualified service person to complete the calibration procedures.

Extended Calibration

The Extended Calibration steps provide the additional routines beyond Self Calibration that require user interaction. The steps require the application of standard voltages to the vertical inputs to calibrate the Attenuators and to the external trigger inputs to calibrate the trigger amplifiers.

Attempting to use the Extended Calibration features without having the correct standard voltage levels available for the Attenuator and Trigger calibration will cause the "FAIL" message to appear above the menu label of the failed areas. However, in the event of a failed attempt, the previous calibration constants will not be overwritten, and the instrument will remain in its previous state of calibration. Also, to warn the user that a calibration attempt has failed, the message "UNCALD" will appear in the EXTENDED DIAGNOSTICS menu, and the instrument will enter the EXTENDED DIAGNOSTICS mode at each power-on.

The FAIL message will also be displayed as the result of an actual hardware failure. Instruments displaying a FAIL message should be referred to a qualified service person for any necessary servicing if a correct calibration attempt does not pass.

Calibration/Diagnostics Operation

All the calibration and diagnostic routines are accessible through the EXTENDED FUNCTIONS menu and via the GPIB. The EXTENDED FUNCTIONS menu is selected by the MENU/EXTENDED FUNCTIONS button when no other menus are displayed. Pressing the bezel button under the CAL/DIAG menu choice that appears produces the following menu display:

<status>	<status>	<status>	<warm-up>
SELF	EXT	SELF	EXT
CAL	CAL	DIAG	DIAG

<status> indicates the most current result of the test or calibration.

For calibration <status> can be:

UNCALD: instrument has not been calibrated.

FAIL: hardware errors were detected during calibration (calibration may not be valid).

PASS: the instrument was successfully calibrated.

For diagnostics <status> can be:

(blank): test has not been executed.

FAIL: test failed on last attempt.

PASS: test passed on last attempt.

<warm-up> is the warning "NOT WARMED UP" which is displayed for approximately ten minutes after power-on. Calibrating the instrument during this period is not recommended.

NOTE

The NOT WARMED UP message is displayed after every power-on for the ten-minute period, even if the scope is turned off and then right back on. In this case, calibration may be performed as soon as the instrument has stabilized after power-on.

Self Calibration

A complete Self Calibration of the instrument is executed when SELF CAL is pressed. If no errors are detected during the calibration sequence, the PASS message is displayed above SELF CAL and the instrument is ready to be used. Assuming no failure or "UNCALD" condition exists, press the MENU OFF/EXTENDED FUNCTIONS button to exit the CAL/DIAGNOSTICS mode and return to the scope mode. Any detected error puts the instrument into the initial EXTENDED DIAGNOSTICS menu shown in Figure A-1 with the appropriate error(s) indicated.

NOTE

If, after running SELF CAL, any test sequence fails SELF DIAG, it is recommended that the instrument be brought to the attention of a qualified and authorized service person.

Extended Calibration

NOTE

If Extended Calibration is internally disabled, the scope will not respond to a press of the ATTEN, TRIGGER, or DISPLAY menu buttons.

Pressing the EXT CAL button selects the Extended Calibration menu:

<status>	<status>	<status>		
ATTEN	TRIGGER	REPET	DISPLAY	↑

A choice of any of the four selections begins execution of the indicated semi-automatic calibration routine. Pressing the up-arrow button returns to the CAL/DIAG menu level. The correct dc test voltages must be available to complete this ATTEN and TRIGGER calibration.

EXT CAL routines can be aborted at any time by pressing the MENU OFF/EXTENDED FUNCTIONS button, but once a calibration sequence is started it must be successfully passed to assure correct calibration.

Power-On Self Diagnostics

At instrument power-on, a self-test sequence is executed automatically in the first 15 seconds. If the instrument has been calibrated and no hardware errors are detected, the instrument will come up in SAVE acquisition mode. If errors are detected or if part of the instrument is uncalibrated, the instrument will come up in the EXTENDED DIAGNOSTICS menu with errors displayed and/or the message UNCALD at the bottom of the screen. Exiting to the Scope Mode from the EXTENDED DIAGNOSTICS mode is done by pressing the MENU OFF/EXTENDED FUNCTIONS button.

Front-Panel Self Diagnostics

Pressing the SELF DIAG button from the CAL/DIAG menu also causes execution of the complete Self Diagnostic test sequence. If no self-test errors occur, the word PASS will appear in the <status> position. If errors are detected, the instrument will be put into the EXTENDED DIAGNOSTICS menu with the appropriate errors displayed, if possible.

Extended Diagnostics

From the CAL/DIAG menu, a choice of EXT DIAG calls up the Extended Diagnostic menu. The display is:

↑ ↓ RUN/SEL MODE HALT

<mode> indicates which looping mode is selected.

On entering the Extended Diagnostics, a list of the top level tests with their most recent status—PASS, FAIL, or blank (indicating that the test has not been run) is displayed (see Figure A-1). In addition, if the instrument is not fully calibrated the word UNCALD is displayed at the bottom of the screen.

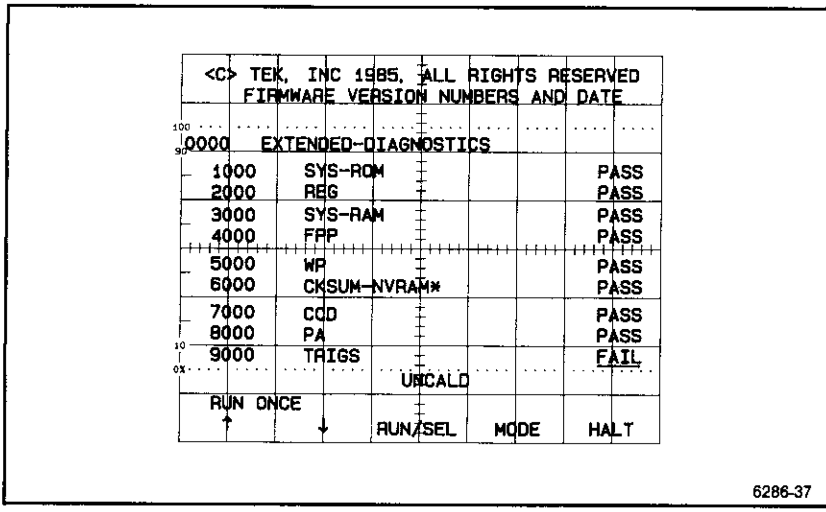


Figure A-1. EXTENDED DIAGNOSTICS Menu.

The display of diagnostics selections is a hierarchically structured set of tests in lists containing the test numbers, test names, and last status of the test results. If the test has not been run since the last "Cold Start," no status will be displayed. If an upper level test in the set (such as REG) is run, all tests in the REG test hierarchy will be done and labeled with a PASS or FAIL status.

UP/DOWN Arrows

The up-arrow and down-arrow buttons move an underscore pointer through the displayed list of diagnostic tests. Moving the pointer to a diagnostic below the title line, then pressing the RUN/SEL button, selects a menu of tests available at the next level down with that diagnostic. Moving the pointer up above the title line returns to the next level of hierarchy in the menu (if not at the top line). If at the top line of 0000, a press of the up-arrow button returns the CAL/DIAG menu choices.

RUN/SEL.

A press of RUN/SEL with the pointer at the title line causes all the tests at and below that diagnostic level to be run. An individual test can be selected by using the arrow keys to move the pointer to the desired test, then pressing the RUN/SEL button. The cumulative result of any test run will be displayed on test completion at the right of the title line. This will be either PASS, FAIL, or blank if an attempt was made to run a non-automatic test.

NOTE

A diagnostic name followed by an asterisk is not testable. The asterisk indicates either that the test is accessible for calibration only using the EXT CAL menu choices or that it may be checked at power-on only. The PASS/FAIL message displayed indicates the results of the last Extended Calibration or the last power-on check. A FAIL label on an asterisked test will be accompanied by an "UNCALD" label above the bezel button labels. An UNCALD label also appears above the uncalibrated selection of the EXT CAL menu.

MODE

The MODE button rolls through choices for how the selected test will be run. The choices are RUN ONCE, RUN CONTINUOUS, RUN UNTIL FAIL, and RUN UNTIL PASS. If RUN CONTINUOUS is chosen before starting the selected test, it will be continually executed until the HALT button is pressed. RUN UNTIL PASS and RUN UNTIL FAIL can also be stopped using the HALT button. In addition, all tests can be aborted with the MENU OFF/EXTENDED FUNCTIONS button. Selecting to run an asterisked test automatically switches to RUN ONCE, and the test does not run.

HALT

Pressing HALT causes all diagnostic test activity to stop at the finish of the current test in progress. It is especially used to halt a continuously looping test.

GPIB Interface Operation

Operation of the GPIB interface is described in the Programmers Reference Guide included with this manual. This additional information describes use of the diagnostic commands. Operation of any of the four Cal/Diagnostic modes is selected by using the keywords SELFCal, EXTCal, SELFDiag, or EXTDiag as arguments with the TESTType command via a GPIB controller. The selected TESTType will start when the EXEcute command is received. During execution of the tests, the scope front panel is locked out, and only user prompts will be displayed. Menus required for controlling the scope from the front panel will not be displayed when controlling the scope via the GPIB interface. See the Programmers Reference Guide for the definition of the GPIB calibration and diagnostics commands.

Self Calibration

If TESTType SELFCal is selected, the Self Calibration portion of the test sequence will be run in its entirety when the EXEcute command is received. A service request (SRQ) will be issued when the sequence is finished if the OPC mask is on. The status byte received by the controller will indicate if the test completed either with error or with no error. See the Programmers Reference Guide for a list of the status bytes.

If an error occurs during SELFCal, it is reported to the controller when the ERRor? query is issued to the instrument. ERRor? returns a string of error numbers (up to nine) resulting from the last EXEcute command. These numbers will be the highest order in the hierarchy of the SELF CAL routine; so, to locate the exact test that failed in the tree, the TESTNum must be set to a lower level and the ERRor? query re-issued until the lowest detection level of the failure is reached. The ERRor? query returns 0 if no errors have occurred. This method of failure location is used for errors generated by any of the calibration or diagnostics sequences.

Extended Calibration

The EXTCAL TESTtype allows specifying the calibration sequence (TESTNum) to be performed. The calibration routine specified may be any steps or sub-steps of the EXT CAL or SELF CAL routines. The user is responsible for assuring that any externally required test equipment has been connected and programmed, and that pauses in the procedure to make manual adjustments or equipment changes are terminated via a menu button push or a GPIB STEp command to advance to the next step in the sequence. The external calibration sequence numbers to be used as the numerical argument for TESTNum are listed in Table A-1 under the "Test Code" column heading. The valid test numbers for Calibration are 7000 to 9300 in the table. Error handling is the same as in SELFCal.

Self Diagnostics

Invoking the TESTType SELFDiag causes execution of the entire self-diagnostic sequence when an EXEcute command is received. Error handling is the same as in SELFCal.

Extended Diagnostics

TESTType EXTDiag allows a specific TESTNum to be selected for execution upon receiving an EXEcute command. Error handling and reporting is the same as in SELFCal. Looping a test is done by issuing the LOOp command prior to the EXEcute command, and the HALt command stops the looping test.

Table A-1
Calibration and Diagnostics Codes and Names

Test Code	Test Name and Hierarchy
0000	CAL-DIAG
1000	SYS-ROM
1100	ROM1
1200	ROM0.0-0
1300	ROM0.1-1
1400	ROM0.2-2
1500	ROM0.3-3
1600	ROM0.0-4
1700	ROM0.1-5
1800	ROM0.2-6
1900	ROM0.3-7
2000	REG
2100	PROCESSOR
2110	DIAG0
2120	DCOK
2130	BUSTAKE
2140	DIAG1
2150	COMREG
2160	WPDN
2170	DIAG2
2180	FLD2
2190	MWPDN
2200	TB-DSP
2210	MISC
2211	1010 0101
2212	0100 1011
2213	1001 0110
2214	0010 1101
2220	MODECON
2221	1010 0101
2222	0100 1011
2223	1001 0110
2224	0010 1101
2230	DISCON
2231	1010 0101
2232	0100 1011
2233	1001 0110
2234	0010 1101

Table A-1 (cont)

Test Code	Test Name and Hierarchy
2300	TB-DSP
2310	VCURS
2311	1010 0101
2312	0100 1011
2313	1001 0110
2314	0010 1101
2320	TCURS
2321	1010 0101
2322	0100 1011
2323	1001 0110
2324	0010 1101
2330	U130
2331	1010 0101
2332	0100 1011
2333	1001 0110
2334	0010 1101
2340	U140
2341	1010 0101
2342	0100 1011
2343	1001 0110
2344	0010 1101
2350	U240
2351	1010 0101
2352	0100 1011
2353	1001 0110
2354	0010 1101
2360	U322
2361	1010 0101
2362	0100 1011
2363	1001 0110
2364	0010 1101
2370	U314
2371	1010 0101
2372	0100 1011
2373	1001 0110
2374	0010 1101
2400	TB-DSP
2410	U670-FISO
2420	U670-SISO

Table A-1 (cont)

Test Code	Test Name and Hierarchy
	REG (cont)
2500	MAIN
2510	INIT-SHFT-REGS
2520	ATTEN
2530	PEAK-DETECTOR
2540	GATE-ARRAY
2550	TRIG
2560	SYSTEM-DAC
2600	SIDE
2610	1010 0101
2620	0100 1011
2630	1001 0110
2640	0010 1101
3000	SYS-RAM
3100	A11U431
3110	0←1
3120	0→1
3130	1→0
3140	1←0
3200	A11U440
3210	0←1
3220	0→1
3230	1→0
3240	1←0
3300	A12U668
3400	A12U350
3410	0←1
3420	0→1
3430	1→0
3440	1←0
3500	A11U430
3600	A11U600
3610	0←1
3620	0→1
3630	1→0
3640	1←0

Table A-1 (cont)

Test Code	Test Name and Hierarchy
	SYS-RAM (cont)
3700	(A12U440
3710	0←1
3720	0→0
3730	1→0
3740	1←0
3800	A12U432
3810	0←1
3820	0→0
3830	1→0
3840	1←0
3900	A12U664
3910	0←1
3920	0→0
3930	1→0
3940	1←0
4000	FPP
4100	U861-9
4200	U861-6
4300	WR-TO-HOST
4400	DIAG-BYTE
4500	FPDNRD
4600	U741/U751
4700	BATT-VOLTS
4710	HIGH
4720	LOW
5000	WP
5100	RUN-TASK
5200	BUSGRANT
5300	VERSION-CK
6000	CKSUM-NVRAM
6100	CAL-CONSTANTS
6200	FP-LAST
6300	WFM-HEADERS

Table A-1 (cont)

Test Code	Test Name and Hierarchy
7000	CCD
7100	CENTERING
7200	GAIN
7300	EFFICIENCY
7310	SLOW
7311	CH1-1
7312	CH1-3
7313	CH2-1
7314	CH2-3
7320	FAST
7321	CH1-1
7322	CH1-3
7323	CH2-1
7324	CH2-3
7400	PD-OFFSET
7410	CH1-1
7420	CH1-3
7430	CH2-1
7440	CH2-3
8000	PA
8100	OFFSET
8110	NORM-SP
8111	CH1
8112	CH2
8120	NORM-FISO
8121	CH1
8122	CH2
8130	ENV-SP-SLOW
8131	CH1
8132	CH2
8140	ENV-FISO-SLOW
8141	CH1
8142	CH2
8150	ENV-FISO-FAST
8151	CH1
8152	CH2

Table A-1 (cont)

Test Code	Test Name and Hierarchy
	PA (cont)
8200	POS-GAIN
8210	CH1
8220	CH2
8300	BALANCE
8310	50MV
8311	CH1
8312	CH2
8320	20MV
8321	CH1
8322	CH2
8330	10MV
8331	CH1
8332	CH2
8340	5MV
8341	CH1
8342	CH2
8350	2MV
8351	CH1
8352	CH2
8400	GAIN
8410	50MV
8411	CH1
8412	CH2
8420	20MV
8421	CH1
8422	CH2
8430	10MV
8431	CH1
8432	CH2
8440	5MV
8441	CH1
8442	CH2
8450	2MV
8451	CH1
8452	CH2

Table A-1 (cont)

Test Code	Test Name and Hierarchy
	PA (cont)
8500	INV-GAIN
8510	50MV
8511	CH1
8512	CH2
8520	20MV
8521	CH1
8522	CH2
8530	10MV
8531	CH1
8532	CH2
8540	5MV
8541	CH1
8542	CH2
8550	2MV
8551	CH1
8552	CH2
8600	VAR-MAX
8610	CH1
8620	CH2
8700	ATTENUATOR*
8710	CH1
8711	X1
8712	X10
8713	X100
8720	CH2
8721	X1
8722	X10
8723	X100

Table A-1 (cont)

Test Code	Test Name and Hierarchy			
9000	TRIGGERS			
9100		OFFSET		
9110			A-TRIG	
9111				CH1
9112				CH2
9113				SLOPE
9114				EXT1X1*
9115				EXT1X5*
9117				EXT2X5*
9116				EXT2X1*
9120			B-TRIG	
9121				CH1
9122				CH2
9123				SLOPE
9124				EXT1X1*
9125				EXT1X5*
9172				EXT2X5*
9200		GAIN		
9210			A-TRIG	
9211				CH1
9212				CH2
9213				EXT1X1*
9214				EXT1X5*
9215				EXT2X1*
9216				EXT2X5*
9220			B-TRIG	
9221				CH1
9222				CH2
9223				EXT1X1*
9224				EXT1X5*
9225				EXT2X1*
9226				EXT2X5*
3300		REPET*		

Appendix B

VOLTS/DIV Range With Attenuator Probes

The range of the VOLTS/DIV front-panel switch for all available probes is displayed in Table B-1.

Table B-1
VOLTS/DIV Readout Switching With Coded Probes

Display Type	Basic Volts/Div	Readout Volts/Div with Indicated Probe			
		1X	10X	100X	1000X
	2 mV	200 μV	2 mV	20 mV	200 mV
EXPANDED	2 mV	500 μV	5 mV	50 mV	500 mV
	2 mV	1 mV	10 mV	100 mV	1 V
	2 mV	2 mV	20 mV	200 mV	2 V
	5 mV	5 mV	50 mV	500 mV	5 V
	10 mV	10 mV	100 mV	1 V	10 V
	20 mV	20 mV	200 mV	2 V	20 V
	50 mV	50 mV	500 mV	5 V	50 V
NORMAL	100 mV	100 mV	1 V	10 V	100 V
	200 mV	200 mV	2 V	20 V	200 V
	500 mV	500 mV	5 V	50 V	500 V
1 V	1 V	10 V	100 V	1 kV	
	2 V	2 V	20 V	200 V	2 kV
	5 V	5 V	50 V	500 V	5 kV

Calibrator Frequency

Table B-2 shows the CALIBRATOR frequency and period for each A SEC/DIV setting.

Table B-2
Calibrator Frequency and Period for Each A SEC/DIV Setting

A SEC/DIV Setting	Calibrator Frequency	Calibrator Period	DIV/ Cycle
5 ns			40
10 ns			20
20 ns	5 MHz	200 ns	10
50 ns			4
100 ns			2
200 ns			1
500 ns			4
1 μs	500 kHz	2 μs	2
2 μs			1
5 μs			4
10 μs	50 kHz	20 μs	2
20 μs			1
50 μs			4
100 μs	5 kHz	200 μs	2
200 μs			1
500 μs			4
1 ms	500 Hz	2 ms	2
2 ms			1
5 ms			4
10 ms			2
20 ms			1
50 ms			0.4
100 ms			0.2
200 ms	50 Hz	20 ms	0.1
500 ms			0.04
1 s			0.02
2 s			0.01
5 s			0.004

Averaging SNIR

Table B-3 shows the signal-to-noise improvement ratio (SNIR) as the number of averages increases. The display updates with each new waveform acquired, so the user sees the averaged waveform improve with each new acquisition.

Table B-3
Signal-to-Noise Improvement Ratio
Versus Number of Averages

Number of Averages	SNIR	SNIR (in dB)
2	1.41	3
4	1.98	5.9
8	2.75	8.8
16	3.84	11.7
32	5.34	14.6
64	7.51	17.5
128	10.6	20.5
256	14.9	23.4

REPETITIVE Acquisition

Table B-4 illustrates the number of acquisitions required to complete a Single Sequence that meets the requirement for USB (Useful Storage Bandwidth) associated with the SEC/DIV setting used.

Table B-4
Repet Acquisitions Required To Complete a Single Sequence

SEC/DIV (ns/div)	Number of Acquisitions
200	5
100	5
50	10
20	15
10	20
5	50

SMOOTH

Figure B-1 indicates the amplitude rolloff with frequency for the moving, five sample-point filter applied to waveforms when SMOOTH is turned on. The frequency is expressed as a percentage of the Useful Storage Bandwidth. Useful Storage Bandwidth is a function of the SEC/DIV setting and is displayed in the BANDWIDTH menu.

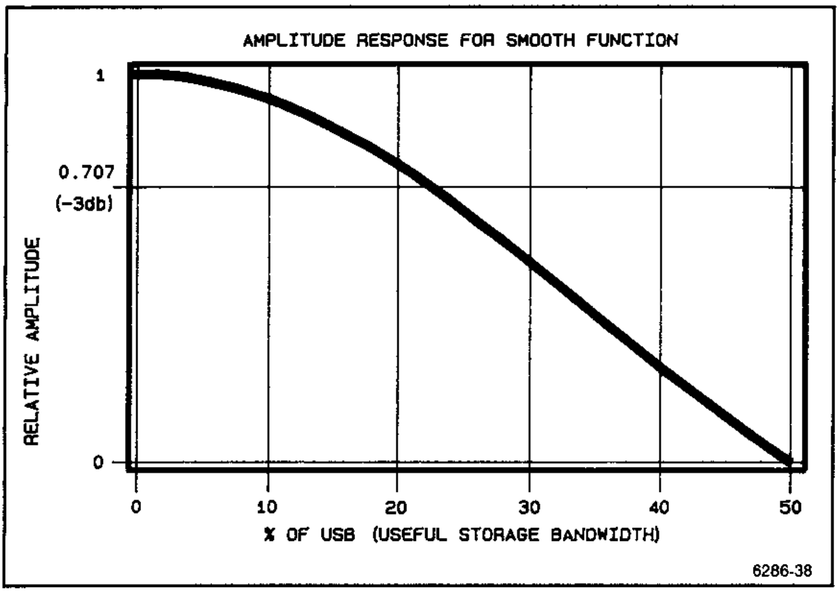


Figure B-1. Amplitude Response for Smooth Function.

Variable HOLDOFF

The front-panel HOLDOFF control knob varies the amount of holdoff time between the end of the acquisition and the time a triggering signal can initiate the next acquisition. Table B-5 shows the time factor for the minimum and maximum holdoff values. The HOLDOFF control setting is shown in percentage between maximum and minimum in the STATUS display.

Table B-5
Variable Trigger Holdoff

A SEC/DIV	MIN HO	MAX HO
5 ns 10 ns 20 ns 50 ns 100 ns 200 ns	2-3 μs	9-15 μs
500 ns	5-10 μs	
1 μs 2 μs 5 μs	10-20 μs 20-40 μs 50-100 μs	100-150 μs
10 μs 20 μs 50 μs	0.1-0.2 ms 0.2-0.4 ms 0.5-1.0 ms	1-1.5 ms
100 μs 200 μs 500 μs	1-2 ms 2-4 ms 5-10 ms	10-15 ms
1 ms 2 ms 5 ms	10-20 ms 20-40 ms 50-100 ms	90-150 ms
10 ms 20 ms 50 ms	0.1-0.2 s 0.2-0.4 s 0.5-1.0 s	0.9-1.5 s
100 ms 200 ms	1-2 s 2-4 s	
500 ms 1 s 2 s 5 s	5-10 s	

Trigger LEVEL Range and Resolution

Table B-6 shows Trigger LEVEL range and resolution for each trigger-gain factor. Trigger gain is equivalent to the gain of the selected trigger source multiplied by the attenuation factor of the attached probe. The selected trigger gain for CH 1 and CH 2 SOURCE is the vertical deflection factor.

Table B-6
Trigger Resolution

Trigger Gain (including probe)	Total Trigger Range CH1 or CH2 (±18 div)	Total Trigger Range EXT1 or EXT2 (±9 div)	Trigger Resolution (1-point) 64 pt/div
5 kV/div	90 kV	----	78.125 V
2 kV/div	36 kV	----	31.25 V
1 kV/div	18 kV	----	15.625 V
500 V/div	9 kV	4.5 kV	7.8125 V
200 V/div	3.6 kV	----	3.125 V
100 V/div	1.8 kV	900 V	1.5625 V
50 V/div	900 V	450 V	781.25 mV
20 V/div	360 V	----	312.5 mV
10 V/div	180 V	90 V	156.25 mV
5 V/div	90 V	45 V	78.125 mV
2 V/div	36 V	----	31.25 mV
1 V/div	18 V	9 V	15.625 mV
500 mV/div	49 V	4.5 V	7.8125 mV
200 mV/div	3.6 V	----	3.125 mV
100 mV/div	41.8 V	900 mV	1.5625 mV
50 mV/div	900 mV	----	781.25 µV
20 mV/div	360 mV	----	312.5 µV
10 mV/div	180 mV	----	156.25 µV
5 mV/div	90 mV	----	78.125 µV
2 mV/div	36 mV	----	31.25 µV
1 mV/div	36 mV	----	31.25 µV
500 µV/div	36 mV	----	31.25 µV
200 µV/div	36 mV	----	31.25 µV

Auto Triggering and Auto Leveling

Table B-7 shows the approximate time interval (after the last trigger) until the system decides either that the scope has been triggered or that triggering has been lost. If the scope considers itself currently to be untriggered, it waits for the time interval in the table column labeled "Triggered" before forcing a trigger. Conversely, if the scope is receiving triggers, it waits for the interval shown in the "Trigger Lost?" column before deciding that triggering is indeed lost.

Table B-7
Auto Triggering and Auto-Leveling Intervals

SEC/DIV Setting	Triggered?	Trigger Lost?
5 ms/div & faster	100 ms	300 ms
10 ms/div	200 ms	600 ms
20 ms/div	400 ms	1.2 s
50 ms/div	1 s	3 s

B Trigger Source

The B trigger circuit is used to precondition trigger signals as a source for three different functions: B Triggering, External Clock, and DELAY by EVENTS. The B TRIG SOURCE menu changes to correspond to the role that B Trigger is playing. Table B-8 shows the specific function.

Table B-8
B Trigger Source Menu Versus B Trigger Mode

B TRIGGER Mode	DELAY by EVENTS	EXT CLK	Menu Label
RUNS AFTER	OFF	OFF	B TRIG SOURCE
		ON	EXT CLK SOURCE
	ON	OFF	EVENTS SOURCE
		ON	EVENTS, EXT CLK SOURCE
TRIG AFTER	OFF	OFF	B TRIG SOURCE
		ON	B, EXT CLK SOURCE
	ON	OFF	B, EVENTS SOURCE
		ON	B, EXT CLK, EVNT SOURCE

Trigger Position

The RTRIG (record trigger) position is the horizontal point on the waveform about which the waveform samples are displayed. Although a single time-base generator is used for either the A or the B acquisitions, the RTRIG point for either is independently selectable. Table B-9 indicates the selectable RTRIG position versus the data point at which it will be displayed in the next waveform acquisition.

Figure B-2 illustrates the A or B RTRIG point possibilities in each of the various Horizontal Display modes and the effects of DELAY by TIME and DELAY by EVENTS on the occurrence of a RECORD TRIGGER.

Table B-9
RTRIG Point versus Trigger Position Menu Selection

Trigger Position Menu Entry	RTRIG Data Point In Display
1/8	128
1/4	256
1/2	512
3/4	768
7/8	896

Delay Time and Delay Time Resolution

Table B-10 shows the maximum delay time and delay time resolution for each B SEC/DIV setting. Maximum DELay time setting is 2621.4 times the B SEC/DIV setting, with a resolution of 1/125 of the B SEC/DIV setting up to and including 500 ns per division. From 500 ns per division to 5 ns per division, the sampling rate does not change, so the maximum delay time is also constant.

Table B-10
Maximum B SEC/DIV Delay Time and Resolution

B SEC/DIV Setting	Maximum Delay	Delay Resolution
5 sec	3.64 hrs	200 ms
2 sec	1.46 hrs	80 ms
1 sec	43.7 min	40 ms
500 ms	21.9 min	20 ms
200 ms	8.74 min	8 ms
100 ms	4.37 min	4 ms
50 ms	2.18 min	2 ms
20 ms	52.4 sec	800 μs
10 ms	26.2 sec	400 μs
5 ms	13.1 sec	200 μs
2 ms	5.24 sec	80 μs
1 ms	2.62 sec	40 μs
500 μs	1.31 sec	20 μs
200 μs	524 ms	8 μs
100 μs	262 ms	4 μs
50 μs	131 ms	2 μs
20 μs	52.4 ms	800 ns
10 μs	26.2 ms	400 ns
5 μs	13.1 ms	200 ns
2 μs	5.24 ms	80 ns
1 μs	2.62 ms	40 ns
500 ns	1.31 ms	20 ns
200 ns	1.31 ms	20 ns
100 ns	1.31 ms	20 ns
50 ns	1.31 ms	20 ns
20 ns	1.31 ms	20 ns
10 ns	1.31 ms	20 ns
5 ns	1.31 ms	20 ns

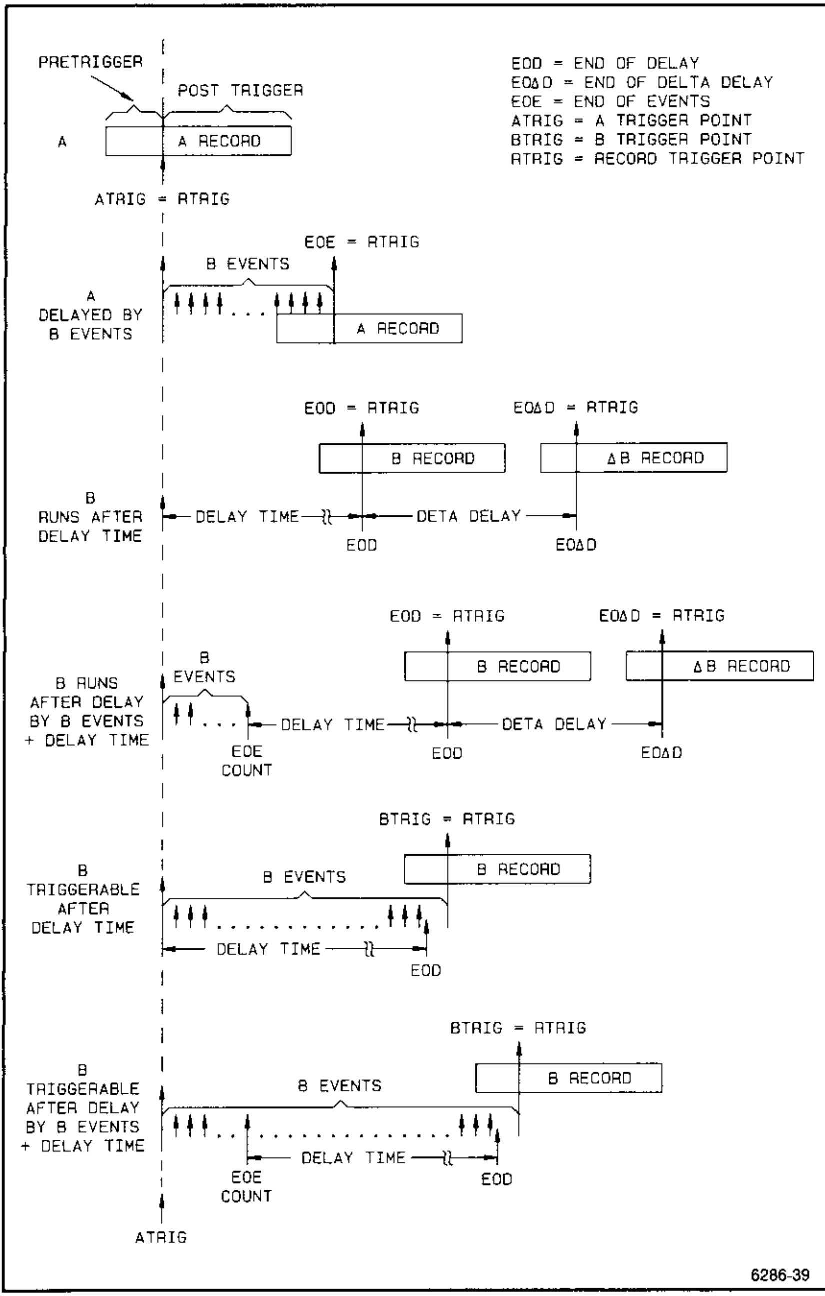


Figure B-2. RTRIG versus Horizontal Display Modes.

Trigger Status Indicators

The Trigger Status Indicators successively light up to indicate how acquisitions are progressing in the scope. At A SEC/DIV settings of 100 ms per division and slower, the acquisitions occur slowly enough that the switching on and off of the indicators can be seen and the acquisition progress observed.

The only time during normal operation that all trigger status lights are off is when the scope is in SAVE mode. Table B-11 is a summary of the switching states of the indicators.

ARMED. Indicator lights up at the start of each acquisition while pretrigger data is being acquired. During this time, no triggers are accepted. Turns off at the end of pretrigger holdoff.

READY. Indicator lights up at the end of pretrigger holdoff. Pretrigger data continues to be acquired. While this indicator is on, the instrument is looking for RTRIG (the trigger event required to complete the record). When the Record Trigger occurs, the READY indication turns off.

TRIG'D. Indicator lights up at A TRIGGER; turns off when acquisition is done.

NOTE

For an acquisition involving both A and B triggers, the READY and TRIG'D lights will both be lit during the time between the occurrence of the A Trigger and the final B Trigger.

Table B-11
TRIG'D, READY, and ARM Indicator Status

LIGHT	STATE				
	Armed	**Ready**	**Atrig**	**Rtrig**	**Save**
TRIG'D	Off	Off	Lit	Lit	Off
READY	Off	Lit	Lit	Off	Off
ARM	Lit	Off	Off	Off	Off

Waveform Display Summary

This scope can display a maximum of six waveforms simultaneously; therefore, when more than six waveforms are selected for display, the system uses a priority scheme. Table B-12 shows the available waveforms and the display (in decreasing order of priority) versus the display modes. In the table, CHx is the selected vertical channel, FUNC refers to ADD or MULT, D1 and D2 are the two delays in DELTA mode, and REF1 through REF4 are the four SAVEREF memories.

Whether an available waveform is actually displayed or not is determined by the VERTICAL MODE menu, the DISPLAY REF menu, and the availability of memory.

Table B-12
Display Priority Versus Display Mode

YT			XY Mode
DELTA			
OFF	ON		
	DUAL (CH1 and CH2)		
	NO	YES	
FUNC	FUNC @ D1	FUNC @ D1	CH1 vs CH2
CH1	FUNC @ D2	FUNC @ D2	REF1 vs REF2
CH2	CHx @ D1	CH1 @ D1	
REF1	CHx @ D2	CH2 @ D2	
REF2	REF1	REF1	
REF3	REF2	REF2	
REF4	REF3	REF3	
	REF4	REF4	

STACK REF Storage Operation

Pushing either the STACK REF menu button or SAVE with the SAVE control menu displayed will store the displayed waveforms in predefined SAVEREF memory location, treating the reference memories as a push-up stack. STACK REF storage operations for each of the vertical and horizontal mode combinations are shown in Table B-13.

In Table B-13, the letter "F" and the heading FUNC denote either ADD or MULT function. Also, CHx to Rx means that the selected channel will go into the correspondingly numbered reference memory (e.g. CH1 to R1 or CH2 to R2) and the FUNC (ADD or MULT) will go into Ry (the open REF). D1 and D2 refer to the two delays available in DELTA mode. The notation XXX with DELTA TIME and a FUNC ON means that it is a "don't care" situation, because neither CH 1 nor CH 2 is stored.

Table B-13
SAVEREF Storage Operation versus Horizontal and Vertical Modes

DELTA TIME	FUNC (F)	Channels Displayed	Reference Waveform Storage			
OFF	OFF	ONE	R3 to R4	R2 to R3	R1 to R	CHx to R1
		TWO	R2 to R4	R1 to R3	CH2 to R2	CH1 to R1
	ON	ONE	R2 to R4	R1 to R3	F to Ry	CHx to Rx
		TWO	R4 to R4	F to R3	CH2 to R2	CH1 to R1
		NONE	R3 to R4	R2 to R3	R1 to R2	F to R1
ON	OFF	ONE	R2 to R4	R1 to R3	CHx@D2 to R2	CHx@D1 to R1
		TWO (YT)	R2 to R4	R1 to R3	CH2@D2 to R2	CH1@D1 to R1
		TWO (XY)	R2 to R4	R1 to R3	CH2@D1 to R2	CH1@D1 to R1
	ON	XXX	R2 to R4	R1 to R3	F@D2 to R2	F@D1 to R1

SAVE ON DELTA Operation

The comparison channel for the SAVE ON Δ feature is given in Table B-14. The designated Display Ref waveform must be displayed for the comparison to take place. The user must create the limits of the comparison waveform either by using CONT ENVELOPE acquisition mode or by sending in a comparison envelope waveform via the GPIB interface. The created reference is stored in the DISPLAY REF memory location against which the active channel is to be compared.

In the table, CHx vs REFx signifies that the displayed channel is compared against the correspondingly numbered reference waveform. REFy refers to either REF1 or REF2, opposite to what REFx is when used together in the same line of the table. The "don't care" condition when neither CH 1 nor CH 2 is compared to a reference waveform is indicated by XXX.

Table B-14
SAVE ON DELTA Comparisons

DELTA TIME	**FUNC** (F)	**Channels** Displayed	Waveform Comparison		
OFF	OFF	ONE	CHx vs REF1		
		TWO	CH2 vs REF2	CH1 vs REF1	
	ON	ONE	F vs REFy	CHx vs REFx	
		TWO	CH2 vs REF2	CH1 vs REF1	F vs REF3
		NONE	F vs REF1		
ON	OFF	ONE	CHx@D2 vs REF2	CHx@D1 vs REF1	
		TWO	CH2@D2 vs REF2	CH1@D1 vs REF1	
	ON	XXX	F@D2 vs REF2	F@D1 vs REF1	

Front-Panel Settings for INIT PANEL

Table B-15 lists the front-panel settings which are returned when INIT PANEL is executed from the AutoStep menu (PRGM).

Table B-15
INIT PANEL States

AUTOSETUP Controls	
Mode	VIEW
RESolution	LO
CURSOR Controls	
CURSOR/DELAY Knob	CURSOR POSITION
CURSOR FUNCTION	All off
VOLTS UNITS	VOLTS
TIME UNITS	SEC
SLOPE UNITS	VOLTS/SEC
CURSOR Mode	Δ
ATTACH CURSORS TO:	CH 1
X-Axis Cursor Position	± 3 divisions
Y-Axis Cursor Position	± 3 divisions
TIME Cursor Position	± 4 divisions
VOLTS Ref Value	1.0 V
TIME Ref Value	1.0 SEC
SLOPE Ref Value	1.0 V/SEC
DELAY Controls	
DELAY by EVENTS	OFF
Δ TIME	OFF
DELAY TIME	40 μs
Δ DELAY Time	0.0
DELAY EVENTS Count	1

Table B-15 (cont)

DEVICES/SETUP (OUTPUT)	
DEVICES	
HPGL PLOTTER	OFF
THINKJET PRINTER	ON
SETUP	
Print SETTINGS	ON
Print TEXT	ON
Print GRAT	ON
Print WFM	ON
PGSIZ	US
GPIB SETUP (OUTPUT)	
DEBUG	OFF
LONG	ON
LOCK	LLO
PATH	ON
RQS Mask	ON
OPC Mask	ON
CER Mask	ON
EXR Mask	ON
EXW Mask	ON
INR Mask	ON
USER Mask	OFF
PID Mask	OFF
DEVDEP Mask	ON
Data Encoding (ENCDG)	BINARY
Data Target	REF 1
Data Source	CH 1
FASTXMIT	OFF
FASTXMIT	1
CURVE ONLY	OFF
START	256
STOP	512
LEVEL	0
HYSTERESIS	5
DIRECTION	PLUS
SETUP ATTRIBUTE	0
DT	OFF

Table B-15 (cont)

HORIZONTAL Mode Controls	
MODE	A
A SEC/DIV	1 ms
EXT CLK Expansion	
Factor	1
EXT CLK	OFF
POSITION Waveform	LIVE
POSITION Reference	REF 1
POSITION set to	Midscreen
POSITION REF mode	INDependent
INTENSITY Controls	
SELECT	DISP
READOUT Intensity	50%
DISP Intensity	40%
GRAT Illum	0%
INTENS Level	80%
VECTORS	ON
MEASURE Controls	
MARK	OFF
DISPLAY	OFF
WINDOW	OFF
METHOD	MIN/MAX
LEVEL (units)	%
LEVEL (settings)	
PROXIMAL	10%/0.4 volts
MESIAL	50%/1.3 volts
MESIAL2	50%/1.3 volts
DISTAL	90%/2.4 volts
TARGET	CH 1

Table B-15 (cont)

STORAGE Mode Controls	
STORAGE Mode	SAVE
ACQUIRE Mode	NORMAL
REPET	OFF
AVG Number	2
ENVELOPE Number	1
SAVE ON Δ	OFF
REF1 through REF4	OFF
TRIGGER Controls	
A/B TRIG set for	A
A TRIG MODE	AUTO LEVEL
B TRIG MODE	RUNS AFTER
SOURCE (both)	CH 1
COUPLING (both)	DC
SLOPE (both)	+ (plus)
TRIG POSITION	1/2 (512)
LEVEL (both)	0.0
EXT GAIN (both)	÷ 1
HOLDOFF	Minimum
VERTICAL MODE Controls	
CH 1	ON
VOLTS/DIV (both)	100 mV
VARIABLE (both)	CAL
COUPLING (both)	DC
50 Ω (both)	OFF
INVERT (both)	OFF
POSITION set to	Mid screen
Display Mode	YT
BANDWIDTH	FULL
SMOOTH	OFF

Table B-15 (cont)

VIDEO OPTION Setup (SET TV)	
Interlaced Coupling	FIELD1
Noninterlaced Coupling	FIELD1
TV SYNC	−(minus)
CLAMP	OFF
Line Count	525
Line Start	PREFLD
WORD RECOGNIZER (SET WORD)	
Word Match	Don't care (all x)
RADIX	HEX
CLOCK	ASYNC

Front-Panel Settings for AUTOsetup

AUTOsetup forces some front-panel controls to certain settings. Table B-16 list those controls and indicates whether or not they are affected when AUTOsetup executes.

Table B-16
Front-Panel Settings After an AUTOsetup

AUTOSETUP Controls	
Mode	AS SELECTED
RESolution	AS SELECTED
CURSOR Controls	
CURSOR/DELAY Knob	LAST[3]
CURSOR FUNCTION	All off
ALL OTHER CURSOR SETTINGS LEFT AT SET LAST. SEE TABLE B-15 FOR THE NAMES OF THE REMAINING CONTROLS.[2]	
DELAY Controls	
DELAY by EVENTS	OFF
Δ TIME	OFF
DELAY TIME	40 μs
Δ DELAY Time	0.0
DELAY EVENTS Count	1
DEVICES/SETUP (OUTPUT)	
ALL DEVICES SETTINGS ARE LEFT AS SET LAST. SEE DEVICES/SETUP in TABLE B-15 FOR A LIST OF THE CONTROLS.[2]	

Table B-16 (cont)

GPIB SETUP (OUTPUT)	
ALL GPIB OUTPUT SETTINGS ARE LEFT AS SET LAST. SEE TABLE B-15 (GPIB SETUP) FOR A LIST OF THE CONTROLS.[2]	
HORIZONTAL Mode Controls	
MODE	A
A SEC/DIV	AUTOsetup[1]
EXT CLK Expansion	
Factor	1
EXT CLK	OFF
POSITION Waveform	LIVE
POSITION Reference	LAST[3]
POSITION set to	AUTOsetup[1]
POSITION REF mode	LAST[3]
INTENSITY Controls	
SELECT	LAST[3]
READOUT Intensity	LAST[3]
DISP Intensity	AUTOsetup[1]
INTENS Level4LAST[3]	
VECTORS	ON
MEASURE Controls	
ALL MEASURE SETTINGS ARE LEFT AS SET LAST. SEE MEASURE in TABLE B-15 FOR A LIST OF THE CONTROLS.[2]	
STORAGE Mode Controls	
STORAGE Mode	ACQUIRE
ACQUIRE Mode	NORMAL
REPET	AUTOsetup[1]
AVG Number	LAST[3]
ENVELOPE Number	LAST[3]
SAVE ON Δ	OFF
REF1 through REF4	OFF

Table B-16 (cont)

TRIGGER Controls	
A/B TRIG set for	A
A TRIG MODE	AUTO
B TRIG MODE	RUNS AFTER
SOURCE (both)	VERT
COUPLING (both)	DC
SLOPE (both)	AUTOsetup[1]
TRIG POSITION	AUTOsetup[1]
LEVEL (both)	AUTOsetup[1]
EXT GAIN (both)	LAST[3]
HOLDOFF	Minimum
VERTICAL Controls	
MODE	LAST[3,4]
VOLTS/DIV4AUTOsetup[1]	
VARIABLE (both)	CAL
COUPLING (both)	AUTOsetup[1,5]
50 Ω (both)	LAST[3,5]
INVERT (both)	OFF
POSITION set to	AUTOsetup[1]
Display Mode	YT
BANDWIDTH	FULL
SMOOTH	OFF
VIDEO OPTION Setup (SET TV)	
ALL GPIB OUTPUT SETTINGS ARE LEFT AS SET LAST. SEE TABLE B-15 (VIDEO OPTION) FOR A LIST OF THE CONTROLS.[2]	

Table B-16 (cont)

WORD RECOGNIZER (SET WORD)
ALL WORD RECOGNIZER SETTINGS ARE LEFT AS SET LAST. SEE TABLE B-15 (WORD RECOGNIZER) FOR A LIST OF THE CONTROLS.[2]

[1]Settings established depend on the mode and resolution for AUTOsetup, as well as the input signal(s) being setup. See AUTO in Section 5 for more information.

[2]Use Table B-15 only to see a listing of unaffected controls. Since the controls are left as last set after executing an AUTOsetup[1], ignore the INIT values listed with the controls.

[3]The setting in effect before AUTOsetup executes is left unchanged after AUTOsetup executes.

[4]The VERTICAL mode setting is only changed if no display source is selected. In that case, CH 1 is turned on.

[5]The input COUPLING is only changed if GRD is selected. In that case coupling becomes DC.

Waveform Parameter Extraction

Introduction

This appendix describes the methods used to calculate waveform parameters returned by the MEASURE feature for this instrument.

This information is to help the user understand how this instrument performs the parameter extractions specified. By knowing the methods employed to characterize the waveform and calculate the parameters, users can better understand how to set up the scope for best measurement results and how to interpret such results.

This section does not describe all the ways the MEASURE feature is accessed and specified. Parameter extractions using the MEASURE features can be specified via the front-panel MEASURE menu or by using system commands sent by a controller to the instrument over the GPIB. Once specified, extractions can be stored and later recalled as part of a sequence using the AutoStep Sequencer feature. Section 5, "Controls, Connectors, and Indicators" covers accessing MEASURE via the front panel, and the Programmers Reference Guide details GPIB use. An example of MEASURE being incorporated as part of an AutoStep Sequence is included in the familiarization procedure of Section 2 of this manual.

Parameter Extraction from the Waveform

Overview

Parameter extraction is done in two phases. First, the waveform is characterized to determine various Amplitude Reference Levels, TOP and BASE levels, and, if time-related parameters are requested, Time Reference Points. Once these waveform references are found, the second phase is to calculate the requested parameters, so they can be displayed.

During the first phase, the scope first determines the minimum and maximum amplitude levels within the active window of the waveform. BASE and TOP levels for the targeted waveform are then determined according to the user-selected MEASURE METHOD. Next, the PROXIMAL, MESIAL, MESIAL2, and DISTAL Amplitude Reference Levels are calculated according to the current settings for LEVEL. At this point, if only amplitude-related parameters are requested, they can be extracted.

If time-related parameters are requested, the targeted waveform must be next searched for waveform crossings of the PROXIMAL, MESIAL, and DISTAL levels. The crossing times become the Time Reference Points and are then used to calculate parameters such as FREQuency, WIDTH, PERIOD, etc.

BASE-TOP Determination

Three methods of determining the TOP and BASE for waveforms can be user-selected: MIN/MAX, HISTOgram, and CURSOR. The optimum method for BASE-TOP determination depends on the type of waveform that is to be measured.

MIN/MAX Method

The MIN/MAX method is for general purpose use and is the default setting. MIN/MAX defines the 0% and 100% levels of the waveform as the lowest amplitude (most negative), and greatest amplitude (most positive) samples found in the active window.

MIN/MAX method is useful for measuring FREQuency, WIDTH, and PERIOD on most types of signals. MIN/MAX is sensitive to ringing and spikes on the waveform, however, and cannot be used to accurately measure RISE time, FALL time, OVeRSHooT, and UNDeRSHooT.

HISTOgram Method

The HISTOgram method attempts to ignore ringing and spikes on waveforms when determining the 0% (BASE), and 100% (TOP) levels. It's the best method to use when measuring square waves and pulse-type waveforms. Figures C-1 and C-2 illustrate the differences between HISTOgram and MIN/MAX methods (note the differences in how the TOP and BASE levels are located on the waveform and how the Amplitude Reference Levels are affected).

HISTOgram makes several assumptions about the waveform.

1. The TOP level is always more positive than the BASE level.

2. The rising edge of a signal always has a positive slope, and the falling edge has a negative slope.

When a histogram determines the TOP and BASE levels, the process is as follows:

1. The waveform data-array is used to create a histogram array. This array consist of 256 value ranges or "buckets", each containing the number of times that the sample value occurs in the targeted waveform.
2. The absolute maximum and minimum points are also determined from the waveform data-array.
3. The absolute minimum point is subtracted from the absolute maximum point to determine the peak-to-peak amplitude of the waveform.
4. The peak-to-peak amplitude is divided by two to obtain the mid-point of the range for the waveform sample points (i.e., for a waveform with an absolute maximum of 120 and a minimum of 20, the peak-to-peak is 100 and the mid-point is $(100/2) + 20 = 70$.
5. Beginning at the mid-point level, the histogram array is searched upward (values greater than the mid-point) to find the initial histogram maximum and downward (values less than mid-point) to find the initial histogram minimum. The value associated with the bucket containing the largest count of corresponding sample points ABOVE the mid-point becomes the waveform TOP. The value of the bucket containing the largest count BELOW the mid-point value becomes the waveform BASE.

CURSOR Method

The CURSOR method lets the user directly set the BASE and TOP levels for the waveform. The value set by the most-positive VOLTS cursor becomes the TOP of the waveform; the least-positive VOLTS cursor establishes the BASE. The user-specified BASE and TOP are then used with the current PROXIMAL, MESIAL, and DISTAL settings for LEVEL when the scope calculates the Amplitude Reference Levels.

Level Calculations

Regardless which BASE-TOP determination method is used, once the TOP and BASE are found the scope must next determine the Amplitude Reference Levels. These levels are called the PROXIMAL, MESIAL, DISTAL, and MESIAL2 Reference Levels. The Reference Levels are determined by the settings established for each in the LEVEL submenu for MEASURE. Each level can be set to a percentage of the current waveform's base-to-top amplitude or to an absolute voltage level.

If the level is set in percentage, the corresponding voltage must be calculated. The resolution for the voltage calculated is determined by the VOLTS/DIV setting at which the targeted waveform was acquired. The vertical resolution of the scope is 25 digitizing levels per division (25 DL's/DIV). The resolution is, therefore, 1/25 of the VOLTS/DIV setting for the target waveform. For example, if the VOLTS/DIV setting is 1 V, the resolution of the level calculation is

$$\frac{\text{1 VOLT/DIV}}{\text{25 DL's/DIV}} = 0.04 = 40\text{ mV resolution}$$

Example:

PROXIMAL	=	10% (these are the default levels)
MESIAL	=	50%
DISTAL	=	90%

1 VOLT/DIV

1 Volt peak-peak waveform

BASE	=	0 Volts
TOP	=	1 Volt

PROXIMAL value = BASE + (0.1 × TOP−BASE) = 0 + (0.1 × 1− 0) = 100 mV

MESIAL value = 0 + (0.5 × 1−0) = 500 mV

DISTAL value = 0 + (0.9 × 1−0) = 900 mV

But the resolution at 1 VOLT/DIV is 40 mV, so these values must be rounded to the nearest increment of 40 mV. Values exactly midway between DL levels (as in this case) are rounded down.

PROXIMAL	=	80 mV
MESIAL	=	480 mV
DISTAL	=	880 mV

The following is a quick way to figure the value set for a given display:

1. Determine the BASE and TOP Levels for the display (consider the METHOD, HISTOgram, MIN/MAX, or CURSOR used).
2. Count the number of vertical divisions between the TOP and BASE and multiply it by 25 DL's/DIV.
3. Multiply the result by the decimal corresponding to the level to be calculated (PROXIMAL = 0.1, MESIAL = 0.5, DISTAL = 0.9) and round the result to the nearest whole DL.
4. Multiply the results by the VOLTS/DIV setting and divide the results by 25 DL's. Add this number to BASE voltage to get the level value.

As an example, for a 5-volt square wave with a 0-volt BASE level at 2 V/DIV:

$$2.5 \text{ DIV's} \times 25 \text{ DL's/DIV} \times .9 = 56.25 \text{ DL's, and rounds to } 56 \text{ DL's}$$

$$\text{DISTAL} = \frac{2 \text{ V/DIV} \times 56 \text{ DL's}}{25 \text{ DL's/DIV}} + 0 \text{ (BASE)} = 4.480 \text{ V}$$

If the LEVEL menu is switched to set the Amplitude Reference Level in VOLT instead of %, the vertical resolution for the current VOLTS/DIV setting again limits the setting that can be obtained. If, for example, the PROXIMAL level was set to 100 mV at 1 V/DIV, it would be rounded to 80 mV as was calculated for percent.

The PROXIMAL, MESIAL, and DISTAL levels are indicated on Figure C-1 for HISTOgram method waveforms and in Figure C-2 for MIN/MAX method waveforms.

MESIAL2 is an independent Amplitude Reference Level for use with the only parameter extraction that uses two target waveforms, DELAY. MESIAL2 provides a crossing threshold for the TO target for the DELAY measurement independent of the crossing thresholds for the FROM target.

Error messages are provided to insure that the proper relationship between PROXIMAL, MESIAL, and DISTAL (PROXIMAL ≤ MESIAL ≤ DISTAL) is maintained. PROXIMAL must also be greater than or equal to the BASE, and DISTAL must be less than or equal to the TOP. MESIAL2 must also be within the BASE and TOP of the DELAY TO waveform if the DELAY measurement is selected.

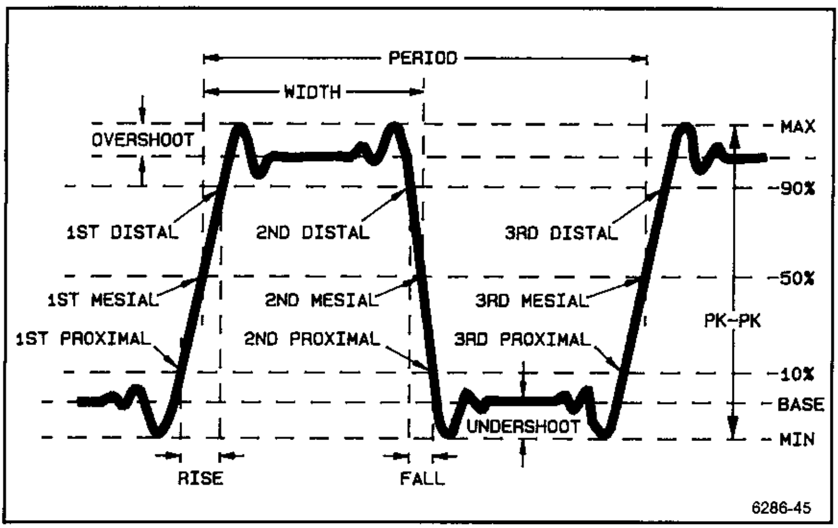


Figure C-1. Parameter Extraction Using HISTOgram Method.

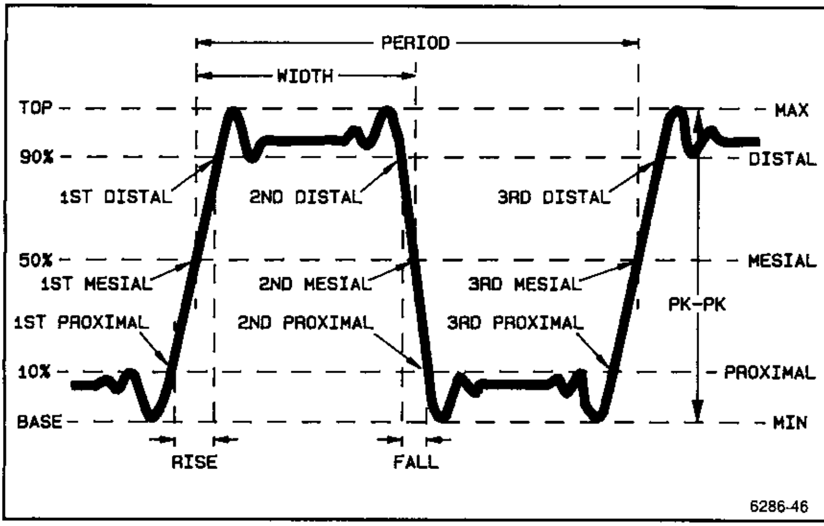


Figure C-2. Parameter Extraction Using MIN/MAX Method.

Determination of Time Reference Points

Once the Amplitude Reference Levels have been calculated, the waveform data-array can be searched for crossings at these reference levels. The direction of (positive or negative) and the time at these crossings define the Time Reference Points for calculating the waveform parameters.

Time Reference Search Procedure

The scope uses the Amplitude Reference Points in a search algorithm to determine where (at what time in the record) the waveform crosses the Reference Points and what direction (positive or negative) the waveform is moving at the crossing. In general, the MESIAL level crossings are used to determine where valid edges exist, and the search sequence locates the PROXIMAL and DISTAL crossings on those edges. Once found, the time at each crossing is mapped into one of three arrays to be used later in calculating the waveform parameters.

The first MESIAL crossing in the waveform record (or active window) is located and the polarity of the crossing determined. The waveform is then searched backward in the record. If the first MESIAL found was on a rising edge (positive crossing), the scope searches for a PROXIMAL crossing; it looks for a DISTAL crossing if the MESIAL was on a falling edge (negative crossing).

After finding the first crossing that occurred before the first MESIAL, the search is again reversed and the scope looks forward in the record to find the first crossing (DISTAL for positive first MESIALs, PROXIMAL for negative first MESIALs) after the first MESIAL. At this point, the search has located all three Amplitude Reference crossings for the first edge in the record (or in the active window). The search continues forward until the next MESIAL crossing is found.

Once the second MESIAL is found, the backward/forward search just described repeats to locate the other two reference levels for the second edge, followed by the next MESIAL for the third edge (last rising edge in Figure C-1 and C-2). This process of finding the Amplitude Reference Points (and using the corresponding times to build arrays of Time Reference Points) is repeated until four sets of edge information is collected or until the entire active window has been searched.

NOTE

The Amplitude Reference Levels just found are shown for the first through third edge on Figure C-1 and Figure C-2. The crossing points labeled "1st" (1st MESIAL, etc.) are on the first edge; those labeled "2nd" are on the second edge; etc.

Calculation of the Waveform Parameters

Table C-1 lists how each waveform parameter is calculated. Some parameters are calculated directly from the Time Reference Points derived from the three arrays. For example, the parameter WIDTH is calculated by subtracting the time at the second MESIAL crossing from the time at the first MESIAL crossing of the waveform, where both MESIAL crossings are on edges bracketing the pulse. All array-derived Time Reference Points are illustrated in Figure C-1; this figure is useful in visualizing the calculations made directly from these reference points.

Some parameters are calculated indirectly from the reference points. For the parameter duty cycle ("DUTY"), for example, the parameter is calculated by using the pulse width ("WIDTH"•) to determine the duration of the positive portion of the waveform and dividing by the period ("PERIOD") for the waveform. Both WIDTH and PERIOD are calculated directly from the Time Reference Points and used in the indirect calculation for DUTY.

Table C-1
Definition of Parameters

The 21 parameters available for extraction are defined as follows:

AREA: The area under the waveform:

$$\text{AREA} = \sum_{i=j}^{k} W(i)$$

Where

Window OFF
j = 1
k = 1024

Window ON
j = Left Time Cursor Location
k = Right Time Cursor Location

W = Target Waveform Array

Points above ground contribute positive AREA;
Points below ground contribute negative AREA.

BASE: Determined by the method chosen in 2nd-Level SETUP menu. Defines the 0% level of the waveform for calculating percentage-based PROXIMAL, MESIAL, and DISTAL levels.

DELAY: Time delay is defined as:

WINDOW mode OFF:

DELAY = Time @ first MESIAL of FROM target
−Time @ first MESIAL of TO target.

Window ON:

DELAY = Time @ first MESIAL after left-most TIME cursor on FROM target
− Time @ last MESIAL before right-mostTIME cursor on TO target.

WINDOW ON definition allows delay measurements on any selected edge of the FROM waveform to any edge on the TO waveform.

DISTAL: Determined by the method chosen in the 2nd-Level SETUP menu and the DISTAL percentage or voltage level chosen in the 3rd-Level LEVEL menu.

DUTY: Duty cycle is defined as:

$$\text{DUTY CYCLE} = \frac{\text{TIME ON}}{\text{PERIOD}} = \times 100\%$$

where "TIME ON" is the duration
of the positive portion of the waveform.

FALL time: The time between the DISTAL and PROXIMAL crossings of the first complete negative-going edge.

FREQ: This measurement is simply the reciprocal of the PERIOD measurement, which is calculated as described above:

$$\text{FREQ} = \frac{1}{\text{Time @ third MESIAL} - \text{Time @ first MESIAL}}$$

MAXimum: The largest (most positive) value found in the active window.

MEAN: The mean value of the waveform:

$$\text{MEAN} = 1/(k - j + 1) \times \sum_{i=j}^{k} W(i)$$

Where

Window OFF
$j = 1$
$k = 1024$

Window ON
j = Left Time Cursor Location
k = Right Time Cursor Location

W = Target Waveform Array

MESIAL: Determined by the method chosen in the 2nd-Level METHOD menu and the DISTAL percentage or voltage level chosen in the 3rd-Level LEVEL menu.

MIDpoint: The vertical midpoint for the waveform:

$$\text{MID} = (\text{MAX} + \text{MIN})/2$$

MINimum: The smallest (most negative) value found in the active window.

OVERSHOOT (TOP Overshoot):

$$\text{OVRSHT} = \frac{\text{MAX} - \text{TOP}}{\text{TOP} - \text{BASE}} \times 100\%$$

This calculation does not select the maximum on the first rising edge. Instead, the maximum is the most positive value found within the entire active window of the waveform.

PERIOD: The measurement of period requires the acquisition of three consecutive MESIAL points. The period is defined as:

PERIOD = Time @ third MESIAL − Time @ first MESIAL.

PROX: Determined by the method chosen in the 2nd-Level METHOD menu and the PROXIMAL percentage or voltage level chosen in the 3rd-Level LEVEL menu.

P-P (peak-to-peak): MAX - MIN

RISE time: The time between the PROXIMAL and DISTAL crossings of the first complete positive-going edge.

RMS: The voltage in RMS.

$$RMS = [(1/(k-j+1))(\sum_{i=j}^{1} W(i)^2)]^{1/2}$$

Where

For WINDOW OFF:
If Period exists
j = First MESIAL crossing found
k = Third MESIAL crossing found

If Period does not exist
j = 1
k = 1024

For WINDOW ON:
j = Left TIME Cursor Location
k = Right TIME Cursor Location

W = target waveform array

With WINDOW OFF, the calculation returns a RMS measurement of a periodic signal; with WINDOW ON, the scope returns a RMS measurement over the user-specified "windowed" area.

TOP: Determined by the method chosen in 2nd-Level SETUP menu. Defines the 100% level of the waveform for calculating percentage-based PROXIMAL, MESIAL, and DISTAL levels.

UNDERSHOOT (BASE Overshoot):

$$\text{UNDRSHT} = \frac{\text{MIN} - \text{BASE}}{\text{TOP} - \text{BASE}} \times 100\%$$

Similar to overshoot, this calculation does not select the minimum on the first falling edge. Instead, the minimum is found within the entire active window of the waveform.

WIDTH: This is an edge-to-edge measurement, defined as:

WIDTH=Time @ second MESIAL on the pulse minus the Time @ first MESIAL on the pulse, where the pulse is that portion, positive or negative, of a periodic waveform with the LEAST duration relative to the waveform period.

Note that WIDTH might be measured from a rising to a falling edge or from a falling to a rising edge, depending on which of the available edges in the active window define a pulse. This instrument defines a pulse as that part of the waveform having the shortest duty cycle. In other words, for a rectangular waveform that is at a more positive level 60% of the time and a more negative level 40% of the time, the two mesials for the edges bracketing the negative 40% of the waveform are used for measuring WIDTH.

Interaction of MEASURE with Acquisition Modes

ENVELOPE ACQUIRE Mode

MEASURE can be used with waveforms acquired in ENVELOPE mode; however, a wide envelope can cause unintended results for time-related parameter extractions. ENVELOPE mode finds the MIN and MAX values for each sample point, and, when they are displayed, the transitions between these MIN and MAX values (for each sample point) can cross Amplitude Reference Levels. Such crossings can cause the Time Reference Points to be located on undesired points of the waveform. For this reason an ENV? warning message is displayed to the left of the selected measurement. Alway use MARKs when using MEASURE with ENVELOPE mode, so measurement points on the waveform are seen.

MEASURE uses the envelope when determining amplitude-related parameters.

MULTiplied or ADDed waveforms cannot be selected in ENVelope mode; they cannot be measured, either.

AVERAGE ACQUIRE Mode

Waveform Parameter Extraction is always performed on 8 bits of data; for AVERAGE Mode the 8 bits measured are the 8 upper (most-significant) bits of the 16-bit average data.

REPET ACQUIRE Mode

In REPET mode, a minimum number of acquisitions must be taken before sufficient sample points are acquired to let parameters be extracted. Until enough sample points are acquired, the selected parameter value is replaced with "?? WAIT ??" in the MEASURE display.

SAVED Expanded Waveforms

The area measured on the waveforms that have been SAVED, and then horizontally expanded, depends on the horizontal position. Up to 200 screens of data is available (with 100× expansion), but only 2 screens are available for measurement at any one time. Typically the 2 screens, 20 horizontal divisions (1024 points) of data are measured beginning at the left edge of the graticule and continuing to one screen of data beyond the right edge of the graticule. The exception to this rule is when the start of the expanded waveform is positioned right of the left-edge of the screen, or when the end of the waveform is positioned less than 10 divisions beyond the end (right edge) of the screen:

- If the beginning of the expanded waveform is positioned to the right of the screen's left edge, the 1024 points to be measured BEGIN at the START of the waveform. The start of the waveform cannot be positioned right of center screen.

- If the end of the waveform is positioned less than 10 divisions beyond the right edge of the screen, the 1024 points to be measured STOP at the END of the waveform. In other words, the measurement begins as far left of the screen's LEFT edge as is necessary to use the full 1024 sample points. The end of the waveform cannot be positioned left of center screen.

Vertical Expansion

If a waveform is expanded (either a "live" waveform using AVERAGE ACQUIRE mode, or a SAVEd waveform), the vertical expansion is done before the parameter is extracted. The waveform may produce a "CLIP" message (see Table C-3) if vertically expanded outside the 10.24-division vertical window. Resolution is not increased for parameter extraction by vertically expanding waveforms.

SMOOTH Acquisition Mode

Smoothing, if enabled, is performed prior to any parameter extraction calculations. Since SMOOTH performs a moving, 5-point average on waveforms, it can affect the values returned for MEASURE. See Section 5 for more information about SMOOTH.

ROLL Acquisition Mode

Parameters cannot be extracted from a "live" ROLL mode waveform, but they can be extracted using SAVE mode. Saving the ROLL waveform, either as a result of pushing the SAVE front-panel button or a SAVE-ON-DELTA occurring, allows the selected parameter to be displayed.

Glossary of Parameter Extraction Terms

Active Window: Active window is the portion of the waveform over which the selected parameter is extracted. If WINDOW is OFF, the active window is from the first waveform sample to the last waveform sample: sample 1 to sample 1024. If window is ON, the active window is the section of waveform between and including the left and right time cursors. All parameter extraction is performed within the active window.

BASE: The 0% level of the waveform determined by the currently selected Measurement Method (Cursor, HISTOgram, or MIN/MAX).

Crossing: Time location in waveform where the waveform crosses an Amplitude Reference Level (PROXIMAL, MESIAL, MESIAL2, or DISTAL).

DISTAL Level: This is a voltage threshold that provides the ending Time Reference Point for rise time measurements and the starting Time Reference Point for fall time measurements. It can be set by the user to any voltage from −999 V to +999 V or from 0 to 100%. The INIT PANEL value for DISTAL is 90%, which is the typical value for rise time and fall time measurements.

MESIAL Level: This voltage threshold is typically 50% of the waveform. MESIAL crossings determine the Time Reference Points used to calculate Frequency, Width, Period, RMS, Delay.

MESIAL2 Level: This voltage threshold is similar to MESIAL, but it is used to determine the Time Reference Point for the TO waveform target when measuring DELAY (DELAY is a two-channel measurement). MESIAL2 level can be set independently from MESIAL, but the default is 50%.

PROXIMAL Level: This is the other threshold that is used with the DISTAL crossing to calculate the rise time and fall time parameters. The default value of PROXIMAL is 10%.

TOP: The 100% level of the waveform determined by the current Measurement Method (CURSOR, HISTOgram, or MIN/MAX).

Warning and Error Messages for MEASURE

ERROR Messages

Error messages are issued when the scope cannot perform the requested parameter extraction.

NOTE

When "active window" is used in descriptions for error or warning messages, it refers to the section of the targeted waveform that is being measured. If WINDOW is on and the TIME cursors are on, the active window is the section between and including the left and right TIME cursors. If WINDOW is off, the active window is the entire 1024-sample, 20-horizontal division waveform.

Table C-2
Error Messages for MEASURE

Error Messages	Description
ADD IN ENV?	ADD waveforms also cannot be displayed in ENVELOPE mode and is deselected as described for "MULT IN ENV?"
EMPTY REF	A measurement was requested on an empty DISPLAY REF waveform.
LEVEL LIMIT	The level settings do not satisfy the condition. PROXIMAL ⩾ BASE and DISTAL < TOP
LEVEL ORDER	The level settings do not satisfy the condition PROXIMAL ⩽ MESIAL ⩽ DISTAL
MES2 LIMIT	The MESIAL2 level does not satisfy the condition BASE ⩽ MESIAL2 ⩽ TOP
MULT IN ENV?	The MULT VERTICAL MODE cannot be selected while in ENVELOPE acquisition mode. If the MULT waveform was selected before entering ENVELOPE mode, the MULT waveform will be turned off. Any measurements previously targeted for the MULT waveform will have the "MULT IN ENV?" error displayed since the MULT waveform no longer exists.
NO DEL DELAY	A measurement was requested on a delta-delayed waveform and the scope was not in B Horizontal mode or delta-delay was off.
NEED 2 EDGES	Less than two edges were found in the active window.

Table C-2 (cont)

Error Messages	Description
NEED 3 EDGES	Less than three edges were found in the active window.
NO _/‾ EDGE	No rising edge was found in the active window.
NO ‾_ EDGE	No falling edge was found in the active window.
OVERFLOW	This message is displayed for the RMS measurement when the dynamic range capability of the RMS calculation has been exceeded. This may happen with certain combinations of SAVED vertical expansion settings and data values.
ROLL-NO MEAS	Measurements are not permitted while the trigger mode is ROLL and the scope is acquiring. SAVE the waveform to make the measurement.
???TIME/DIV	The SEC/DIV settings of the FROM and TO targets of the delay parameter don't match.
?? WAIT ??	The REPET waveform has not yet acquired enough sample points.

WARNING Messages

Warning messages are issued when the requested parameter may not be valid.

NOTE

When "active window" is used in descriptions for error or warning messages, it refers to the section of the targeted waveform that is being measured. If WINDOW is on and the TIME cursors are on, the active window is the section between and including the left and right TIME cursors. If WINDOW is off, the active window is the entire 1024-sample, 20-horizontal division waveform.

Table C-3
Warning Messages for MEASURE

Warning Message	Description
CLIP	The amplitude of the targeted waveform is outside the 10.24 divisions available for vertical display. Increase the VOLTS/DIV or vertically position the waveform toward center screen.
ENV?	The measurement is taken on an ENVELOPE waveform and MIN to MAX transitions may cross level thresholds, generating unintended results. Use the MARKS to determine if the correct level crossings were obtained.
HISTO?	Displayed when less than $2 \times \sqrt{N}$ points are available for determining either the TOP and/or BASE when using the HISTOgram METHOD. N is the number of points in the active measurement window. If window is off (N = 1024), there must be more than 60 points in both the TOP and BASE levels or this warning is displayed.
LO AMPL?	Time measurements were requested on a waveform with less than 12 DL's (digitizing levels, about 1/2 DIV) from the BASE to the TOP.

Table C-3 (cont)

Warning Message	Description
LO RES?	Greater resolution may be needed for an accurate result. Go to a faster SEC/DIV setting to obtain greater resolution. The warning message is displayed when: a. RISE or FALL is specified and the Rise time or fall time allowed less than 5 samples to be acquired for the parameter. b. FREQ or PERIOD is specified and ≤ 15 samples are acquired for the parameter. c. Pulse WIDTH is specified and ≤ 10 samples are acquired for the parameter. d. DELAY is specified and ≤ 5 samples are acquired for the parameter.
MIN/MAX?	Overshoot or undershoot was requested and MIN/MAX was the METHOD specified. Overshoot and undershoot is always 0% for MIN/MAX.
NO DISP	Measurements were requested on a non-displayed waveform.
< 1 PER?	Less than one period was found in the active window. RMS will be calculated from sample 1 to sample 1024 since this warning is only displayed if WINDOW is OFF.

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MANUAL CHANGE INFORMATION

Date: 04-09-87 **Change Reference:** C1/0487

Product: 2430A OPERATORS **Manual Part No.:** 070-6286-00

DESCRIPTION Product Group 38

EFFECTIVE ALL SERIAL NUMBERS

Page 3-24

Change step 1 of General Information for Delay Acquisition Usage to:

1. TRIGGER POSITION. When using the DELAY by TIME feature to set up exact time delays, the time between A and B acquisitions is affected by the TRIGGER POSITION settings for A and B. In general, set the A and B TRIGGER POSITION to equal settings. See APPENDIX B, TRIGGER POSITION for further information regarding the position of the record trigger.

Page 3-41

Change step 2 and add step 3 of V@T TIME CURSOR PLACEMENT as shown below.

2. Align the cursors to just bracket one cycle of the periodic waveform displayed.

3. Fine adjust the position of one of the TIME cursors until the VOLTS cursors are superimposed and cursor readout indicates 0.0 V. (The ACQUIRE mode can be set to AVG if noise causes difficulty obtaining a 0.0 V reading.) See Figure 3-16a.

Page 3-62

Add the following paragraphs after Figure 3-19(a and b).

USING THE SAVE ON Δ IN ROLL ACQUIRE MODE. When using the SAVE ON Δ feature in the ROLL ACQUIRE mode, the vertical dc-error limit waveform is the only reference waveform that should be developed. Since a ROLL mode display is untriggered, "chart-recorder"' type display (see ROLL Mode earlier in this subsection) it is impossible for the ROLL mode "live" waveform to stay within any horizontal window established by comparison envelope reference. The ROLL mode, when used with the SAVE ON Δ feature, is probably most useful for monitoring power supplies for out-of-window dc levels or for out-of-window peak levels on ac waveforms.

NOTE

The "glitch catching" ability of the 2430A can be used with SAVE ON Δ in ROLL mode. Leave the 2430A in ENVELOPE ACQUIRE mode when switching to ROLL mode after creating the vertical reference envelope waveform. Glitches as short as 2 nanoseconds can be captured as specified for Envelope Mode Pulse Response in Table 6-1 of Section 6 of this manual.

The method of using SAVE ON Δ with ROLL mode is almost the same as outlined in the two procedures under FROM THE FRONT PANEL and USING THE GPIB, except the horizontal waveform is not created and the HORIZONTAL MODE must be set to A. The vertical envelope reference waveform is created by vertically positioning a baseline trace (see the first paragraph in FROM THE FRONT PANEL). The envelope is SAVEd in a REF memory, and displayed. The signal to be monitored is centered in the REF envelope displayed and the instrument is switched to ROLL mode (the A SEC/DIV and A TRIGGER MODE should be set as described in ROLL Mode earlier in this subsection).

The SAVE ON Δ comparison of the ROLL mode waveform against the reference envelope occurs at the Trigger Point Indicator riding on the ROLL mode waveform. In other words, the data at the "T" displayed on the ROLL mode waveform (the "T" on the reference envelope is ignored) is compared with the vertical limit established by the comparison envelope signal. If the data is outside the limit, the 2430A enters SAVE mode. The user should note the "T" does not indicate the trigger point for ROLL mode acquisitions.

Page 3-67

Change step 3 of Considerations for Using AUTOsetup to the following:

3. AUTOsetup cannot be used to reliably display signals for which AUTOLEVEL trigger mode cannot trigger a display (AUTOsetup will typically set up on repetitive, non-complex waveforms with amplitudes of about 5 mV and greater at frequencies ranging from approximately 50 Hz to 100 MHz). The instrument sizes the waveforms horizontally to be displayed as previously described according to the AUTOsetup mode selected. If this sizing results in a setting of 100 ms/DIV or slower, the waveform cannot be properly displayed.

Page 5-56

Change the third paragraph of 47 AUTO to the following:

Regardless of the mode used, the scope must have a signal present in the channel selected that is triggerable in AUTOLEVEL setting for TRIGGER MODE (typically, AUTOsetup sets up on repetitive, non-complex waveforms with amplitudes of about 5 mV and greater at frequencies ranging from approximately 50 Hz to 100 MHz). If no signal is present in the channel normally providing the horizontal scale, the scope sets the horizontal scale to 100 μs/DIV.

Page 6-6

Change the third paragraph of EXTENDED FUNCTIONS to the following:

AUTOsetup: The AUTOsetup function is used to automatically setup the scope for viewable display based on the input signal. (Typically, the scope will AUTOsetup on periodic, non-complex waveforms with amplitude levels of approximately 5 mV peak-to-peak or greater and frequencies from about 50 Hz to 100 MHz). The user can specify the waveform characteristic the display is optimized for (front-edge, period, etc.) from a menu displayed upon executing AUTOsetup.

Page 6-18

Change SEC/DIV 0.2 μs per Division or Less, a sub-heading of Trigger Position Jitter (p-p), to the following:

Characteristics	Performance Requirements
SEC/DIV 0.2 μs per Division or Less	(0.02 $\times$ SEC/DIV setting) + 500 ps. Checked at 5 ns/DIV in NORMAL ACQUIRE mode with REPET ON using a 5-division step having less or equal to 1 ns rise time.

Page A-11

Change Extended Calibration to the following:

Extended Calibration

NOTE

If Extended Calibration is internally disabled, the scope will not respond to a press of the ATTEN, TRIGGER, or ADJUST menu buttons.

Pressing the EXT CAL button selects the Extended Calibration menu:

<status>	<status>	<status>		
ATTEN	TRIGGER	REPET	ADJUST	↑

A choice of any of the four selections begins execution of the indicated semi-automatic calibration routine. Pressing the up-arrow button returns to the CAL/DIAG menu level. The correct dc test voltages must be available to complete this ATTEN and TRIGGER calibration.

EXT CAL routines can be aborted at any time by pressing the MENU OFF/EXTENDED FUNCTIONS button, but once a calibration sequence is started it must be successfully passed to assure correct calibration.

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Page 3-24

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Page 3-41

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