TEK OPERATORS MANUAL

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Product Group 37

2430 DIGITAL OSCILLOSCOPE

OPERATORS

Please Check for CHANGE INFORMATION at the Rear of This Manual

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Tektronix®
COMMITTED TO EXCELLENCE

Certificate of the Manufacturer/Importer

We hereby certify that the 2430 DIGITAL 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 2430 DIGITAL OSCILLOSCOPE AND ALL INSTALLED OPTIONS in Übereinstimmung mit den Bestimmungen der Amtsblatt-Verfugüng 1046/1984 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes angezeigt und die Berechtigung zur Überprufüng 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

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

SECTION 1

The electrical, environmental, and mechanical characteristics of the instrument are listed in table form. 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 Specification tables.

SECTION 2

Preparations required for the initial instrument start-up and operating considerations necessary for preventing damage to the oscilloscope are discussed in this section.

SECTION 3

The location of the controls, connectors, and indicators is illustrated and their functions are described. At the rear of the section, the control menus are listed with amplifying details of their use for the user's reference.

SECTION 4

This is a two-part section with part one, "Operating Considerations," giving basic things to be aware of when making measurements. Part two of the section is an "Operator's Familiarization" procedure. The procedure consists of exercising the controls and making simple measurements to become familiar with the ways in which the control menus are used to operate the scope. Use of the very important SELF CAL feature is given to acquaint the user with its operation.

SECTION 5

Operator's checks and adjustments procedures used to ensure the accuracy of measurements are given in this section.

SECTION 6

Detailed procedures for use of the 2430 in basic measurement applications are given in this three-part section. The section is meant as an aid to the user in developing their own methods for any 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," details use of the many cursor modes for making highly accurate measurements of voltage, time, and frequency in the many versatile modes. A triggering application for the combined A*B trigger source is included in "Special Applications." The final part, "Storage Applications," describes the various storage acquisition modes and their uses.

SECTION 7

Information pertaining to instrument options available at time of manual publication 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 provided in Section 7.

Appendix A

General Purpose Interface Bus (GPIB) operating information is given in this appendix. The bus interface communication protocol is described, and the commands and codes for controlling the scope via the GPIB and transmitting waveforms are given in the included tables.

Appendix B

The Extended Functions menus are described, and the operation of the internal calibration and diagnostics capabilities of the 2430 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 C

Supplemental reference tables and information are included in this appendix for the users general reference as aid in understanding some points of the operation of the 2430.

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OPERATORS SAFETY SUMMARY

The general safety information in this summary is for the protection of both operating and service 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.

Terms as Marked on Equipment

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

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

Symbols in This Manual

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

Symbols as Marked on Equipment

Danger–High Voltage.

Protective ground (earth) terminal.

ATTENTION–Refer to Manual.

Power Source

The instrument is intended to operate from a power source that will not apply more than 250 V 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 Instrument

The instrument is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before making any connections to the instrument 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 protective-ground connection, all accessible conductive parts (including knobs and controls that may appear insulated) can render an electric shock.

Use the Proper Power Cord

Use only the power cord and connector specified for the instrument.

Use the Proper Fuse

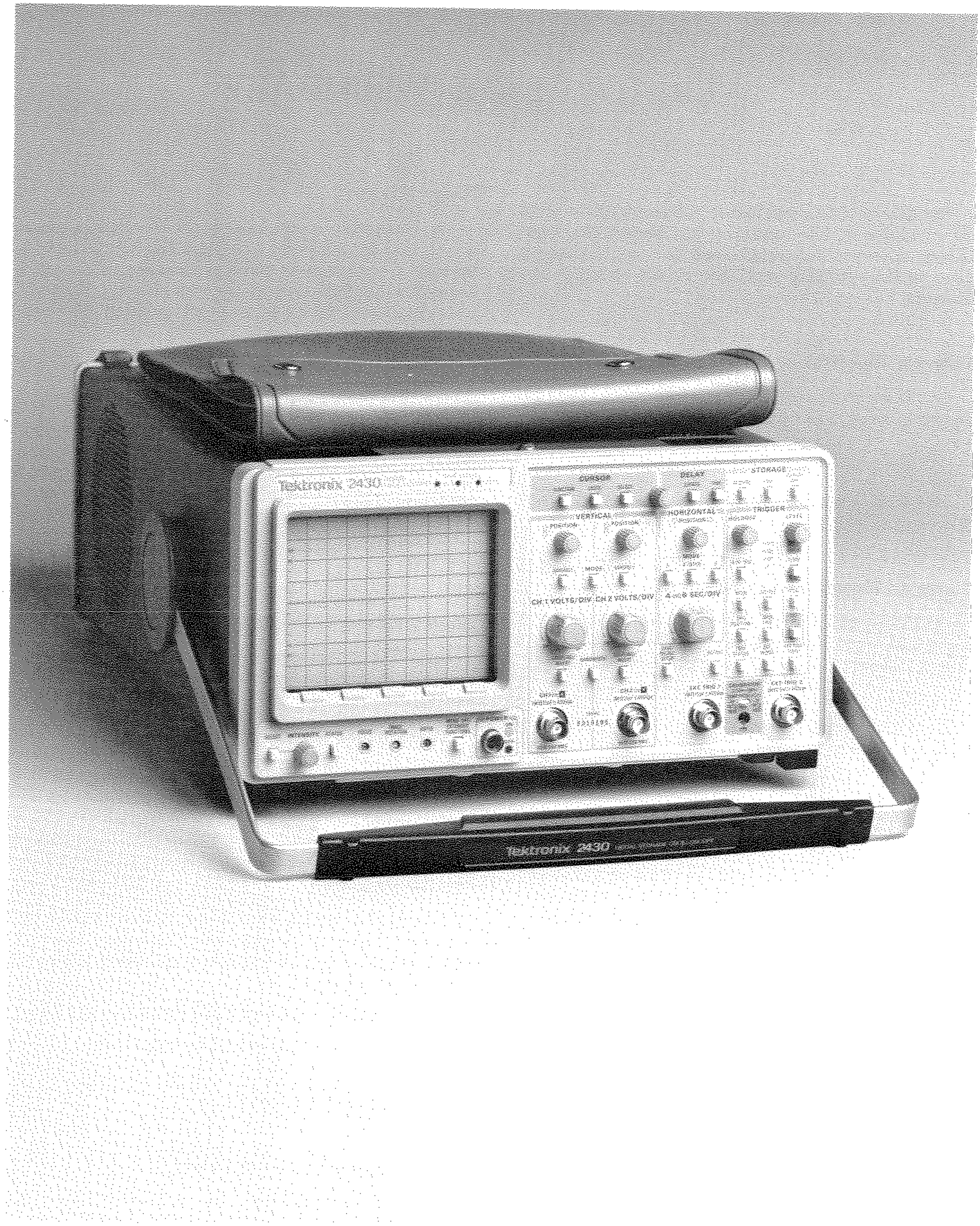
To avoid fire hazard, use only the fuse specified in the instrument parts list. A replacement fuse must meet the type, voltage rating, and current rating specifications for the fuse that it replaces.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate instrument in an atmosphere of explosive gasses.

Do Not Remove Covers or Panels

To avoid personal injury, the instrument covers or panels should only be removed by qualified service personnel. Do not operate the instrument without covers and panels properly installed.



4918-01

The 2430 Digital Oscilloscope.

SPECIFICATION

INTRODUCTION

The TEKTRONIX 2430 Digital Oscilloscope is a portable, dual-channel instrument with a maximum digitizing rate of 100 megasamples per second. The 2430 is capable of simultaneous acquisition of the Channel 1 and Channel 2 input signals. It has a real-time useful storage bandwidth of 40 MHz for single-event acquisitions and an equivalent-time bandwidth of 150 MHz for repetitive acquisitions. 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 are used by the operator to select the operating mode with instrument features displayed at the bottom of the crt.

A user makes decisions as to what operation and mode setup the instrument must have to make the measurement wanted, 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 shows the selectable menu functions. The selection is made (indicated by an underscoring of the menu choice 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 3, "Controls, Connectors, and Indicators."

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 2430 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.

A choice of VERT, CH1 or CH2, EXT1 or EXT2, LINE, and A*B or WORD (16-bit data word recognition) SOURCE for the A time base trigger signal provides a wide range of applications involving specialized triggering requirements. The B time base is provided with a SOURCE choice similar to the A SOURCE, but excluding A*B (A and B both) and LINE (power-source frequency). The selected trigger signal is conditioned by the choice of input CPLG (coupling). These coupling selections are AC, DC, HF REJ, 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 appled 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 2430 operating features are altered in SINGLE SEQ. A complete description of this mode is discussed in the "Controls, Connectors, and Indicators" section 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 point 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 for reading either the voltage difference between the cursor positions or for reading the absolute voltage position of a selected cursor with respect to ground. The volts measurement readouts may be scaled in volts, decibels (dB), or percentage values. 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, percentage, or dB; SLOPE may have units of slope (VOLTS/SEC), percentage (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) offered in the 2430 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 or as many as 205 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.

Up to five front-panel control setups may be saved in nonvolatile memory for recall at a later time. This feature permits rapid switching through a limited set of measurements and provides fast instrument setup for making measurements which are frequently used. On instrument power-up, the 2430 restores the settings present when last powered down.

The 2430 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 2430 to aid in fault detection and servicing are also accessible via commands sent from the GPIB controller.

Another standard feature is the X-Y Recorder output which provides a low-cost method for obtaining hard copies of acquired waveforms. In addition to the X-axis and Y-axis signal outputs, a selectable polarity pen-lift voltage aids the user in automating the plot for those plotters having remote pen-lift capabilities.

The following items are standard accessories shipped with the 2430 instrument:

2 Probe packages
1 Snap-lock accessories pouch
1 Zip-lock accessories pouch
1 Operators manual
1 Instrument interface guide
1 Operators 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 1-1) apply when the 2430 has been calibrated at an ambient temperature between +20°C and +30°C, has had a warm-up period of at least 20 minutes and is operating at an ambient temperature between −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 1-2. The 2430 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 2430 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 2430 are listed in Table 1-3.

Video Option characteristics are given in Table 1-4.

Table 1-1

Electrical Characteristics

Characteristics	Performance Requirements
ACQUISITION SYSTEM—CHANNEL 1 AND CHANNEL 2	
Resolution	8 bits. Displayed vertically with 25 digitization levels (DL)[a] per division, 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 per second to 100 megasamples per second (5 s per division to 500 ns per division).
Sensitivity Range	80 μV per DL to 0.2 V per DL in a 1-2-5 sequence of 11 steps (2 mV per division to 5 V per division).
Accuracy Normal and Average Modes	Within ± (2% + 1 DL) at any VOLTS/DIV setting for a signal 1 kHz or less contained within ±75 DL (±3 divisions) of center when an Autocal has been performed within ±15°C of the operating temperature. Measured on a four- or five-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.
Bandwidth Normal and Average Mode; Repet off; SEC/DIV at 0.5 μs or Faster	DC to 40 MHz (calculated useful storage bandwidth—USB). $USB = \frac{F_{(sample\ freq\ max)}}{2.5}$
Normal and Average Modes with Repet On or Continuous Envelope Mode; SEC/DIV at 0.2 μs or Faster (−3 dB bandwidth)	**VOLTS/DIV Setting** — **Bandwidth** 2 mV — DC-100 MHz 5 mV or greater — DC-150 MHz Bandwidth with a P6131 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.

[a]"Digitization level" is abbreviated "DL" and is equal to 1/25 of a division times the vertical expansion factor.

Table 1-1 (cont)

Characteristics	Performance Requirements
AC Coupled Lower −3 dB Point	
1X Probe	10 Hz or less.
10X Probe	1 Hz or less.
Step Response, Repet and Average On; Average Set to 16	
Rise Time	2.3 ns or less for VOLTS/DIV settings of 5 mV and up (calculated). 3.5 ns or less for VOLTS/DIV setting of 2 mV (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 settings on both channels.
Acquired Channel 2 Signal Delay with Respect to Channel 1 Signal at Full Bandwidth	±250 ps.
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.

Table 1-1 (cont)

Characteristics	Performance Requirements
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	±10 divisions +5, −17 DLs. At 50 mV per division with INVERT off, 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	
Normal or Average Mode	3 DLs or less compression or expansion of a two-division, center-screen signal when positioned anywhere within the acquisition window.
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.

Table 1-1 (cont)

Characteristics	Performance Requirements
TRIGGERING—A AND B	
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 150 MHz; 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 two.
A*B Selected	Multiply all A Trigger specifications by two.
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.
Maximum P-P Signal Rejected by NOISE REJ Coupling Signals within the Vertical Bandwidth	
Channel 1 or Channel 2 Source	0.4 division or greater for VOLTS/DIV settings of 10 mV and higher. Maximum noise rejected is reduced at 2 mV per division and 5 mV per division.
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.

Table 1-1 (cont)

Characteristics	Performance Requirements
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 divisions x VOLTS/DIV setting.
EXT TRIG 1 or EXT TRIG 2 Source	
EXT GAIN = 1	±0.9 volt.
EXT GAIN = ÷5	±4.5 volts.
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 x VOLTS/DIV setting) + 0.5 mV + (0.5 mV x probe attenuation factor)].
−15°C to +55°C (excluding +15°C to +35°C)	Add (1.5 mV x probe attenuation) to +15°C to +35°C specification.
NOISE REJ Coupled	Add ± (0.6 division x VOLTS/DIV setting) to DC Coupled specifications. Checked at 50 mV per division.
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 x 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 x probe attenuation factor)].
NOISE REJ Coupled	Add ±150 mV to DC Coupled specifications.

Table 1-1 (cont)

Characteristics	Performance Requirements		
Variable A Trigger Holdoff	A SEC/DIV	MIN HO	MAX HO
	5 ns 10 ns 20 ns 50 ns 100 ns 200 ns	2-4 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	9-15 s
	500 ms 1 s 2 s 5 s	5-10 s	
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 x SEC/DIV setting.		
B RUNS AFTER Delay	0.08 x SEC/DIV setting.		
SEC/DIV 0.2 μs per Division or Less	(0.02 x SEC/DIV setting) + 2 ns. Checked at 5 ns/div with Repet OFF using a six-division, 10 MHz sine-wave input.		

Table 1-1 (cont)

Characteristics	Performance Requirements
	TIME BASE
Sample Rate Accuracy Average Over 100 or More Samples	±0.01%.
External Clock Repetition Rate Minimum	1 MHz.
Maximum	100 MHz.
Events Count	1 to 65,536
Events Maximum Repetition Rate	100 MHz.
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 divisions 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 divisions at 100 MHz; 3.0 divisions at 100 MHz in ADD mode. Attenuates signals below 60 Hz.
HF REJ Coupled	2.0 divisions from DC to 30 kHz. Attenuates signals above 30 kHz.
LF REJ Coupled	2.0 divisions from 80 kHz to 20 MHz; increasing to 4.0 divisions 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.
Delay Time Range	(0.04 x B SEC/DIV) to (65,536 x 0.04 x B SEC/DIV).
Delay Time Accuracy	Same as the sample rate accuracy.
Delay Time Resolution	The greater of (0.04 x B SEC/DIV) or 20 ns.

Table 1-1 (cont)

Characteristics	Performance Requirements
NONVOLATILE MEMORY	
Front-Panel and Calibration Data Retention Time	Greater than 3 years.
Waveform Data Retention Time	
Storage Temperature	
25°C	Greater than 120 hours.
50°C	Greater than 24 hours.
Battery	3.5-volt lithium thionyl chloride; Type LTC-7P; UL listed. **WARNING** *To avoid personal injury, observe proper procedures for handing 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 1-1 (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%.			
Repetition Period	**A SEC/DIV Setting**	**Calibrator Frequency**	**Calibrator Period**	**Div/ Cycle**
	5 ns 10 ns 20 ns 50 ns 100 ns 200 ns	5 MHz	200 ns	40 20 10 4 2 1
	500 ns 1 μs	500 kHz	2 μs	4 2
	5 μs 10 μs 20 μs	50 kHz	20 μs	4 2 1
	50 μs 100 μs 200 μs	5 kHz	200 μs	4 2 1
	500 μs 1 ms 2 ms	500 Hz	2 ms	4 2 1
	5 ms 10 ms 20 ms 50 ms 100 ms 200 ms 500 ms 1 s 2 s 5 s	50 Hz	20 ms	4 2 1 0.4 0.2 0.1 0.04 0.02 0.01 0.004
Accuracy	±0.01%.			
Symmetry	Duration of high portion of output cycle is 50% of output period ± (lesser of 500 ns or 25% of period).			

Table 1-1 (cont)

Characteristics	Performance Requirements
CH 2 SIGNAL OUTPUT	
Output Voltage	20 mV per division ±10% into 1 MΩ. 10 mV per divison ±10% into 50 Ω.
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. Trigger occurrence indicated by a HI to LO transition.
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.
PLOTTER	
X-Output and Y-Output	
Output Resistance	1 kΩ ±10%.
Output Range	± (2 V ±100 mV). Scale Factors Y—390 mV per division; X—390 mV per division.
Output Center	0 volts ±30 mV.
Home (Lower Left) Position	−2 V ±100 mV.
Slew Rate	Less than 8 volts per second. The instantaneous slew rate is determined by the output stage time constant (3.3 ms) and can exceed 8 volts per second. The System μP computes the length of the stroke needed for each point and waits an appropriate time at each position before proceeding so that the X-Y plotter sees an effective slew rate of less than 8 volts per second.
Pen Lift, SPST Relay Contact to Ground	
Polarity	Menu selectable.
Maximum Applied Open-Circuit Voltage	±25 volts.
Maximum Closed-Circuit Resistance	1 Ω or less.
Maximum Closed-Circuit Current	250 mA or less.

Table 1-1 (cont)

Characteristics	Performance Requirements
	DISPLAY
Graticule	80 mm x 100 mm (8 x 10 divisions).
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 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 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.
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.

Table 1-1 (cont)

Characteristics	Performance Requirements
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 x 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[b]	Type test 0.1 Ω maximum. Routine test to check grounding continuity between chassis ground and protective earth ground.

[b]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 1-2

Environmental Characteristics

Characteristics	Performance Requirements
STANDARD INSTRUMENT	
Environmental Requirements	The 2430 Digital 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.
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).

Table 1-2 (cont)

Characteristics	Performance Requirements
Environmental Requirements (cont)	
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.
RACKMOUNTED INSTRUMENT	
Environmental Requirements	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 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 1-3

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 1-1 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	Tektronix Blue vinyl-clad material on aluminum cabinet.
Construction	Aluminum-alloy/plastic-composite chassis (spot-molded). Plastic-laminate front panel. Glass-laminate circuit boards.
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 (19 in).
Depth	419 mm (16.5 in).

Table 1-4

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 MHz	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.
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 division of ground reference.

Table 1-4 (cont)

Characteristics	Performance Requirements
	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.
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.
EXT GAIN = ÷5 Composite Video	300 mV
Composite Sync	150 mV Peak signal amplitude within ±4.9 V from input ground reference.

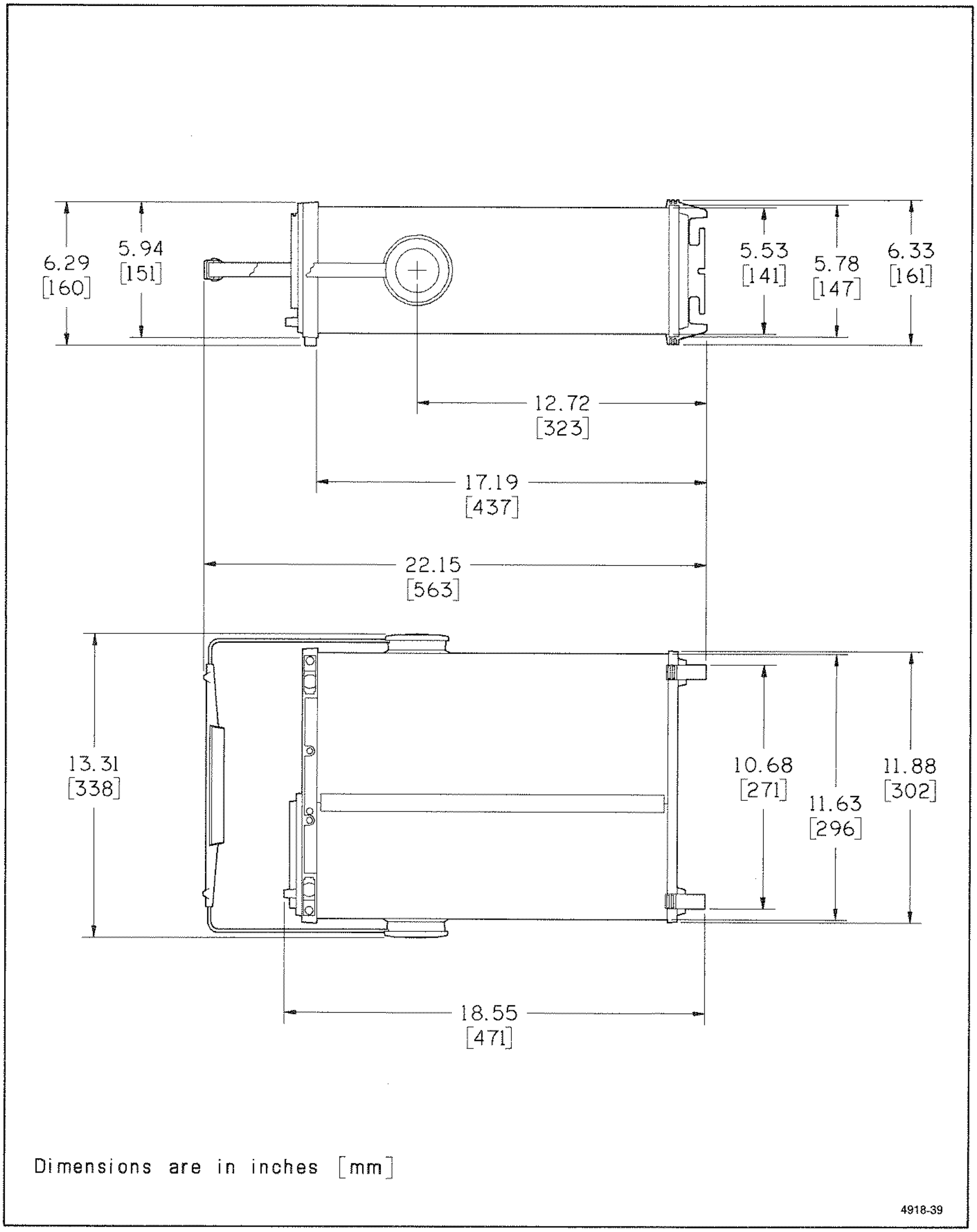


Figure 1-1. Dimensional drawing.

PREPARATION FOR USE

SAFETY

This section tells how to prepare for and to proceed with the initial start-up of the TEKTRONIX 2430 Digital Oscilloscope.

Refer to the Safety Summary at the front of this manual for power source, grounding, and other safety considerations pertaining to the use of the instrument. Before connecting the oscilloscope to a power source, read both this section 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 2430 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 2-1), 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 2-1). The detachable power cord may have to be changed to match the particular ac power-source outlet.

LINE FUSE

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

1. Press in 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 2-1).

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.

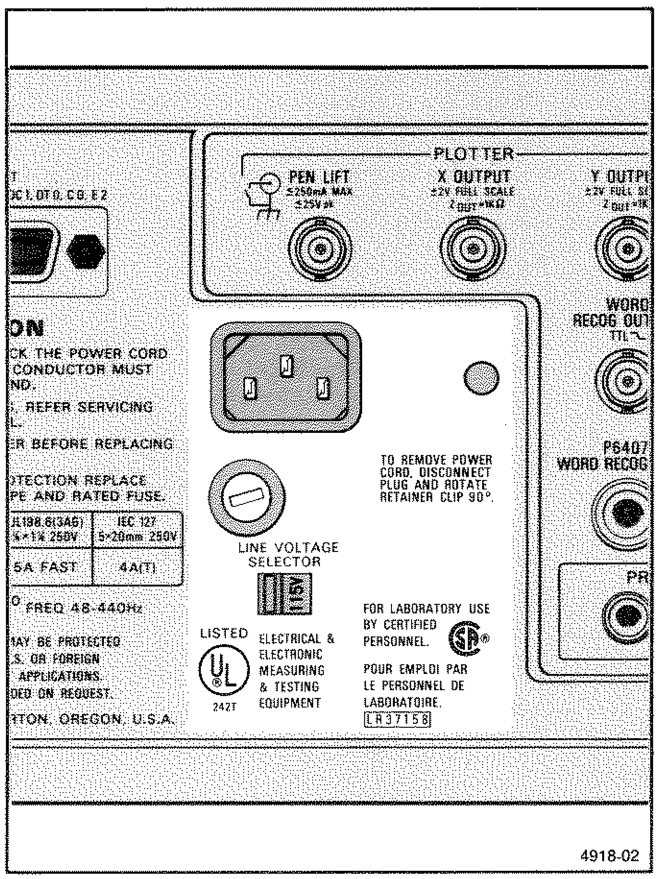
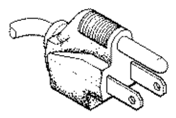
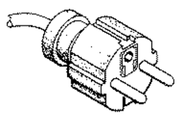
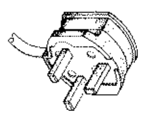
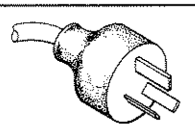
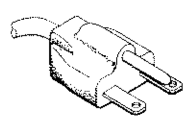
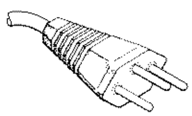


Figure 2-1. LINE VOLTAGE SELECTOR, fuse, and power cord receptacle.

Table 2-1

Voltage, Fuse, and Power-Cord Data

Plug Configuration	Category	Power Cord And Plug Type	Line Voltage Selector Setting	Voltage Range (AC)	Factory Installed Instrument Fuse	Fuse Holder Cap	Reference Standards[b]
	U.S. Domestic Standard	U.S. 120V 15A	115V	90V to 132V	5A, 250V AGC/3AG Fast-blow (UL 198.6)	AGC/3AG	ANSI C73.11 NEMA 5-15-P UL 198.6
	Option A1	EURO 240V 10-16A	230V	180V to 250V	5A, 250V AGC/3AG Fast-blow (UL 198.6)	AGC/3AG	CEE(7), II, IV, VII IEC 83 IEC 127
	Option A2	UK[a] 240V 6A	230V	180V to 250V	5A, 250V AGC/3AG Fast-blow (UL 198.6)	AGC/3AG	BS 1363 IEC 83 IEC 127
	Option A3	Australian 240V 10A	230V	180V to 250V	5A, 250V AGC/3AG Fast-blow (UL 198.6)	AGC/3AG	AS C112 IEC 127
	Option A4	North American 240V 15A	230V	180V to 250V	5A, 250V AGC/3AG Fast-blow (UL 198.6)	AGC/3AG	ANSI C73.20 NEMA 6-15-P IEC 83 UL 198.6
	Option A5	Switzerland 220V 6A	230V	180V to 250V	5A, 250V AGC/3AG Fast-blow (UL 198.6)	AGC/3AG	SEV IEC 127

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

[b] Reference Standards Abbreviations:

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

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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 2-1, 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

The 2430 automatically performs power-up tests each time the instrument is turned on. These tests provide the user with 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 SAVE Storage mode. Failure of a test in the range of 6000 to 9300 may not indicate a fatal scope fault. Several conditions can occur that will cause a non-fatal failure of the tests. In each of these cases, the abnormal condition is brought to the user's attention by the scope entering the "EXTENDED DIAGNOSTICS" mode. Recovery from some abnormal conditions may be possible by simply pressing the MENU OFF button to enter the scope mode. Running the "SELF CAL" procedure after the scope has warmed up ("NOT WARMED UP" message is removed from the main CAL/DIAG menu in about ten minutes after power-on) may also eliminate the cause of the non-fatal error. (The SELF CAL procedure is detailed in Section 4 of this manual.) Refer to Appendix B of this manual for information on the power-up tests and the procedures to follow in the event of a failed power-up test.

If the power-on self-test fails due to an actual component failure, the scope may still be useable 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. Depending on the nature of the failure, the "UNCALD" message may or may not be displayed, but the failed test or tests will be indicated by a "FAIL" message displayed with the associated EXTENDED DIAGNOSTICS test. Press the MENU OFF/EXTENDED FUNCTIONS button to exit EXTENDED DIAGNOSTICS to check out the scope for use.

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 test 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

DO NOT TURN THE 2430 OFF WHILE THE SELF CAL ROUTINE IS RUNNING. Turning off the power prior to completion of SELF CAL will invalidate the instrument calibration constants. The scope will then require a partial calibration to restore the constants to correct values that return the scope to normal operation. The extent of calibration required depends on which constants were invalidated.

For a normal power-off from the scope mode, an orderly power-down sequence that retains the save and saveref waveforms, the current front-panel control settings, and any stored front-panel settings is done. A power-off or transient power fluctuation during SELF CAL, active EXTENDED DIAGNOSTICS testing, EXTENDED CALIBRATION, or shut-down at any time due to overheating does not permit execution of the normal power-down sequence. The result of such an occurrence is the loss of stored calibration constants or last front-panel control settings (or both) and a failure of the next power-on self-test.

NOTE

In the event of a momentary power interruption that starts the power-off sequence of the 2430, 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.

If the scope remains off longer than the short-term nonvolatile SAVE waveform RAM can save data (more than three to five days), the waveforms (or front-panel setups) stored in the SAVE waveform memory may become lost. The result is that SAVE and SAVEREF waveforms stored at power-off are replaced by the invalid waveform display when the scope is again turned on. Each operating period of the scope refreshes the short-term nonvolatile memory.

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 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.

CONTROLS, CONNECTORS, AND INDICATORS

The following descriptions are intended to familiarize the operator with the location and function of the controls, connectors, and indicators of the 2430 Digital Oscilloscope.

CRT DISPLAY, MENU BUTTONS, AND POWER

Refer to Figure 3-1 for location of Items 1 through 10.

(1) **Menu Control Buttons**—These five push buttons, mounted in the bezel under the crt, are used to make selections from the control menu choices that are displayed along the bottom of the crt. Operation of the buttons is programmable by the System Microprocessor, and the manner in which they operate depends on the specific function being controlled. They may toggle choices as in ON!OFF, they may be repeating as when making a number change, or they may work in conjunction with other menu choices as when two functions are mutually exclusive (not available together).

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 as such by the use of an underscore beneath the menu choice. A function may be turned off by pressing the same menu selection button a second time or it may be necessary to press another menu selection to turn off the presently selected choice. A list of all front-panel control menus is found in Table 3-1 at the end this section.

(2) **SELECT Button**—Displays the INTENSITY Menu choices. A single INTENSITY knob controls the four intensity adjustments (readouts, waveform, intensified zone contrast, and graticule illumination). Choosing which function the INTENSITY knob controls (READOUT, DISP, INTENS, or GRAT) is done by pressing the associated menu control button. The activated choice (indicated by an underscore when the SELECT menu is displayed) remains under control of the INTENSITY knob until another selection is made by the user. When the INTENSITY menu is being displayed, if the initial setting is either INTENS or GRAT, pressing the SELECT button a second time immediately selects DISP; subsequent presses then toggle between READOUT and DISP.

Pressing the menu button under VECTORS ON!OFF toggles between vector (lines) and dot waveform displays in YT (vertical vs time) mode. XY displays are done using dots only.

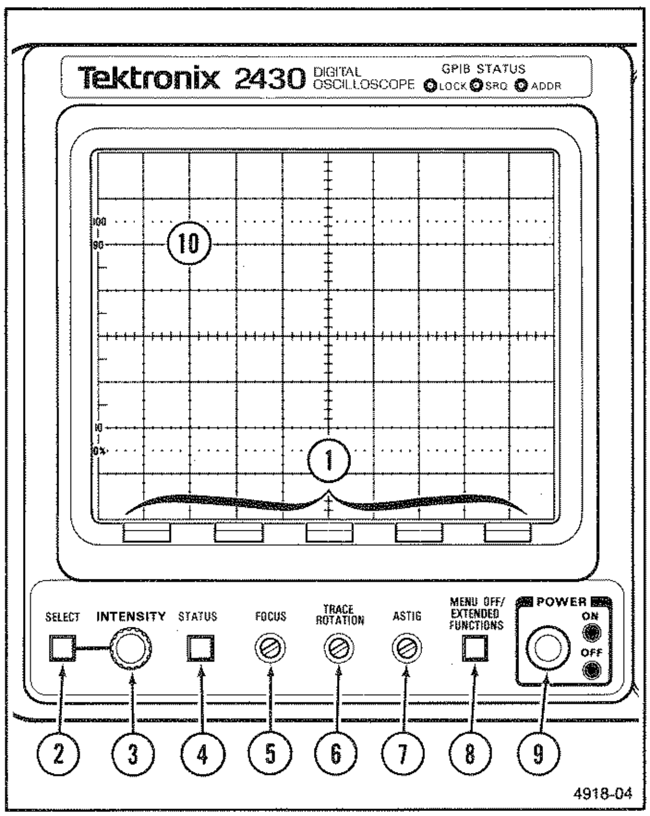

Figure 3-1. POWER, DISPLAY Controls, and MENU Buttons.

(3) **INTENSITY Control Knob**—Adjusts the following: readout intensity, waveform brightness, contrast between the non-intensified and intensified areas of the A INTENS Horizontal Display Mode, or graticule illumination, as determined by the activated choice in the SELECT menu.

(4) **STATUS Button**—Displays the complete operating status of the 2430 to aid the user in determining which control or function setup is preventing a display of the traces. The list includes the volts/div for each vertical display, horizontal mode, acquisition 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 effect of the INTENSITY control knob is directed to set the intensity of the READOUT display.

The status list provides a summary of the operating system settings with all enabled functions identified by an underscore (see Figure 3-2). The INTENSITY settings are shown in percent values of the total range so that a user may determine if the display intensity is set too low for viewing waveforms.

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.

(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.

(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 B 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 will be 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 one second prior to turning off the scope can be restored when the scope is turned on again. The 2430 must be set to PWR ON LAST in the EXTENDED FUNCTIONS menu to return the settings. If set to PWR ON INIT, the 2430 front panel is initialized to a predetermined setup (see Table C-16 in Appendix C 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 3-3 for locations of Items 11 through 20.

(11) **CH 1 OR X and CH 2 OR Y BNC Input Connectors**—Provide 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 2430.

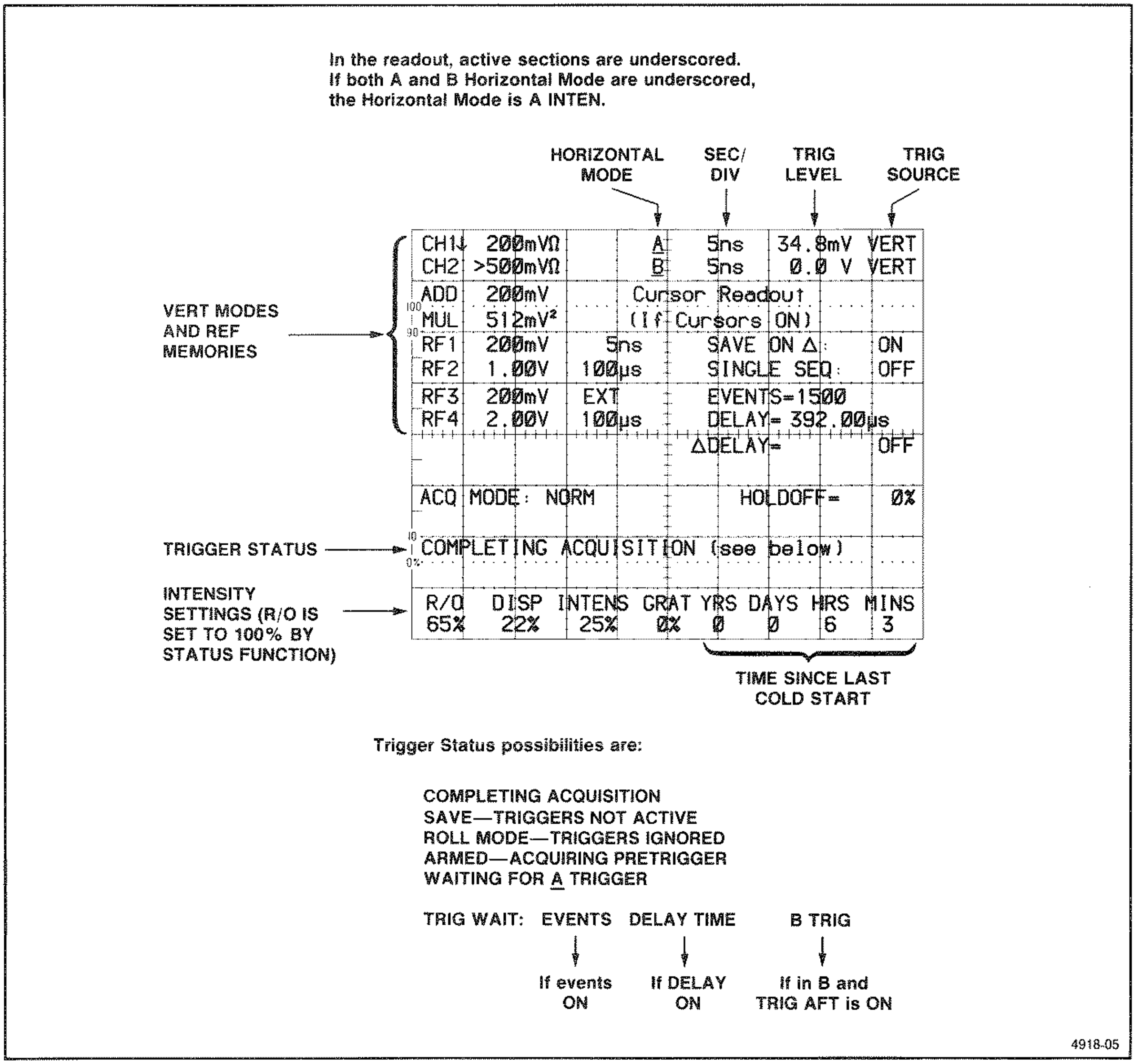

Figure 3-2. STATUS readout display.

(12) **VERTICAL MODE Button**—Calls up the menu used to select the vertical mode of operation. The menu control buttons, with the exception of the YT:XY choice, operate in a push-push manner in that each press of the menu button associated with a control function toggles that function between selected and deselected. Neither ADD nor MULT Vertical MODE is available when the waveforms are acquired in ENVELOPE Mode; and, if either is on when ENVELOPE Mode is turned on, it will be turned off. ADD and MULT are also mutually exclusive functions; they are not available together nor can either be selected in ENVELOPE acquisition mode. Selecting ADD or MULT while the other is active causes the presently active function to be turned off. Selecting ENVELOPE acquisition mode while either ADD or MULT is on will turn off that trace and remove ADD and MULT from the Vertical MODE menu. The YT:XY button toggles between YT (Y-axis vs time) display modes and XY (X-axis vs Y-axis).

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.

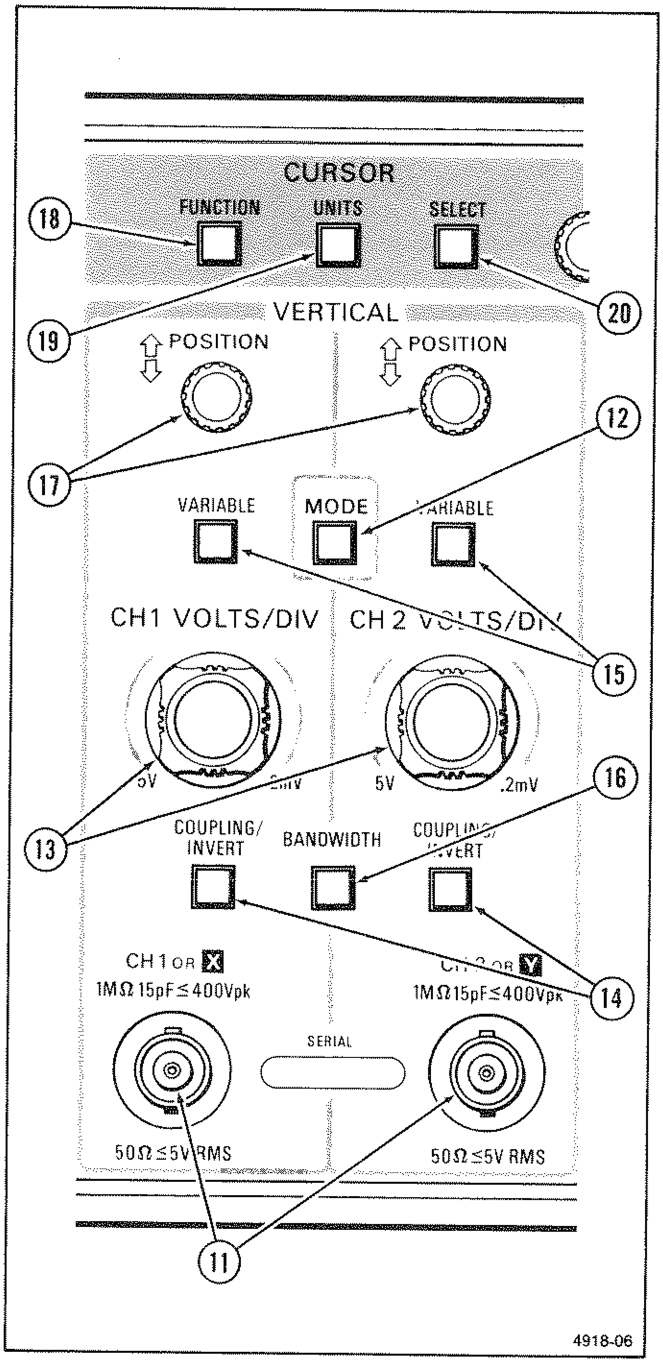

Figure 3-3. Vertical Controls and Connectors.

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 (not available in ENVELOPE mode). 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, will result in a two-division ADD display.

The ADD waveform vertical scale factor will always be 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 (not available in ENVELOPE mode). 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, five-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 that is to be multiplied together is the ground reference value of the acquiring channel. Consequently, any signal level that goes below the ground reference value (or 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 XYREF (REF1 vs REF2) may 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 themselves 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.

Vertical expansion of a displayed waveform up to 10X is possible in SAVE mode. This is accomplished 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 more 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 obtained in acquiring the waveform permits expansion of the "live" waveform to the three added VOLTS/DIV settings (1 mV, 500 μV, and 200 μV per division with 1X signal attenuation). A signal being acquired in AVG mode at one of the three added VOLTS/DIV positions reverts to 2 mV per division when AVG 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. Selecting GND COUPLING automatically disconnects 50 Ω termination.

50 Ω—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 the 50 Ω input termination capability of the 2430 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.

Up-Arrow/Down-Arrow Buttons—Control the variable attenuation factor. The down-arrow 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 down-arrow menu button increases the attenuation factor (a smaller amplitude waveform), and pressing the up-arrow 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).

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.

CAL—Removes all variable attenuation in effect when pressed and returns to the calibrated deflection factor set by the VOLTS/DIV switch setting.

(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 greater than 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.

(17) **CH 1 and CH 2 VERTICAL POSITION Control Knobs**—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 2430 instrument 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 the cursor positions with respect either to the difference between two cursors (delta measurement mode) or from a single cursor and a fixed reference (absolute measurement mode).

The Cursor/Delay position knob is shared with the DELAY by TIME and the DELAY by EVENTS functions (Refer to Cursor/Delay knob, Item 31). 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.

See Figure 3-4 for typical cursor displays for the different display modes and cursor functions.

(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 underscored menu choice. Only one selection choice at a time is allowed, and all cursors are off when none of the choices are underscored in the menu. The units of the readout for the measurement being made are selected using the UNITS menu (see Item 19).

VOLTS Cursors—Two horizontal lines extending the full width of the graticule area in 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.

In XY display mode a pair of vertical VOLTS cursors are added to the display for making X-axis voltage measurements. The SELECT button switches the active cursor selection through all four in Δ cursor mode, and between the one horizontal and one vertical cursor seen in ABS cursor mode.

TIME Cursors—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 "+" symbols attached to the XY waveform.

V@T (coupled) Cursors—VOLTS cursors are attached 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.

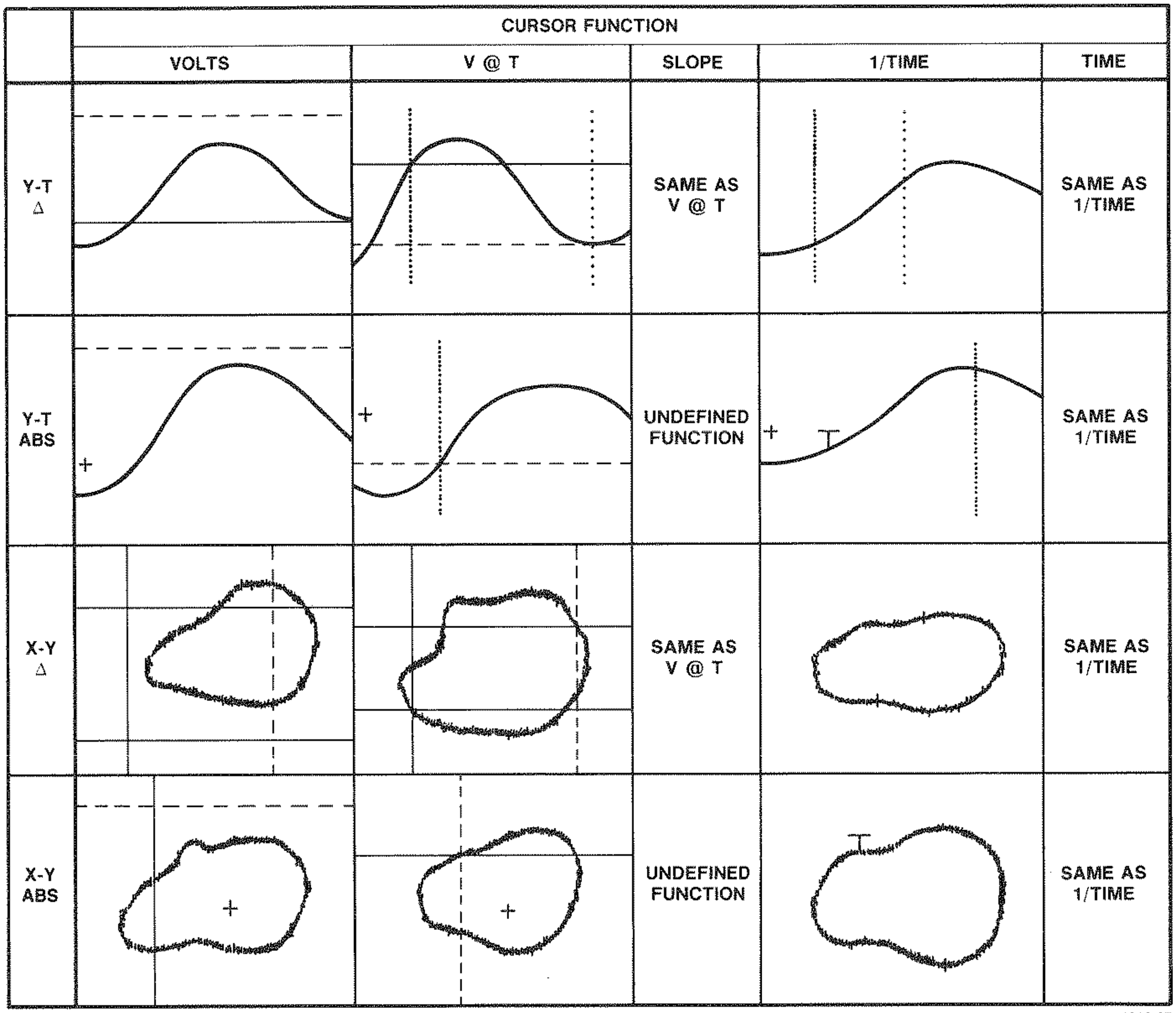

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Figure 3-4. Typical cursor displays.

SLOPE Cursors—Coupled cursors with a readout that is derived from the VOLTS cursor difference divided by the TIME cursor difference (ΔV divided by ΔT—V/sec) in YT mode. In XY mode, the readout is derived from the Channel 2 VOLTS cursor difference divided by the Channel 1 VOLTS cursor difference (ΔY divided by 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 time; therefore, the choice of Δ¦ABS cursor mode is not presented in the SLOPE UNITS menu.

1/TIME Cursors—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 second-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 referenced (%, dB, DEGREES). A reference value to compare against for the referenced measurements is set by positioning the cursors to the desired reference settings and then pressing the NEW REF button. The reference chosen may be a fixed cursor 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 Cursor Mode—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 or DELAY by EVENTS mode is in effect, a press of the SELECT button returns cursor positioning back to the Cursor/Delay knob rather than delay time or events setting.

EXTERNAL INTERFACE

Refer to Figure 3-5 for location of Items 21 through 25.

(21) **EXT TRIG 1 and EXT TRIG 2 Input Connectors**—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 at 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 C-3 in Appendix C 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.

(24) **OUTPUT Button**—Displays the menu for controlling the XY Plotter and GPIB interfaces. The analog XY Plotter interface provides an inexpensive means of producing a hard copy of displayed waveforms using an external XY Plotter. The GPIB interface provides complete two-way digital communication between the 2430 and a GPIB controller. A special application of the GPIB interface is used to obtain hard copies on a Hewlett-Packard HP2225A ThinkJet® printer using the PRINTER feature.

XY Plotter Interface Menu

PLOT—Starts the waveform output to the XY Plotter. The PLOT choice displayed with the FORMAT menu and the PLOT choice displayed with the OUTPUT menu perform the same function. Upon pressing PLOT, the 2430 enters a temporary save

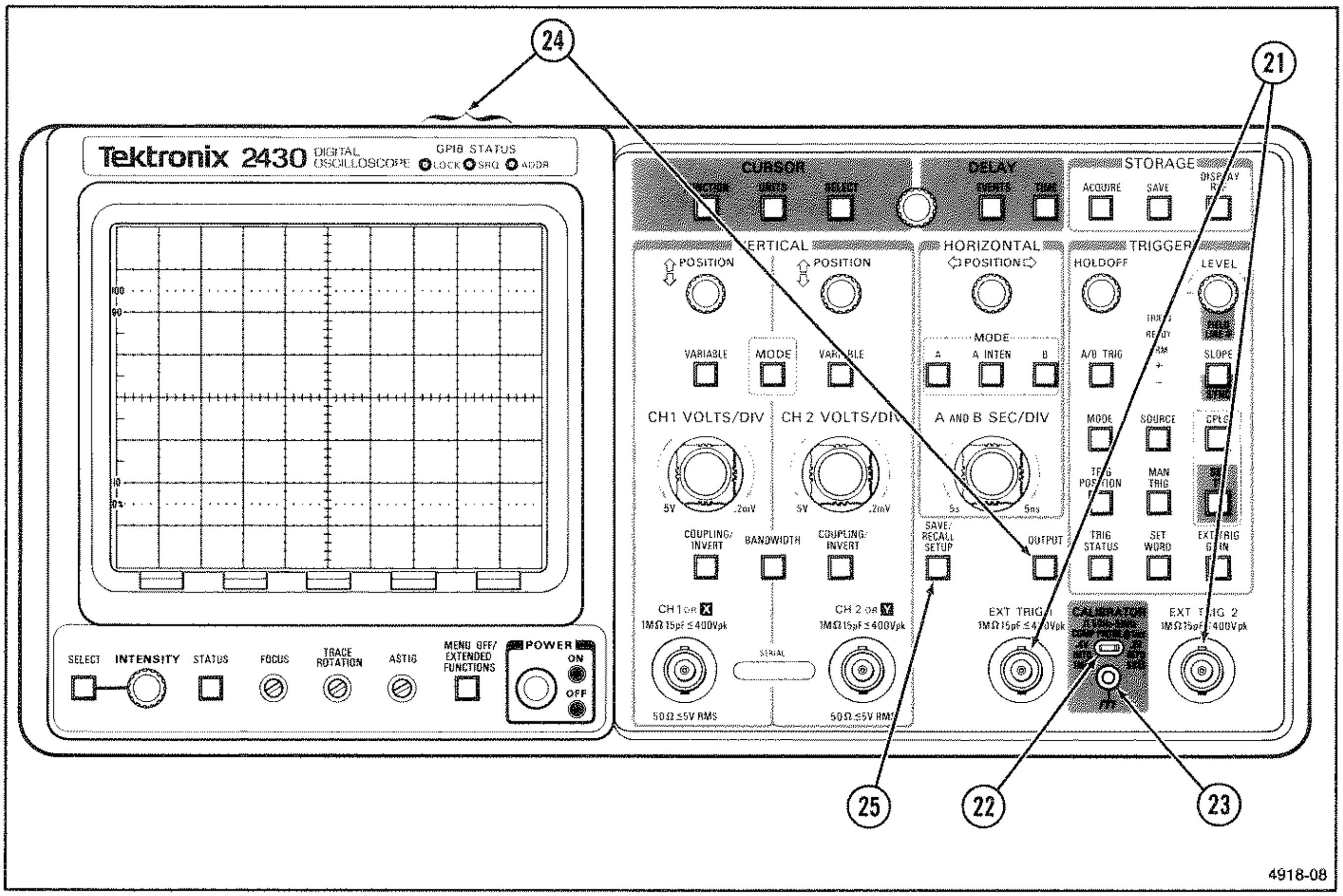


Figure 3-5. External Interface.

state (if not in SAVE mode), and the front-panel controls are locked out with the exception of ABORT. (The PLOT button becomes ABORT when plotting is in progress and may be pressed to stop the plot.) When the plot has finished (or the ABORT button is pressed), the 2430 returns to its previous state of operation.

All data points available in the 10 vertical divisions by 10 horizontal divisions dynamic range of the display system will be plotted. This includes the fill area seen if either the beginning or the end of a trace is horizontally positioned within the graticule area. The user must adjust the HORIZONTAL POSITION control to display only those portions of the waveform record wanted in the plot.

Only waveforms called up for display will be drawn, and they are always plotted as vectors (even the XY displays that are seen as dots on the crt). The location of intensified zones seen with A INTEN horizontal displays are not indicated on the plot, but the trigger location markers and ground dots are drawn.

Also in A INTEN mode, the waveform SEC/DIV scale factors plotted will be those of the A waveform, not those of the B intensified zone.

The VOLTS/DIV and SEC/DIV scale factors of the plotted waveforms, and the 8-by-10 division graticule lines may optionally be drawn (see "FORMAT"). Plot data is output in the following order: graticule lines, all displayed waveforms, then scale factors for the displayed waveforms. The CH 1, CH 2, and ADD or MULT scale factors will be plotted over the top of the graticule area; scale factors for reference waveforms will be plotted beneath the graticule area. None of the other types of crt readouts, including the instrument status display called up with the STATUS feature and the cursors, will be drawn.

FORMAT—Displays a second-level menu of several formatting choices with respect to the data supplied to an external XY Plotter from the 2430.

Second-level FORMAT Menu

READOUT—Permits the user to turn off the VOLTS/DIV and SEC/DIV scale factors if not wanted for the plot.

GRAT—Permits the user to turn off the 8-by-10 division graticule lines if not wanted for the plot.

PEN LIFT OPEN⁝CLOSED—Provides for choosing whether the pen-lift relay should be open or closed for lifting the pen; the correct choice is determined by the requirements of the XY Plotter in use.

PLOT—Provides the user with a means to start a waveform plot without returning to the OUTPUT menu display. Starting a plot from this menu level automatically reverts the user back to the first-level OUTPUT control menu.

GPIB Interface

The 2430 can be commanded to output waveforms via the GPIB from either locally from the front-panel or remotely by a GPIB controller. Selection from the OUTPUT mode menu provides a choice to TRANSMIT waveforms or to SETUP the GPIB interface. See Appendix A of this manual for GPIB operating information.

GPIB Interface Control Menu

STATUS—Displays GPIB parameter settings of interest to a system user (see Figure A-2 in Appendix A).

SETUP—The menus accessible under SETUP permit the user to define the GPIB interface operation. Three of the selections (MODE, TERM, and ADDR) are not accessible via GPIB commands and must be defined by the user from the front panel.

Second-level SETUP Menu

MODE—Provides a menu with five selectable function choices of T/ONLY (talk only), L/ONLY (listen only), T/L (talk/listen), PRINTER, and OFF BUS (to switch the 2430 GPIB interface off the bus).

TERM—Displays a third-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 third-level control menu used to set the 2430 bus address. This is the address that must be sent to the 2430 to cause it to transmit waveforms or listen to commands sent on the bus. Up-arrow and down-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 third-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 2430 expects to receive waveform data in two's-complement format (RIBINary).

DEBUG ON⁝OFF—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. When on, messages received via the GPIB and errors detected by the 2430 are displayed on the 2430 crt. A command string received by the 2430 that is not understood will cause the incoming string to be halted at the end of the semicolon delimiter. A user may then read the string, and the error message that is also displayed, to find out what error has occurred. Reception of the message terminator is indicated by a special rectangle symbol at the end of the string.

Third-level MODE Menu

T/ONLY—Switches to the talk-only mode and presents a fourth-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 WFMPRE/CURVE (all preamble information is sent prior to the waveform data bytes).

These same waveform message format choices are available as queries when the GPIB controller is directing the bus transactions if the 2430 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 2430 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 2430 controls the data output. When the user presses the TRANSMIT button, the 2430 immediately starts handshaking out the waveform message as formatted. If a controller is on the bus, it will not be able to untalk the 2430.

L/ONLY—Permits the GPIB controller to issue front-panel setups to the 2430 in order to implement a specific test setup. The setup data may be acquired either from a previous query of front-panel settings or it may be made up of specific setting commands given to the 2430 via the GPIB controller.

T/L—Selects the normal configuration for full two-way GPIB interface communication. In this mode, the 2430 GPIB interface has full talker/listener capabilities and can be completely controlled by a system controller.

PRINTER—Sets up the GPIB interface to send waveform data to a Hewlett-Packard HP-2225A ThinkJet® printer in an interface mode similar to T/ONLY. The printer must be set to Listen Only, and it should be the only other device on the GPIB besides the 2430 itself.

OFF BUS—Isolates the 2430 GPIB interface from the bus (becomes bus transparent) so that no communication occurs between the 2430 and the GPIB bus. The TRANSMIT menu choice of the first-level output menu is also omitted when the 2430 GPIB interface is set to OFF BUS.

TRANSMIT—Sends an SRQ (service request) to the controller. A typical series of actions that may occur follows. Upon receipt of an SRQ and identifying the source, the controller sets up the DATA SOURCE pointer to indicate the desired waveform(s) and issues either a WAVFRM? query (wants both waveform preamble and data) or a CURVE? query (wants just data). After the appropriate command or commands are sent, the controller releases the bus, and the 2430 executes a waveform transmission.

When output to a ThinkJet® printer is selected (from the third-level MODE menu—PRINTER ON), the TRANSMIT choice is changed to PRINT. While printing a waveform, the front-panel controls (except ABORT) are locked out, and the 2430 is in the SAVE mode. If running the scope in the SAVE ON Δ mode with the PRINTER menu choice on, a switch to SAVE mode on a out-of-limit signal causes an output to the printer. At the completion of the printer output, a page eject is sent to the printer, and the scope switches back to the acquire mode with SAVE ON Δ again in effect.

The TRANSMIT or PRINT function turns into an ABORT button (after the initial push) that may be used to end transmission. 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 2430 is through talking, and the transmission is ended.

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 2430).

TRANSMIT is omitted from the OUTPUT menu when the GPIB interface mode has been set to OFF BUS (see "SETUP").

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 2430 including PRINT, PLOT, 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 2430 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.

(25) **SAVE/RECALL SETUP Button**—Saves and recalls previously saved front-panel control setups. This feature permits a user to quickly place the 2430 into often-used measurement modes and to switch quickly through a limited sequence of setups for a measurement series. A press of the SAVE/RECALL SETUP button brings up a menu for either saving setups or recalling any previously saved setups. The choice of INIT PANEL sets up a predefined front-panel condition, including all GPIB masks and controls that can be accessed by the System μP. See Appendix C, Table C-16 for the INIT PANEL control states. The number of front-panel SAVE/RECALL SETUP memories available is either one or five. The number is determined by the setting of REF4 in the EXTENDED FUNCTIONS SYSTEM menu. If REF4 is set to REF, only one front-panel memory location is available.

HORIZONTAL CONTROLS

Refer to Figure 3-6 for locations of Items 26 through 31.

(26) **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 you are going to use the horizontal expansion feature.

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.

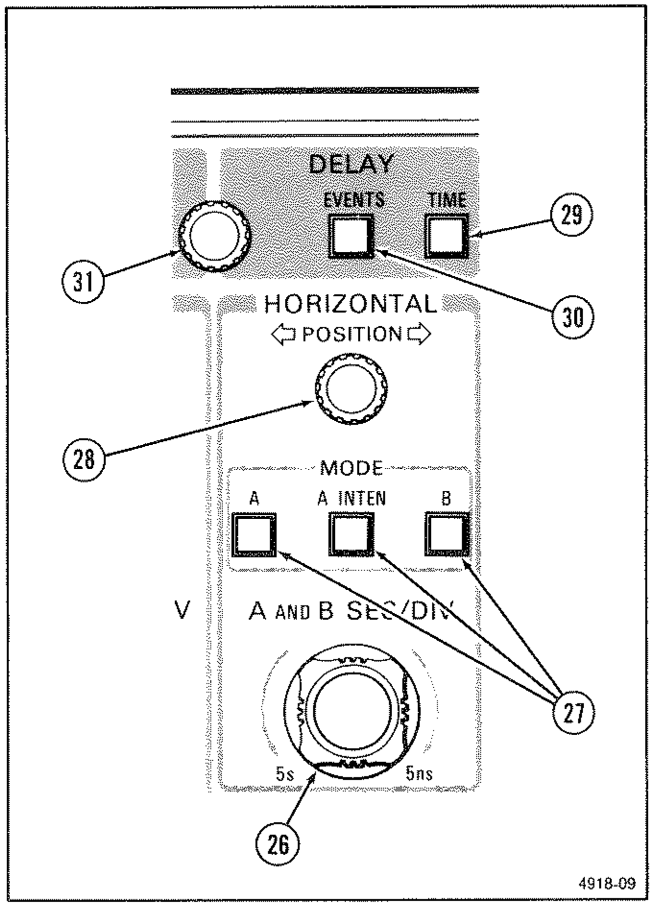


Figure 3-6. Horizontal and Delay Controls.

(27) **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 INTENS or B Delayed mode is selected, the SEC/DIV control knob sets the B SEC/DIV setting. See Item 29, "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 correspond 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.

(28) **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 XYREF 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. The selected REF waveform is the only one that may be positioned, and the HORIZONTAL POSITION menu MUST be displayed for the POSITION control to be in effect for the reference waveforms. Any positioning of the REF1 or REF2 reference waveforms done in YT display mode is removed when switching to XY display mode.

DELAY CONTROLS

Two different delay features are available in the 2430 Digital Oscilloscope: the conventional DELAY by TIME function used in B Delayed application, and a DELAY by EVENTS function used to delay the A acquisitions by a set number of B Trigger events. See Figure C-2 in Appendix C for an illustration of the delaying processes for the separate and combined delay features.

(29) **DELAY by TIME Button**—Calls up the control menu used to setup 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 the choices of a single delay time display referenced to the A record trigger point (Δ TIME OFF) and a dual-delay 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. Switching the action of the Cursor/Delay knob between DELAY TIME and Δ DELAY TIME is done by pressing the DELAY by TIME front-panel button while the DELAY by TIME menu is being displayed. (The delay time selected to be set is indicated by an underscore.)

Maximum delay is 2621.4 $\times$ 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 C11 of Appendix C 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 be 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 AVG 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 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.

(30) **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 the 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 resolution of ±1 event. The B Trigger SOURCE, COUPLING, SLOPE, and LEVEL controls are used to condition the events trigger signal. The events count number is set using the Cursor/Delay control knob while DELAY by EVENTS menu is being displayed.

NOTE

If DELAY by EVENTS is on and no event triggers are occurring (B Trigger conditions not being met), the A acquisitions will have the appearance that the A Triggers are not functioning properly. In this event, a check of the instrument STATUS display (see Figure 3-2) will show that the "Trigger Status" is "WAITING FOR A TRIGGER."

(31) **Cursor/Delay Control Knob**—Used to set delay time, events count, or cursor positions, depending on which function is active. The control is a position-rate potentiometer that produces linear cursor positioning or delay setting in the center positioning region. Rotating the control into its spring-loaded region, produces fast positioning of the cursor or delay-time 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 the absolute (ABS) mode of DELAY by TIME, the Cursor/Delay control knob sets the main delay time. In Δ Time mode, the control knob is used to set either the main delay or the delay difference between the main delay and the delta delay (user selected by pressing the DELAY by TIME button while Δ Time is ON with the DELAY by TIME menu displayed). For DELAY by EVENTS, the knob is used to set the events count for the number of B Trigger events that must occur after the A Trigger event before an A Record Trigger (RTRIG) is permitted. For cursor functions, the Cursor/Delay knob positions the active cursor (as determined by pressing the SELECT button when a cursor function is active). The function of the knob defaults to CURSORS if neither the DELAY by TIME nor the DELAY by EVENTS menu is displayed.

TRIGGER CONTROLS

Refer to Figure 3-7 for location of Items 32 through 48.

(32) **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 control menu and the effect of the SLOPE and LEVEL controls between the A Trigger system and the B Trigger system.

(33) **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 the 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 CHAN 1:2 is selected, pushing SOURCE also toggles the Source between Channel 1 and Channel 2.

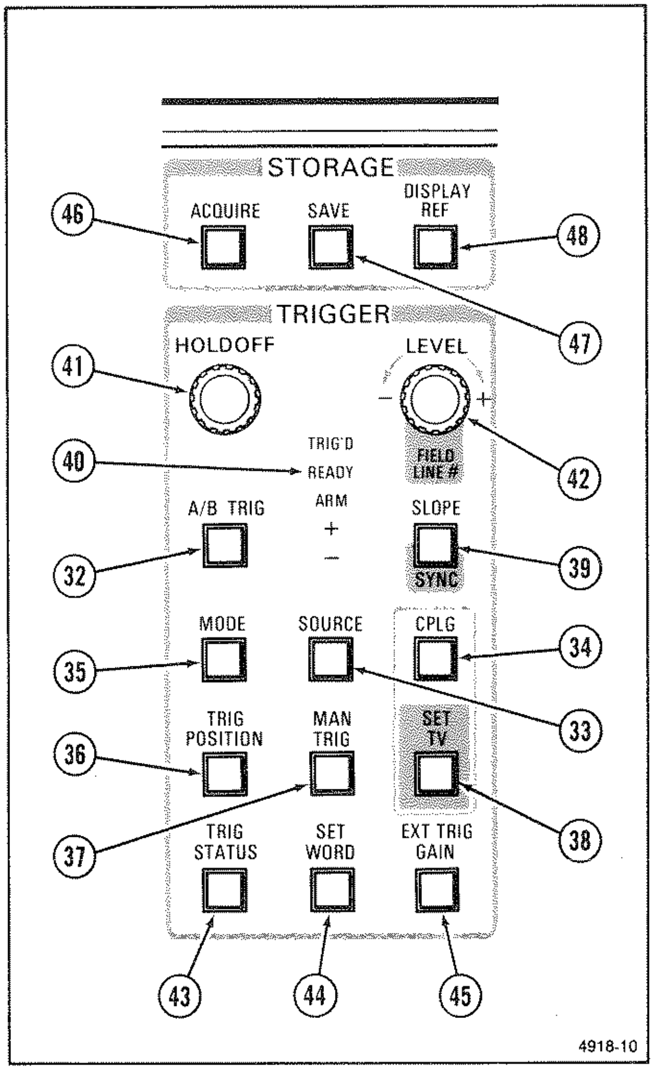


Figure 3-7. Storage and Trigger Controls.

EXT 1:2—Selects the signal applied to either the EXT TRIG 1 or EXT TRIG 2 connector as the source for the triggering signal. When initially selected, EXT1 is the default source. Each subsequent push toggles the selected source between EXT1 and EXT2. While the SOURCE menu is displayed with an external trigger source chosen, pressing the Trigger SOURCE front-panel button also toggles the source selected between EXT1 and EXT2.

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 TV 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 2430. 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."

(34) **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.

TV (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. TV 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 and blocks the dc component of the signal. 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.

(35) **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 2430 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.

If the trigger signal amplitude decreases to below the trigger level setting or if the Trigger LEVEL control is adjusted beyond either peak of the current reference peak levels, the AUTO LEVEL trigger acquisition sequence is automatically performed to reset the trigger level.

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 "T" indicator 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 is set to GND to acquire a ground reference level. The NORMAL mode auto-trigger with GND input coupling allows the user to position the baseline trace to a desired vertical position in the display while the normal trigger signal is shut off. Loss of the trigger signal during a waveform acquisition stops the acquisition process and freezes the display.

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, it is necessary to temporarily exit SINGLE SEQ 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 trigger events required to complete the sequence depends on the storage acquisition mode in effect and the requirements of that mode. The display updates when the single sequence has completed prior to entering SAVE mode. A new single sequence is started by pressing the ACQUIRE button.

NOTE

The difference between an acquisition and a single sequence is as as follows. An 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. For instance, if system was in the ENVELOPE mode with number of sweeps = 32, and the HORIZONTAL MODE is set to B Delayed with Δ TIME delay mode ON, the complete sequence would consist of 64 acquisitions. After the initial single sequence performed when the SINGLE SEQ TRIGGER MODE menu button is pressed, follow-on single sequence acquisitions must be started by either pressing the ACQUIRE 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 A Trigger event has elapsed. The B Trigger Mode of RUNS AFTER provides for continuous 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 effect of the Cursor/Delay knob between 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 occurs. The maximum usable external clock signal frequency is 100 MHz, and the minimum is 1 MHz.

When using the external clock function, the A and B SEC/DIV switch (Item 26) 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.

(36) **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 C-10 in Appendix C 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.

(37) **MAN TRIG (Manual Trigger) Button**—Generates a single trigger (RTRIG) that forces the current acquisition (not sequence) to complete when pressed. DELAY by EVENTS and DELAY by TIME requirements are ignored; therefore, any delay time readouts are meaningless when MAN TRIG is used to generate the acquisition. One acquisition is made for each press of the MAN TRIG panel button only when the trigger status is READY. If the 2430 is in the SAVE mode or if the trigger status is ARM or TRIG'D, pressing the MAN TRIG button is ignored.

(38) **SET TV 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 TV menu, it remains on even if the TV Coupling selection is off (as indicated in the crt readout display). If the 2430 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 TV and switch CLAMP off.

(39) **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.

(40) **Status Indicators (TRIG'D, READY, and ARM)**—Show the state of the instrument trigger system during an acquisition sequence. See Table C-12 in Appendix C for an interpretation of the trigger status shown by the Status Indicators.

(41) **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 aids in obtaining stable triggering on aperiodic signals. Minimum and maximum holdoff values versus SEC/DIV settings are given in Table C-6 of Appendix C 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%.

(42) **LEVEL Control Knob (LEVEL/FIELD LINE # with Video Option)**—Sets the amplitude point 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 4-2 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 ±8 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 peak-to-peak reference level causes the triggering level to be recalculated. The new trigger level obtained as a result of the recalculation is placed at 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 a video signal acquisition will occur (FIELD1 or FIELD2 triggering). See the "Video Option" information in Section 7 for operation of this control with the Video Option.

(43) **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 underscore beneath the selected trigger system. Any trigger changes sent to the 2430 via the GPIB interface will be immediately reflected in the TRIG STATUS display.

(44) **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.)

In the 2430, the output of the Word Recognizer Probe may 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 will appear at this connector each time a word match occurs, however the holdoff time of the 2430 may prevent each match from being accepted as a scope triggering signal if the selected trigger word occurs too often in a data stream.

(45) **EXT TRIG GAIN Button**—Displays the menu for setting the attenuation of the EXT TRIG 1 and EXT TRIG 2 input amplifiers. 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 channel are mutually exclusive; selection of one turns off the other choice.

STORAGE SYSTEM

Refer to Figure 3-7 (previously shown) for location of Items 46 through 48.

(46) **ACQUIRE Button**—Calls up the control menu used to select the acquisition mode.

NOTE

When either ENVELOPE or AVG 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-waveform display similar to that of a conventional scope.

ENVELOPE—Causes the instrument to execute fast analog peak detection of both channels. The data-point values of each min-max sample are compared to the previously acquired maximum and minimum data-point values that occur during a sampling interval. The maximum and minimum peak values found in each sampling interval 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.

AVG (average)—Causes the instrument to average the selected number of successive acquisitions. The averaged waveform display is updated with each new acquisition. The waveshape definition of noisy signals is improved with each average up to the selected number. The user selects the number of sweeps 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 C-4 in Appendix C 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 (with 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 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.

REPET (Repetitive)—Enables repetitive sampling for NORMAL and AVG mode acquisitions when ON. At SEC/DIV settings of 500 ns per division and faster, the time base is sampling the incoming waveform at its maximum rate of 100 megasamples per second; and with REPET OFF, data points of a waveform between the actual digitized data points 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 500 ns per division to 5 ns per division, REPET ON turns on random-time sampling of the incoming signal to extend the bandwidth of the instrument to 150 MHz for repetitive signals.

Each REPET acquisition cycle produces from 10 to 205 randomly-sampled display points. The user sees the waveform take shape as the newly acquired data points are successively added into the accumulating display. See Figure C-1 in Appendix C for information regarding the number of sweeps required to fill a waveform at a 99% confidence level.

SAVE ON Δ—Controls the Save-on-Delta mode. The ON selection requests the system to compare each incoming waveform to a reference waveform and enter the SAVE mode if any part of the waveform is outside the limits of the comparison envelope waveform. A comparison envelope reference may be generated from the front-panel by selecting continuous ENVELOPE and using the Vertical POSITION and DELAY by TIME controls to set the comparisons limits, then saving that in the correct REF memory. The usual method of obtaining an accurate comparison envelope would be to send it into the desired REF memory via the GPIB interface. Both methods are described in the "Basic Applications" section 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 C-15 in Appendix C 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 power-on time since the last cold start occurred is also displayed as Y (years), D (days), H (hours), and M (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.

(47) **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. SAVE mode holds the current waveform display and calls up the SAVEREF SOURCE menu for use in storing the SAVE waveform in one of the REF memories as a reference waveform, if wanted. 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 cursor functions may be used to make measurements on the saved waveforms, and the waveforms may be vertically and horizontally positioned using the normal POSITION controls. They may 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 may be added or multiplied with a recalculation of data taking place to obtain the additional trace.

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. 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.

SAVE SOURCE—A waveform to be stored in SAVEREF memory is selected from choices displayed in the SAVEREF SOURCE menu. Only waveforms selected for display from the possible choices of CH 1, CH 2, and either ADD or MULT will appear as specific choices. When DELTA TIME mode is in effect for the B Horizontal Display Modes, two delayed waveforms are acquired, and the added selection sub-menu of DELAY1—DELAY2 is displayed permitting user to make the desired SOURCE choice for saving. The REF selection that appears in SAVEREF SOURCE menu provides a means of saving from one reference memory to another.

The user may wish to use the reference memories in a push-up stack manner. If so, a press of the STACK REF menu button stores the displayed SAVE waveforms in a predefined manner. The reference memory written to is determined by which VERT MODES were in effect at the time SAVE mode was entered. 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 C, Table C-14 for the storage configuration when STACK REF is used for saving waveforms in reference memory.)

NOTE

If the extra front-panel settings for the SAVE/RECALL SETUP feature have been selected in the EXTENDED FUNCTIONS—SYSTEM menu (REF4 set to PNL), REF4 will be missing from the Destination and Display choices for reference waveforms. Also, that memory location will not be overwritten by pressing the STACK REF menu button.

SAVEREF DESTINATION—If a specific SOURCE is selected, the SAVEREF DESTINATION menu is then displayed to permit the user to select 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 48 "DISPLAY REF").

(48) **DISPLAY REF Button**—Calls up a 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. If the REF4 memory location has been selected to store extra front-panel settings, the word "PANEL" is displayed above the menu choice.

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 (REF 1, REF 2, REF 3, and REF 4) is positionable with the Horizontal POSITION control. Pressing the DISPLAY REF menu button returns the system back to the original menu DISPLAY REF control menu.

IN XY mode, only one reference waveform (made up of REF 1 against REF 2) is displayed. Pressing the STACK REF button in the SAVE menu saves the XYREF waveform by storing CH 1 in REF 1 and CH 2 in REF 2 at the same time with a single button press. Storing 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 REF 1 or REF 2 is EMPTY, the XYREF choice will be marked empty in XY mode.

Waveforms for the XYREF may be individually entered in the REF 1 and REF 2 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.

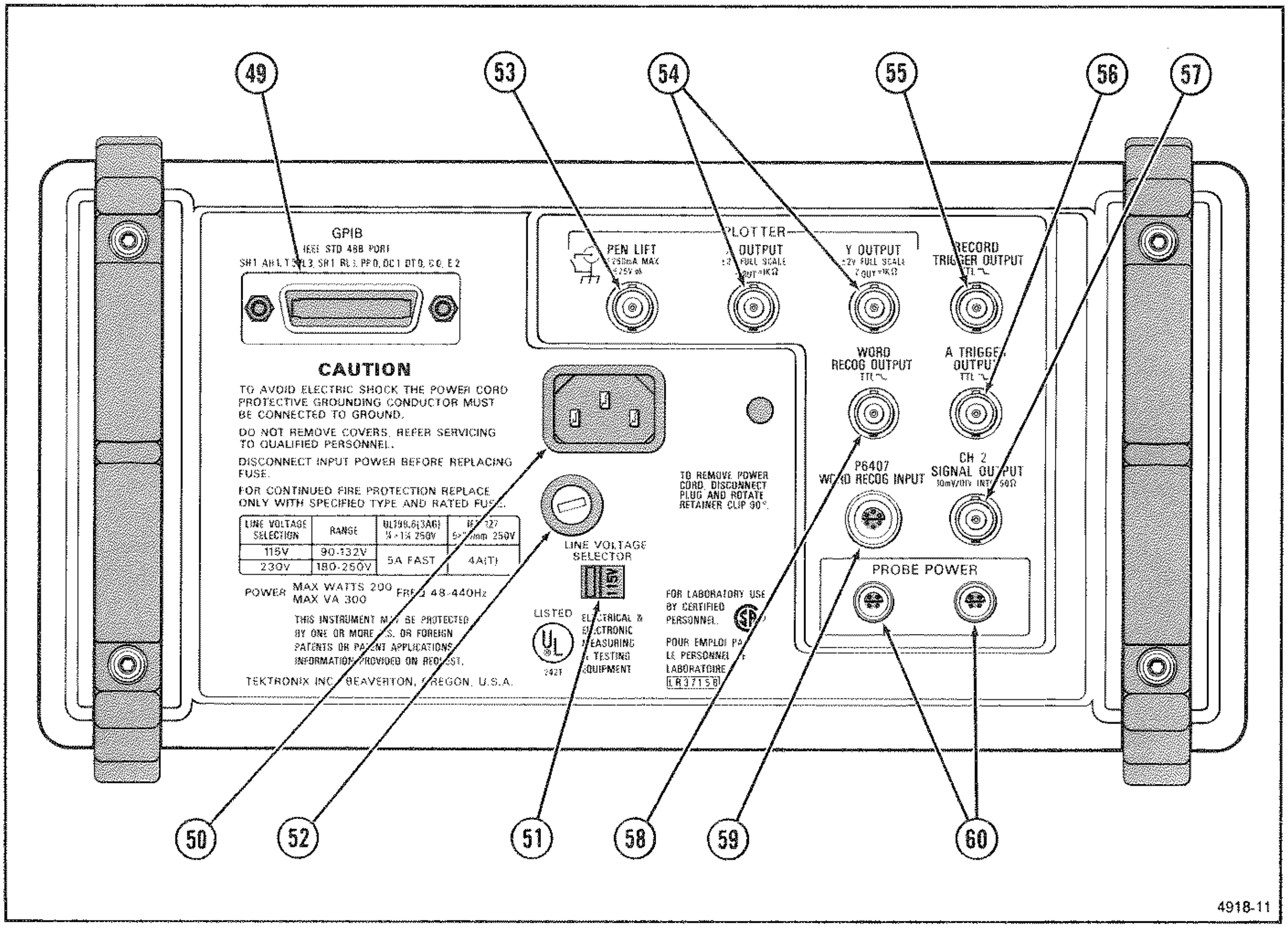


Figure 3-8. Rear Panel Controls and Connectors.

REAR PANEL

Refer to Figure 3-8 for location of Items 49 through 60.

(49) **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 3-9 for an illustration of the connector and pin assignments.

(50) **Detachable-Power-Cord Receptacle**—Provides the instrument connection point to the appropriate ac voltage.

(51) **LINE VOLTAGE SELECTOR Switch**—Selects the nominal operating voltage for the instrument. When set to 115V, the instrument operates from a power source range of 90 V to 132 Vac. When set to 230V, the instrument operates from an input voltage range of 180 V to 250 Vac.

(52) **Fuse Holder**—Contains the primary ac power-source fuse.

(53) **PLOTTER PEN LIFT Connector**—Provides access to a relay contact which either opens or closes for proper pen operation when interconnecting the 2430 to an external XY Plotter. Either a TTL-level HI or LO is available. (See Item 24 "OUTPUT" in the External Interface part of this section.)

(54) **PLOTTER X OUTPUT and Y OUTPUT Connectors**—Provide analog X-axis and Y-axis drive signals for use with an external XY Plotter. Output amplitude is approximately 200 mV per division with an output impedance of about 1 kΩ.

(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 C-2 in Appendix C of this manual).

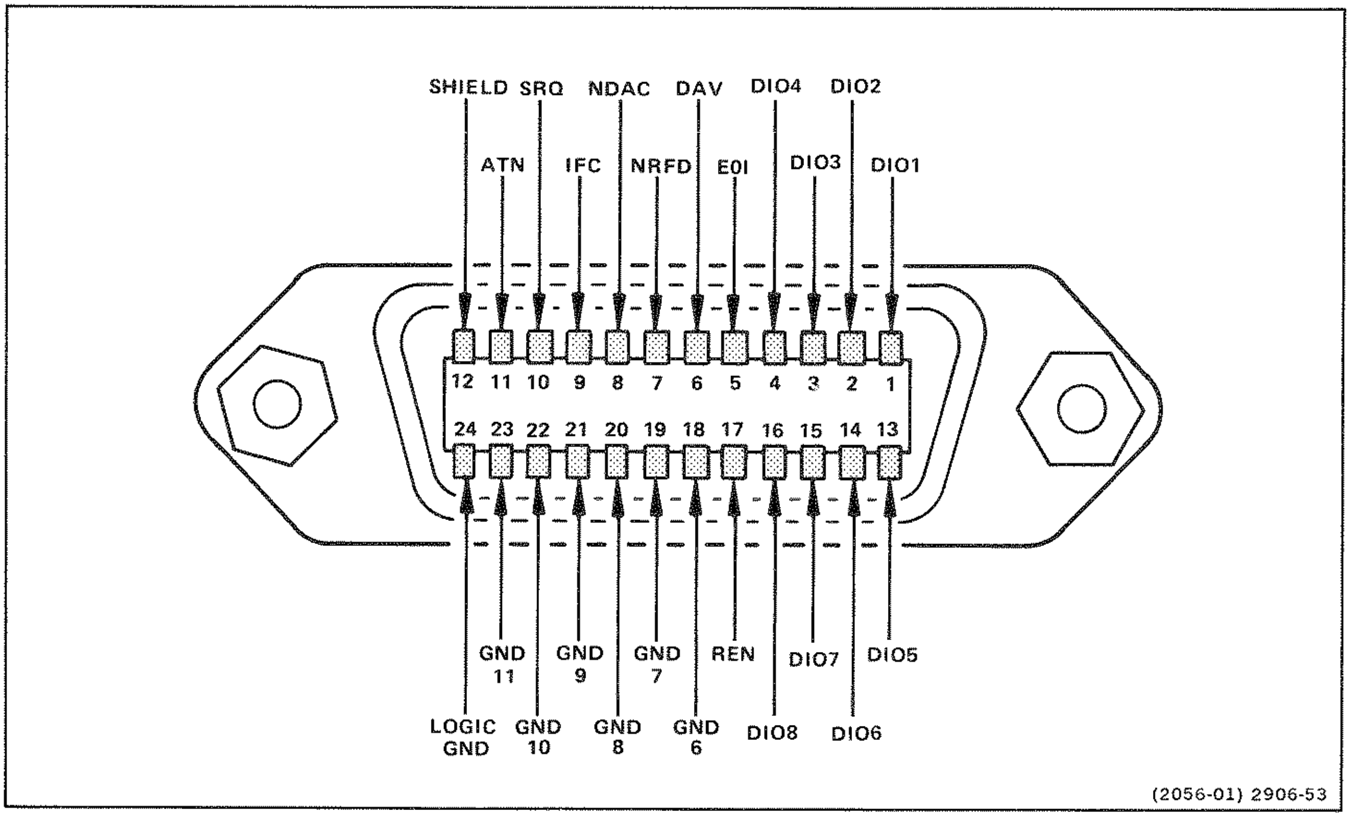


Figure 3-9. GPIB Connector pin arrangement.

(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 33 "SOURCE" and Item 44 "SET WORD" in this section).

(60) **PROBE POWER Connectors (Option 11)**—Provides output power for optional Tektronix active probes.

2430 SYSTEM MENUS

The following information is an aid in understanding the 2430 menus that an operator must use to control the operation of the scope. Each menu is an extension of the front-panel control button that calls it up, and provides the same function as a multi-position switch with the buttons mounted in the crt bezel selecting the switch position. Very few of the menus are more than one layer deep, and the choices displayed by a press of the front-panel button are self-explanatory. Table 3-1 provides a listing of each menu and menu subset of those menus that are more than one level for use as a reference guide.

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 Front-Panel SAVE/RECALL SETUP.

Table 3-1

2430 Control Menus and Displays

CRT Display Menus					
SELECT	**INTENSITY READOUT**	**DISP**	**INTENS**	**GRAT**	**VECTORS ON:OFF**
STATUS	Presents an instrument status display and increases the readout intensity to 65% to ensure visibility (see Figure 3-2).				
MENU OFF/ EXTENDED FUNCTIONS	Turns off any menu being displayed or, if none are on, calls up the EXTENDED FUNCTIONS menus. See Appendix B for the Extended Functions Calibration and Diagnostics menus.				
	EXT FUNCT		**SYSTEM**	**SPECIAL**	**CAL/DIAG**
	Second-level menu for SYSTEM.				
	PWR ON LAST:INIT	**BELL ON:OFF**	**PREFIL ON:OFF**	**REF4 REF:PNL**	**TV SYS M:NON/M**
	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				**FORCE DAC**
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**	↓	↑		
	CH2 VARIABLE **CAL**	↓	↑		
COUPLING/INVERT	**CH1 COUPLING** **AC**	**DC**	**GND**	**50 Ω ON:OFF**	**INVERT ON:OFF**
	CH2 COUPLING **AC**	**DC**	**GND**	**50 Ω ON:OFF**	**INVERT ON:OFF**
BANDWIDTH	**BANDWIDTH** **20 MHz**	**USB=xxxxHz** **50 MHz**	**FULL**	**USR=xxxx s**	
	The number xxxx depends on the Acquisition Mode, the SEC/DIV setting, and the bandwidth selected.				

Table 3-1 (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—CH2 on				
	CH2	**CH2Δ**	(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 3-1 (cont)

	DELAY Control Menus
DELAY by TIME	With ΔTIME OFF **DELAY TIME = xxxxxx s** — **ΔTIME ON!OFF**
	With ΔTIME ON **DELAY TIME = xxxxxx s** **Δ DELAY 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 time may be changed only while the Delay by Time menu is displayed.
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 knob only while Delay by Events menu is displayed.
	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 SAVEREF SOURCE (except SAVEREF) is selected. REF4 is omitted if the extra front-panel setups have been turned on for the SAVE/RECALL SETUP feature. - - - - - - - - - - - - - - - - **SAVEREF DEST** - - - - - - - - - - - - - - - - **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**
DISPLAY REF	In YT Mode. **DISPLAY REF** **REF1** — **REF2** — **REF3** — **REF4** — **HORIZ POS REF**
	In XY Mode **XYREF** — **HORIZ POS REF**
	Second-level menu displayed when HORIZ POS REF is called. - - - - - - - - - - - - - - **HORIZONTAL POSITION** - - - - - - - - - - - - - - **REF1P** — **REF2P** — **REF3P** — **REF4P** — **DISPLAY REF**

Table 3-1 (cont)

A TRIGGER Control Menus					
TRIGGER MODE	A TRIGGER MODE				
	AUTO LEVEL	AUTO	NORMAL	SINGLE SEQ	
	AUTO switches to ROLL at 100 ms/div and slower.				
TRIGGER SOURCE	A TRIG SOURCE				
	VERT CH1 CH2 ADD	CHAN 1:2	EXT 1:2	LINE	A*B:WORD
TRIGGER CPLG	Without the Video option.				
	A COUPLING		- - - - - - - - - - - - REJECT - - - - - - - - - - - -		
	DC	AC	NOISE	HF	LF
	With the Video option installed.				
	A COUPLING		- - - - - - - - - - - - REJECT - - - - - - - - - - - -		
	DC:AC	TV	NOISE	HF	LF
SET TV (Video option only)	A TV COUPLING				CLAMP
	FIELD1	FIELD2	ALT	TV LINE	ON:OFF
	FIELD2 is 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

Table 3-1 (cont)

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) **VERT** **CH1** **CH2** **ADD**	**CHAN** **1:2**	**EXT** **1:2**		**WORD**
	In B RUNS AFTER Delay Mode. **B TRIG SOURCE** **EXT CLK SOURCE** (with EXT CLOCK) **EVENTS SOURCE** (with DELAY by EVENTS) **EVENTS, EXT CLK SOURCE** (with both) **VERT** **CH1** **CH2** **ADD**	**CHAN** **1:2**	**EXT** **1:2**		**WORD**
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) **DC**	**AC**	- - - - - - - - - - - - **REJECT** - - - - - - - - - - - - **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) **DC**	**AC**	- - - - - - - - - - - - **REJECT** - - - - - - - - - - - - **NOISE**	**HF**	**LF**
TRIG POSITION	**B TRIGGER POSITION** **1/8**	**1/4**	**1/2**	**3/4**	**7/8**
EXTERNAL TRIGGER and TRIGGER STATUS Menus					
EXT TRIG GAIN	**EXT GAIN** **EXT 1**	**EXT1÷5**		**EXT 2**	**EXT2÷5**
TRIG STATUS	**TRIG STATUS** **MODE** - - - - **A** (Setup conditions for the A Trigger Controls.) **B** (Setup conditions for the B Trigger Controls.)		**SOURCE** - - - - - -	**CPLG** - - - -	**TRIG POS** - - - - - - -

Table 3-1 (cont)

	WORD RECOGNIZER Control Menus				
SET WORD	**RADIX OCT:HEX**	**- - - - CLOCK - - - - ⌠**	**⌝_**	**ASYNC**	**SET BITS**
	SET BITS second-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**	**←**	**→**
	FRONT PANEL SETUP MEMORY				
SAVE/RECALL SETUP	If the REF4 selection is set to REF in the EXTENDED FUNCTIONS—SYSTEM menu, only one front-panel setup may be saved or recalled and only the number 1 will be displayed in the SAVE and RECALL second-level menus. Front-panel memory 1 is long-term nonvolatile storage; memories 2 through 5 are short-term nonvolatile storage (3 to 5 days). **SAVE/RECALL SETUP**				
	SAVE	**RECALL**			**INIT PANEL**
	SAVE second-level menu. **SAVE SETUP**				
	1	**2**	**3**	**4**	**5**
	RECALL second-level menu. **RECALL SETUP**				
	1	**2**	**3**	**4**	**5**

Table 3-1 (cont)

OUTPUT Control Menus

OUTPUT

- - - - - - - - XY - - - - - - - -			- - - - - - - GPIB - - - - - - - -	
PLOT	**FORMAT**	**STATUS**	**SETUP**	**TRANSMIT/ (PRINT)**

STATUS calls up an on-screen display of most GPIB parameters that a system user might be interested in (see Figure A-2 in Appendix A).

PLOT and TRANSMIT/(PRINT) switch to ABORT when the function is active. TRANSMIT/(PRINT) is off in OFF BUS mode.

XY FORMAT second-level menu.

XY FORMAT READOUT	**GRAT**	**PEN LIFT OPEN:CLOSE**		**PLOT**

Pressing PLOT in this level menu reverts back to the first level menu with ABORT displayed.

GPIB SETUP second-level menu.

MODE	**TERM**	**ADDR**	**ENCDG**	**DEBUG ON:OFF**

GPIB MODE third-level menu.

T/ONLY	**L/ONLY**	**T/L**	**PRINTER**	**OFF BUS**

Selecting PRINTER changes TRANSMIT to PRINT in the OUTPUT control menu. Selecting OFF BUS turns off the TRANSMIT/PRINT choice.

GPIB T/ONLY fourth-level menu.

CURVE ONLY		**WFMPRE/CURVE**		

GPIB TERM third-level menu.

EOI	**LF/EOI**			

GPIB ADDR third-level menu.

GPIB ADDRESS =	↑		**nn** ↓	

GPIB ENCDG third-level menu.

ASCII	**RP BIN**	**RI BIN**		

RIBIN data encoding is two's-complement format. RPBIN encoding is positive-integer format. At power-on the 2430 assumes that the data is formatted RIBIN. The user must select RPBIN or send ENCDG RPBIN to get positive-integer formats interpreted correctly.

OPERATING INFORMATION

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 an operators familiarization procedure intended as an aid in getting 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 division are further divided into five subdivisions of 0.2 division each, marked along the center vertical and horizontal graticule lines (see Figure 4-1). 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.

TIME AND VOLTAGE MEASUREMENTS

The 2430 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 determining voltage or time values 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 for measurements 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 displayed 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). Additional cursor modes provide coupled VOLTS and TIME cursors (V@T) for making voltage measurements at chosen time points on a waveform and slew rate (SLOPE) measurements, and a 1/TIME mode for making frequency measurements. The units of measurement are also selectable to serve a wide range of measurement applications.

Time difference measurements requiring the highest degree of accuracy and those involving delays beyond the on-screen limits of the TIME cursors are made using the DELAY by TIME and Δ TIME 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 3 "Controls, Connectors, and Indicators." Use of the various cursor and B Delay modes for making measurements is described in Section 6, "Basic Applications."

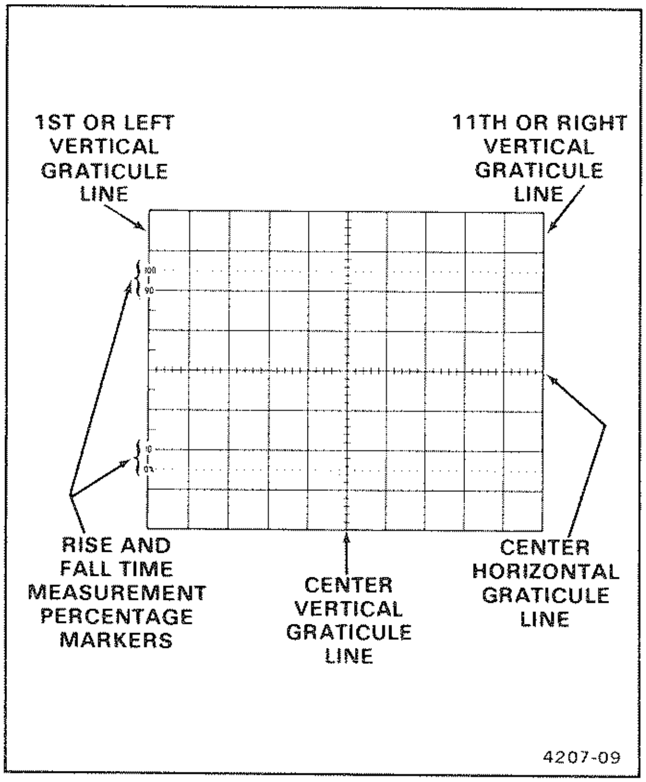


Figure 4-1. Graticule measurement markings.

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 all 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. Figure C-1, in Appendix C of this manual, shows the number of sweeps required to fill the waveform acquired using REPET mode with a 99% confidence level. A SINGLE SEQ acquisition in REPET mode acquires enough data points to fill the waveform to approximately 50%. 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 (for SEC/DIV settings of 200 ns and faster).

A SAVE-ON-Δ feature enables the 2430 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.

Acquired waveforms are also saved when the user presses the front-panel button labeled SAVE. The 2430 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 any time either 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 2430 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 will affect system bandwidth and will 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 "Operator's Checks and Adjustments," Section 5 of this manual and in the instructions supplied with the probe.

AUTOMATIC SCALE FACTOR SWITCHING. The VOLTS/DIV scale factors are displayed on the CRT. This feature permits the 2430 VOLTS/DIV readout to be automatically switched in response to a control change received via the GPIB or as a result of change in the probe attenuation factor. Table C-1 in Appendix C 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 2430 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-COUPLING CAPACITOR 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 provides external circuit protection by reducing the current levels that can be drawn from the external circuitry during capacitor charging.

EXTERNAL TRIGGERING

The A and the B trigger signals are independently obtainable from a variety of sources. When viewing signals that require a trigger source different than one of the displayed signals on Channel 1 or Channel 2, a free vertical input channel or either of the external trigger input channels may be used to input the signal. The vertical channels may 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 very limited choice of attenuation factors (either divided by 1 or by 5 without the use of external attenuation).

OPERATORS FAMILIARIZATION

INTRODUCTION

The Tektronix 2430 is an easy-to-use Digital Oscilloscope that provides the user 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 the user's guide to how the instrument controls are setup. 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 4-2.

FRONT-PANEL CONTROLS

The front-panel controls are divided into two types:

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

Those that call up a menu with the specific entry choices that actually make an instrument function change (ie., 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 will be pointed out.

FAMILIARIZATION PROCEDURES

The following procedures are intended as an aid to assist the first-time user in becoming acquainted with the system menus and front-panel function buttons. Performing the step-by-step instructions and simple exercises of the familiarization procedures will enhance the user's abilities with the instrument and provide visual reinforcement of how the controls affect the operation of the 2430. Once the user becomes acquainted with how menus are used to control the operating system and how quickly initial setups can be made, developing efficient techniques for making specific measurements should prove to be very easy.

The detailed operation of each control and connector is described in "Controls, Connectors, and Indicators," Section 3 of this manual. A complete list of the control menus is also given at the end of that section for the user's reference.

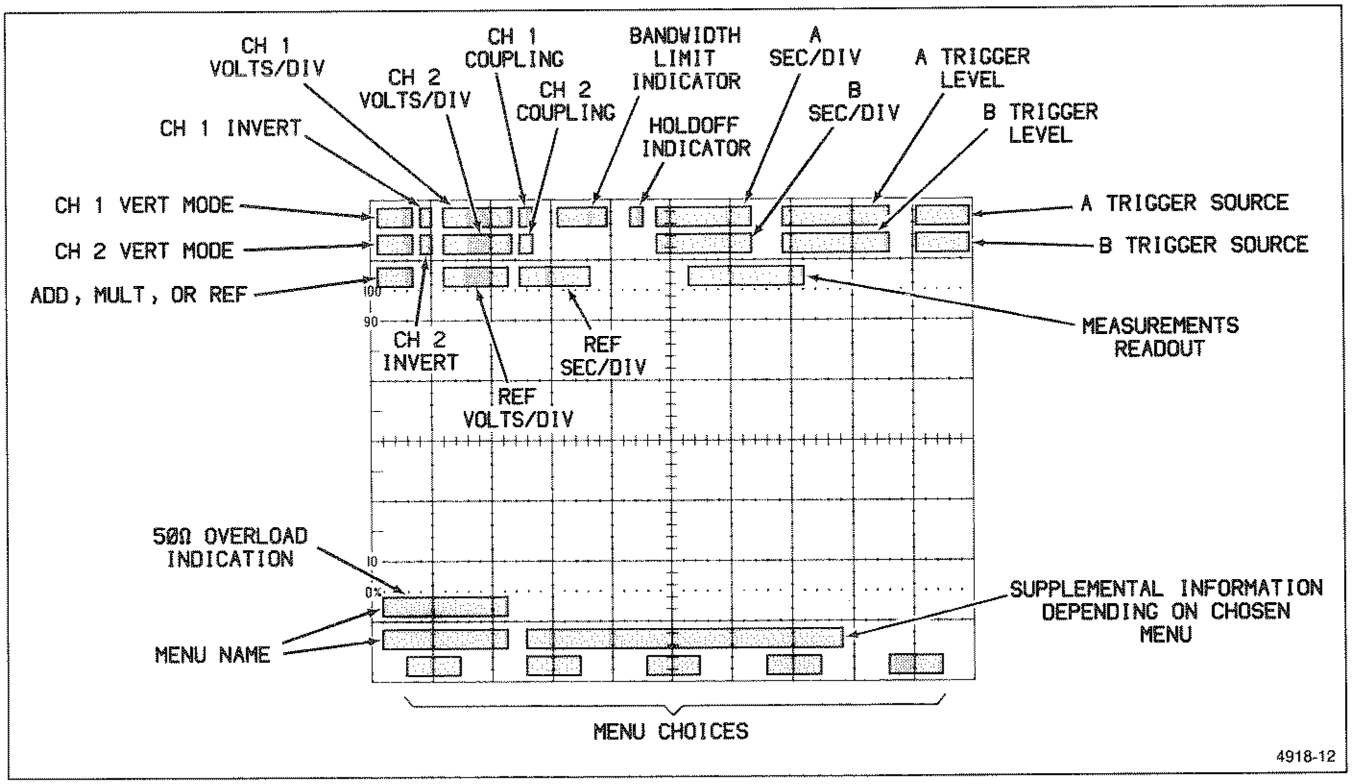


Figure 4-2. 2430 Readout display locations.

Initialization of the Front-Panel Controls

1. With the 2430 connected to an appropriate power source, press the POWER button IN (green indicator is seen in button). The 2430 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.

2. If the crt readout intensity has not been turned completely down, some type of readout display should be seen. Some waveform displays or traces may be present on the crt. Both depend on the front-panel setting and type of operation in effect when the 2430 was powered off. Panel settings in effect at power down are returned when the instrument is turned on again. If either a readout or waveform display is seen, go to Step 4.

3. If no displays are seen, press the STATUS button. This sets the intensity level of the READOUT to 65% and gives a readout of INTENSITY level settings in percentages and the instrument operating status display (see Figure 3-2 in "Controls, Connectors, and Indicators"). The percentage shown for DISP indicates if the DISP (waveform trace) intensity level is set too low for viewing a display (25% or more should give an easily viewable trace). If pressing STATUS causes the readout display to be seen, the READOUT Intensity level was probably set too low; it is now 65%.

NOTE

If no traces are called up for display (no VERT MODES and no REF waveforms on), the STATUS list will have none of the display entries underscored. It will then be necessary to select a VERT MODE display to set the DISP (waveform trace) INTENSITY to the desired viewing level in Step 4. Press VERT MODE and select CH 1.

4. Press SELECT button to display the INTENSITY control menu. Figure 4-3 illustrates the SELECT Menu entries and the position of the Menu Control buttons in case the menu is not visible.

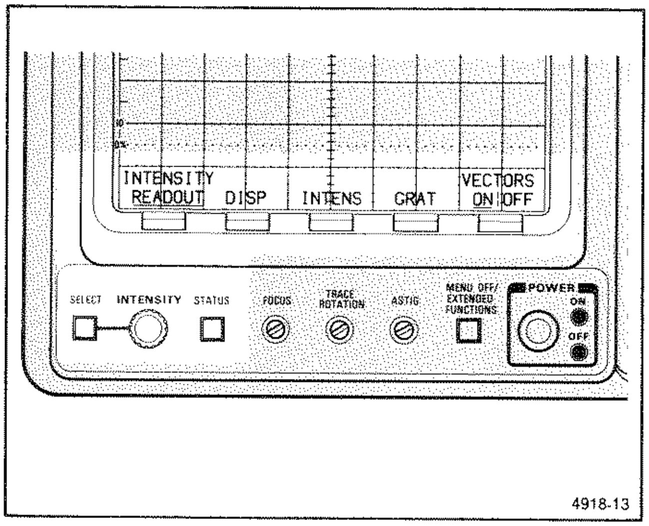


Figure 4-3. SELECT Menu and Menu Control buttons.

5. Press the READOUT menu entry 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. Basically the user must decide by observing the feature being controlled when maximum or minimum control effect has been achieved.

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

NOTE

If none of the VERT MODE or REF waveform displays are called up for display, no CH 1, CH 2, or REF VOLTS/DIV readouts will be shown in the upper left-hand corner of the crt (see Figure 4-2). The user must then call up a VERT MODE display to correctly set the waveform trace (DISP) INTENSITY. This is done by first pressing the VERT MODE button (located between the CH 1 and CH 2 control areas), then pressing the button located beneath the CH 1 menu choice to turn on the CH 1 display (should be underscored). Press the SELECT button again to recall the INTENSITY menu for the next step.

7. Press DISP menu entry button and use the INTENSITY control knob to adjust the waveform trace to a viewable level. If the traces called up for display are positioned out of the viewing area, the trigger position indicator (T) and ground indicator (+) should still be visible at the edges of the graticule area. In this event, adjust the INTENSITY for a viewable display of the indicators. (Pressing the SELECT button with the INTENSITY menu displayed toggles the selection between READOUT and DISP.)

8. Set the VECTORS menu entry to ON (if OFF). Each press of the menu button under VECTORS toggles the selection between ON (vector display) and OFF (dots display).

9. You are now ready to set up the remaining 2430 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.

FRONT-PANEL SETUP

Press the VERTICAL MODE button to display the Menu. An active state is underscored. To turn off a mode or function, press the menu button beneath the menu selection to remove the underscore.

Vertical

MODE	CH1—ON (underscored) CH2, ADD, and MULT—OFF YT:XY—YT (toggling choice)
CH 1 VOLTS/DIV	10 mV
CH 1 COUPLING/ INVERT	COUPLING—AC INVERT—OFF
BANDWIDTH	FULL
CH 1 VARIABLE	CAL

Horizontal

MODE	A
A SEC/DIV	500 μs

B Trigger (Press A/B TRIG for B Trigger menus)

TRIG POSITION	1/2
CPLG	AC
SOURCE	VERT (CH 1 is displayed)
MODE	RUNS AFTER—ON, EXT CLK—OFF
SLOPE	+ (plus)

A Trigger (Press A/B TRIG for A Trigger menus)

SLOPE	+ (plus)
MODE	AUTO
SOURCE	VERT (CH 1 is displayed)
CPLG	AC
TRIG POSITION	1/2

Cursors

FUNCTION	All OFF (none underscored)

Delay by Events

EVENTS	OFF

Delay by Time

ΔTIME	OFF

Storage

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

Extended Functions

SYSTEM	REF4—PNL

10. Center the record trigger position indicator (T) on the graticule using the CH 1 Vertical POSITION and the Horizontal POSITION controls.

11. Attach the standard accessory 10X probe to the CH 1 Vertical Input BNC connector. (The CH 1 VOLTS/DIV readout should now read 100 mV).

12. Connect the probe tip to the CALIBRATOR output connector and the ground lead to scope ground. A four-division peak-to-peak display of the CALIBRATOR output signal should now be seen. The waveform display may or may not be stable depending on the setting of the A Trigger LEVEL control.

13. 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 will automatically follow trigger signal changes to maintain stable triggering. If the TRIGGER LEVEL control is positioned beyond the peak-to-peak limits of the trigger signal, automatic level setting reoccurs to regain the trigger level setting for stable triggering.

14. You now have a basic front-panel display setup for viewing a signal applied to the CH 1 input. This setup may be saved for returning the 2430 to a known front-panel condition. Save the setup by using the following three-step procedure:

NOTE

The INIT PANEL choice shown with the SAVE/RECALL menu may be used to completely set up a predefined operating state for the 2430 (except certain controls that are not accessible to change). See Table C-16 in Appendix C for a list of the setup states called up by the INIT PANEL choice. The feature is provided so that if the front- panel controls have been left in some seldom used states, the user may quickly return to a known operating condition without having to search through the Status display or the menu selections to determine each front-panel control state.

   a. Press the SAVE/RECALL SETUP front-panel button to display the control menu.

   b. Press the SAVE menu button. This calls up a sub-menu for choosing a memory location number to store the setup.

   c. Press memory location number 1 to save the front-panel setup.

NOTE

If the REF4 choice in the EXTENDED FUNCTIONS—SYSTEM menu is set to REF, there is only one setup memory location available.

The RECALL SETUP menu selection is used in a similar manner to recall the front-panel setup just saved.

DEMONSTRATING THE FEATURES AND CONTROLS

Self Calibration

The SELF CAL feature assures the user that the most accurate measurements possible are being made. Self Calibration should be performed after instrument warm-up, 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 approximately ten minutes after power-on (whether the instrument is warm or not) the message "NOT WARMED UP" is displayed in the CAL/DIAG menu to warn the user that the temperature of the 2430 has possibly not yet stabilized for the best calibration result. The message may be ignored at any time by simply starting the SELF CAL procedure. At the end of the warm-up time, the message is removed from the CAL/DIAG menu display.

Self Calibration of the 2430 is done using the following procedure.

1. If any menus are displayed, press the MENU OFF/EXTENDED FUNCTIONS button twice (first time to turn off the menus; second time to turn on the EXTENDED FUNCTIONS menu); otherwise, press it once.

2. Press the CAL/DIAG menu choice button. This brings up the Calibration/Diagnostic choices. A message is also displayed to indicate if the last self calibration and self diagnostic tests performed were passed or failed.

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 (indicated by the "RUNNING" message leaving the display) and a PASS message should be above the SELF CAL menu choice. The 2430 is then ready to return to its operating state.

NOTE

If the self calibration should fail, the self-diagnostic mode will be entered. In this event, press 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 B for more information on the Self Test and Self Calibration features. Depending on the test failed, the scope may be functional for the measurements you need to make. Press the MENU OFF/EXTENDED FEATURES 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 press ACQUIRE to start the waveform acquisitions again.

Exercising the A and B SEC/DIV Switch

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.

NOTE

The CALIBRATOR output frequency changes with SEC/DIV switch settings in range steps between a maximum and a minimum output frequency. See Table C-3 in Appendix C for the CALIBRATOR output frequency for each SEC/DIV setting.

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. (For this signal the period = 2 ms and the frequency = 500 Hz.)

Exercise the CH 1 VOLTS/DIV, COUPLING, and VARIABLE controls.

1. Set CH 1 VOLTS/DIV control clockwise to 50 mV then switch slowly through settings counterclockwise to 1 V. Observe how the VOLTS/DIV readout changes and the effect on the waveform display 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 200 mV for a two-division peak-to-peak display amplitude.

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 markings 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 presses of the button will rotate the Input Coupling selections first to DC, then GND, then back to AC. Observe the change in the vertical position of the display as the Input Coupling is switched between AC and DC. Also notice the change in the symbols displayed with the VOLTS/DIV readout for each Input Coupling selection.

Input Coupling may also be chosen (as well as the 50 Ω termination and INVERT features) by use of the individual menu entry 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 Input 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 a 10X high impedance probe is being used to connect the CALIBRATOR output to the CH 1 Vertical input connector.)

6. Again select the AC menu entry Coupling 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 down-arrow menu button until the displayed peak-to-peak amplitude decreases to about 1 division. Also note the symbol preceding the VOLTS/DIV readout to indicate when the vertical display is uncalibrated.

8. Press and hold the up-arrow 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 pressing the CAL menu button.

Setting Up the CH 2 Controls

1. Attach the second 10X accessory probe to CH 2 BNC input connector. Press the VERTICAL MODE front-panel button, and turn on the CH 2 display.

2. Now use the CH 2 VERTICAL controls and menus to duplicate the the CH 1 front-panel setup. Try it, using the readout display, without referring back to the previous procedure steps. When the CH 1 and CH 2 waveform displays are the same, proceed to next step (be sure to check the CH 2 Vertical POSITION).

3. Separate the two traces using the CH 1 and CH 2 Vertical POSITION control knobs. Place the CH 1 display in the top half of the graticule area and the CH 2 display in the bottom half, about equally spaced from the center horizontal graticule line.

4. Save the dual-channel front-panel setup in SAVE/RECALL memory location 2.

Demonstrating SAVE and DISPLAY REF Storage Modes

Entering SAVE mode is normally done in one of three ways: pressing 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 completing a plot without having an acquisition restarted. SAVE mode may be entered using a command via the GPIB, and it is entered temporarily during the signal output to an external XY Plotter or printer. At the completion of the plotter output, the scope returns to the same operation it was doing before the plot was started.

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 Y (years), D (days), H (hours), and M (minutes) is the scope run time since the last cold start.

Upon entering the SAVE Storage Mode, the SAVEREF SOURCE control menu is displayed. The menu permits the user to select 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 permit the user to select which of the three reference memories is used to store the selected source.

NOTE

Extra front-panel memory has been selected in the initial setup using the EXTENDED FUNCTIONS menu. If this were not the case, there would be four reference memory locations displayed as destinations for storing waveforms.

Besides storing selected channel signals as reference waveforms, the user has the choice of moving one of the stored references to another memory location. Selecting REF as the source displays the choice of any of the three reference waveforms to be selected. Upon selecting a source, the SAVEREF DESTINATION menu appears as before to choose the reference destination.

A final option to the user for storing waveforms into the reference memories is offered by the STACK REF menu choice displayed with the SAVEREF SOURCE menu. This choice treats the reference memories as a push-up stack with REF1 as the bottom stack location and REF3 as the top. The first push of STACK REF will store a single channel display first into REF1, then repeated presses with push it to REF2, then REF3, and finally off the stack. 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, pressing STACK REF will store CH 1 in REF1, CH 2 in REF2, and the ADD or MULT function in REF3. See Table C-14 in Appendix C for the detailed STACK REF storage arrangement.

1. Use the dual-channel display from the previous "Setting Up the CH 2 Controls" procedure for this demonstration.

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

3. In the SAVEREF SOURCE menu, press CH1. 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 reference source selections if wanted.

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

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

7. To display the stored references, press the DISPLAY REF Storage Mode button. A menu of the selection choices is displayed for choosing the reference waveform for display. A reference memory without a waveform stored in it will be labeled "EMPTY" and ignored if display of that reference is requested.

8. Press REF1 and REF3 to display those reference waveforms overlaid. Use the VERTICAL MODE menu to remove the CH 1 and CH 2 SAVE waveforms from the display, then press DISPLAY REF again to return that control menu to the display.

NOTE

The DISPLAY REF button and the DISPLAY REF menu choice that appears in the HORIZONTAL POSITION menu both act in the same manner. A press of either switches between the DISPLAY REF and the HORIZONTAL POSITION menus.

9. Press the HORIZ POS REF menu button and select REF1P from HORIZONTAL POSITION menu to direct the effect of the HORIZONTAL POSITION control to the REF1 waveform. Position the REF1 waveform to observe the way it works.

NOTE

In the HORIZONTAL POSITION control menu, one of the references will always be underscored, and the selections are mutually exclusive. Only one choice may be enabled at a time, and the HORIZONTAL POSITION control menu must be displayed for the effect of the HORIZONTAL POSITION control to be directed to a reference waveform.

10. Select REF3P to be positioned horizontally, and position that reference waveform using the HORIZONTAL POSITION control.

11. Turn off the reference waveform displays and turn on the CH 1 and CH 2 displays.

Exercise BANDWIDTH Control

NOTE

The BANDWIDTH control setting is for both CH 1 and CH 2.

1. Press the BANDWIDTH button to display the selection menu. The choice of 20 MHz, 50 MHz, and FULL are available. Selection is made either by pressing the BANDWIDTH switch repeatedly to scroll through the choices or by pressing the menu selection button of the desired bandwidth.

2. Select 20 MHz Bandwidth, and notice the BWL symbol displayed in the upper line of readout. Press the 50 MHz menu entry, then the FULL choice and see the change in the displayed BWL symbol.

NOTE

The supplemental information displayed with the BANDWIDTH menu is an indication of the usable storage bandwidth (USB) and the usable storage rise time (USR) for the present SEC/DIV setting. These two pieces of information provide the user with the upper frequency limit and fastest rise time of a signal from which good waveform data may be acquired at any chosen SEC/DIV setting for the acquisition mode in effect.

3. Set the BANDWIDTH to FULL.

Using the Dual-Channel Displays

1. Press Vertical MODE and select ADD (three traces 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; then 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 have a positioning effect on the ADD trace.

4. Press the ACQUIRE button to restart the waveform acquisitions.

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

6. 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).

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

8. Press the SAVE button, then press the SAVEREF menu choice. This menu choice 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.

9. Turn the ADD Vertical Mode OFF.

10. 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 has no positioning effect on the XY display, but it does move through which 512 data points of the 1024 data point record are being displayed.

11. Press the SAVE/RECALL SETUP button and recall setup 1. Display should revert to a single channel display of the CH 1 signal.

Demonstration of ENVELOPE and AVG (Average) Acquisition Modes

1. Press the ACQUIRE panel button; then press and release the ENVELOPE acquisition menu button until the numeric display above the ENVELOPE menu label is set at 1. This sets the number of waveforms that are included in the Envelope display to only one acquisition before it is reset to start a new acquisition.

2. Press the ENVELOPE menu button and release it 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 press the ACQUIRE panel button again to erase the continuous Envelope display and restart the acquisitions for a new Envelope waveform.

5. Select the 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. Observe the effect of a maximum average weighting factor of two on the displayed waveform.

6. Now press the AVG entry button to increment through the range from 2 to 256 one step at a time. Watch at each step and notice 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 C-4 in Appendix C for the expected improvement ratio as the number of averages increases. Return the number of Averages setting to 32.

7. 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.

Demonstrating SINGLE SEQ Trigger Mode

Single Sequence mode permits the user to select an acquisition process that, when completed, will not restart until directed to do so. At the completion of a SINGLE SEQ acquisition, the 2430 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 commencing another acquisition. For this demonstration, Average acquisition mode is used; Envelope acquisition mode works in a similar manner.

1. Set the A TRIGGER MODE to SINGLE SEQ.

2. Observe 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 32 averages has completed.

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

4. Store the CH 1 waveform in SAVEREF memory REF 3. You now have an averaged CH 1 signal waveform stored as reference for making comparison measurements.

USING THE CURSORS

VOLTS Cursor Functions

1. The display should remain as acquired by the preceding SINGLE SEQ procedure to start this demonstration.

2. Press the CURSOR FUNCTIONS button to display the cursor type choices and press VOLTS to make voltage measurements.

3. 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.

4. 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.

5. Press the SELECT button and see that the second cursor becomes the active one. Position it to the bottom of the waveform display.

6. Press the NEW REF menu entry. This saves the present VOLTS cursor difference as the reference level for making percentage and dB measurements.

7. Select the % units entry; the VOLTS cursor readout should now read 100%.

8. Move the active cursor up and down, observing the percentage change from the reference signal level. The readout indicates the percentage of difference between the present cursor positions and the reference cursor difference. A greater difference gives more than 100% and a lesser difference gives less than 100%. Now position the active cursor to regain a readout of 100%.

9. Press dB menu entry and NEW REF again. Observe the readout is 0 dB (no difference between the present cursor positions and the reference amplitude).

$$dB = 20 \log \frac{\text{Cursor difference voltage}}{\text{Reference voltage}}$$

10. Position the active cursor to produce a cursor difference of about 1 division less than the waveform peak-to-peak amplitude. Observe that the dB readout is negative (indicating that the cursor difference is less that the reference amplitude by the dB readout shown).

11. Now position the active cursor for a cursor difference of about 1 division more that the waveform perk-to-peak amplitude. The readout is now positive and indicates how much greater (in dB) the cursor difference is than the reference amplitude.

12. Select VOLTS units and switch Δ/ABS to the ABS cursor mode.

13. Position the VOLTS cursor to the ground indicator and observe that the readout is 0 volts when exactly aligned with ground.

14. Set the VOLTS cursor to the positive peak of the waveform to see that the readout is the positive voltage difference from the cursor position to the ground indicator.

15. Now set the VOLTS cursor to the negative peak of the waveform and see that the readout is negative; indicating that the cursor position is below ground.

16. Switch back to Δ mode cursors.

V@T Cursors

These coupled cursors (VOLTS cursors position coupled to the TIME cursors position on the waveform) provide voltage readout with VOLTS cursors that are confined to within the peak-to-peak amplitude points of the waveform. As with the VOLTS FUNCTION, the alternate units of measurement are % and dB.

1. Select V@T CURSOR FUNCTION and set the CURSOR UNITS to VOLTS in the Δ cursor mode.

2. Position the active cursor pair to place the TIME cursor at the peak amplitude of a positive peak of the CALIBRATOR signal. Observe that the VOLTS cursor does not leave the limits of the displayed waveform.

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

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

5. Press the NEW REF button, set the CURSOR UNITS to ABS mode, and select % units for the measurement.

6. Read the percentage of the peak amplitude from the ground marker as compared with respect to the 100% level set in Step 5.

7. 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 non-symmetry of the CALIBRATOR square wave. (The difference is typically very 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 additional 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 time, therefore the Δ/ABS choice is omitted from the SLOPE UNITS menu.

The CALIBRATOR signal is a poor signal source to display SLOPE measurement with unless the SAVE horizontal expansion feature 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 "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. Press SAVE and 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 vertical cursor with the most dots) to one of the rising edges of the displayed CALIBRATOR square-wave signal.

4. Press SELECT to activate the second 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 any place 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. Notice that the time readout is negative when the TIME cursor is positioned before the trigger point and positive when positioned to the right.

1/TIME Cursors

These cursors provide for convenient measurement of 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 frequency (in percent) a signal is 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 1.

2. Select 1/TIME cursors from the CURSOR FUNCTION menu and set the CURSOR UNITS to Hz.

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

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

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

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

7. Switch units of Hz and read the frequency (500 Hz × 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 Display. Using Δ TIME delay mode, precise timing measurements may 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 sets the delay time for a visible intensified zone on the A waveform record.

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

2. Press the DELAY by TIME button and hold the Cursor/Delay control knob 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 bring the intensified zone on the display.

9. Position one of the rising waveform edges in the middle of the intensified zone.

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

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

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

13. 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.

14. Turn Δ TIME delay mode on and select A INTEN Horizontal MODE again.

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

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 align the two leading edges. The Δ DELAY TIME readout is the period of the CALIBRATOR square wave.

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 (131.07 ms). At 50 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 20 μs. Observe that the DELAY TIME readout is reduced to the maximum delay time possible for 20 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 the user 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

This delay feature permits the user to 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 1. The initial setup conditions saved for the B trigger are: CPLG—AC; SOURCE—CH 1; MODE—RUNS AFTER. Verify the trigger conditions by pressing 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 increases the CALIBRATOR signal frequency so that the wait for events is not excessive 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 ends from minimum to maximum or maximum to minimum if the control knob is held in the rate region for a moment after the end has been reached.

6. Increase the EVENTS COUNT number up to the maximum (65,536) and observe that the update rate of the displayed waveform decreases as the number get higher. A new waveform is acquired only after the set number of B trigger events has been counted.

7. Wrap the EVENTS COUNT number back to 1. The new setting will not take effect until the last number of events has been counted, and the display has been updated.

8. Adjust the B Trigger LEVEL to a point that the waveform stops updating.

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

10. Reset the B trigger level to start acquiring again and press STATUS to rewrite the status display.

11. Observe that the trigger message has changed to "COMPLETING ACQUISITION."

This ends the Operators Familiarization procedures. A majority of the controls have 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 3 of this manual gives more details on the way in which each control functions, and the "Basic Applications" procedures in Section 6 give more detail about making actual measurement. 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.

OPERATOR'S 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 the scope of these operator's checks and adjustments, refer the scope to a qualified service person.

For new equipment checks, before proceeding with these instructions, refer to "Preparation for Use," Section 2 of this manual, to prepare the instrument for the initial start up before applying power.

Verify that the POWER switch is OFF (out position without a visible green indicator in the button), then plug the power cord into an appropriate ac-power-source outlet suppling 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 4, "Operator's Familiarization" before commencing 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.

INITIAL SETUP

1. Press in 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 SAVE/RECALL SETUP button when the "RUNNING SELF TEST" message is cleared from the display.

3. Press the INIT PANEL menu selection button. This sets up the front-panel controls in predefined states. In general, it 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 C-16 of Appendix C for the user's reference.

4. Perform the SELF CAL procedure. (A demonstration procedure of SELF CAL is given in "Operator's Familiarization," Section 4, and a detailed description of the built-in calibration and diagnostics is given in Appendix B of this manual.)

5. After SELF CAL is done, 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 to 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 not in good focus, adjust the FOCUS pot for the best focus over the entire graticule area.

NOTE

If the ASTIG adjustment is set properly already, 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).

HORIZONTAL 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 SAVE/RECALL SETUP 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 5-1). 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 CH 2 on in the display. Then, press the CH 1 menu button to turn that channel off.

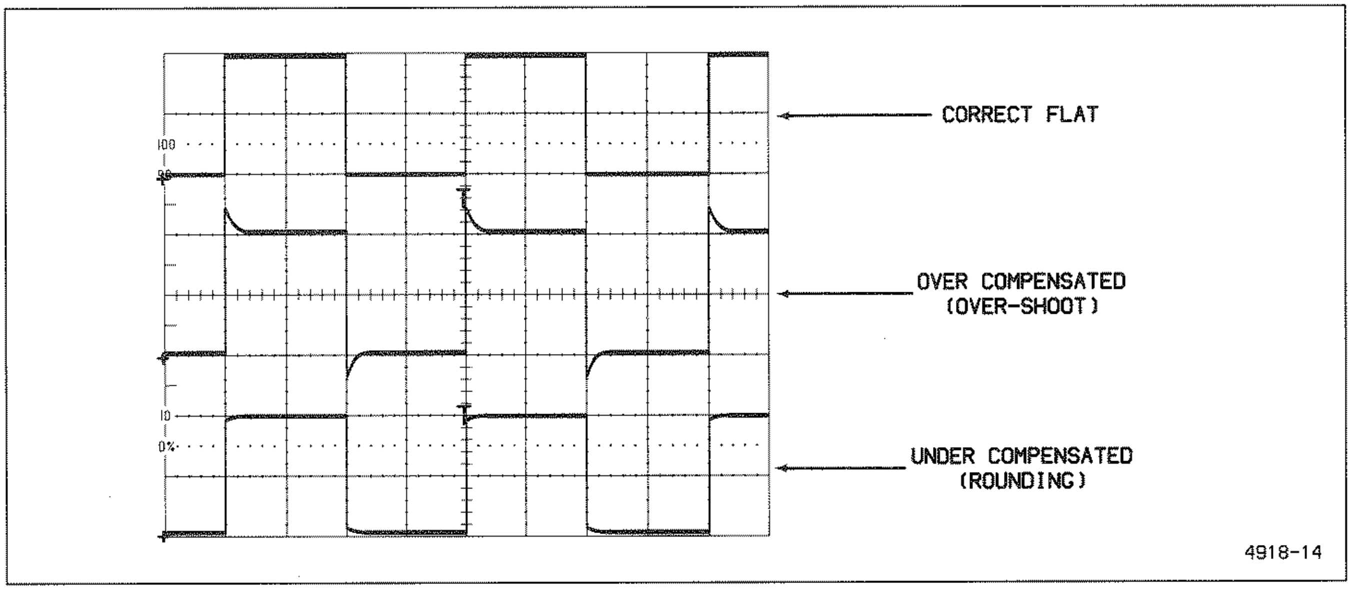


Figure 5-1. Probe low-frequency compensation.

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.

BASIC APPLICATIONS

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

This section is divided into three 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.

The procedures for the various applications assume operator 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 "Controls, Connectors, and Indicators," Section 3 of this manual. The "Operators Familiarization" information contained in Section 4 of this manual provides some additional assistance in becoming familiar with the operation of the 2430 for the first-time user.

GENERAL APPLICATIONS

The 2430 has two vertical 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:

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

Example calculation for the waveform pictured in Figure 6-1:

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

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.

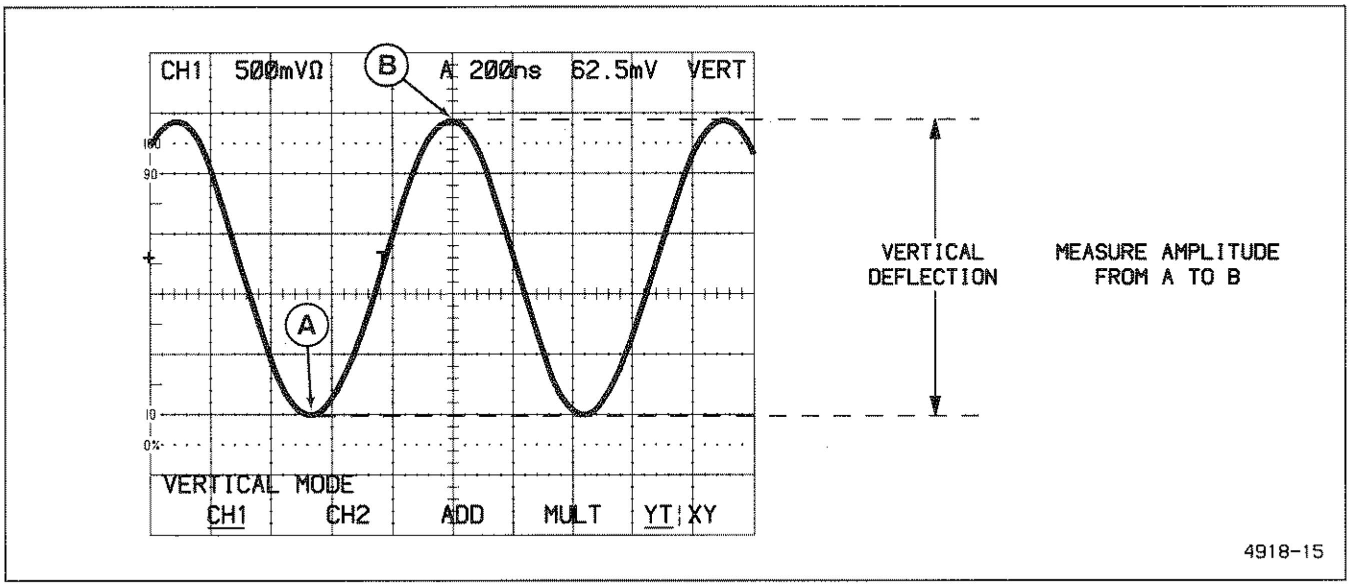


Figure 6-1. Sine wave peak-to-peak voltage.

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 both 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 6-2.

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

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

$$\text{Volts (DC Level)} = \begin{matrix}\text{Number of} \\ \text{Divisions}\end{matrix} \times \begin{matrix}\text{VOLTS/DIV} \\ \text{Setting}\end{matrix}$$

Multiply the result of 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 6-2:

$$\begin{matrix}\text{Volts} \\ \text{(DC Level)}\end{matrix} = 1.8\text{ div} \times 10\text{ mV/div} \times (-1) = -18\text{ mV}$$

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.

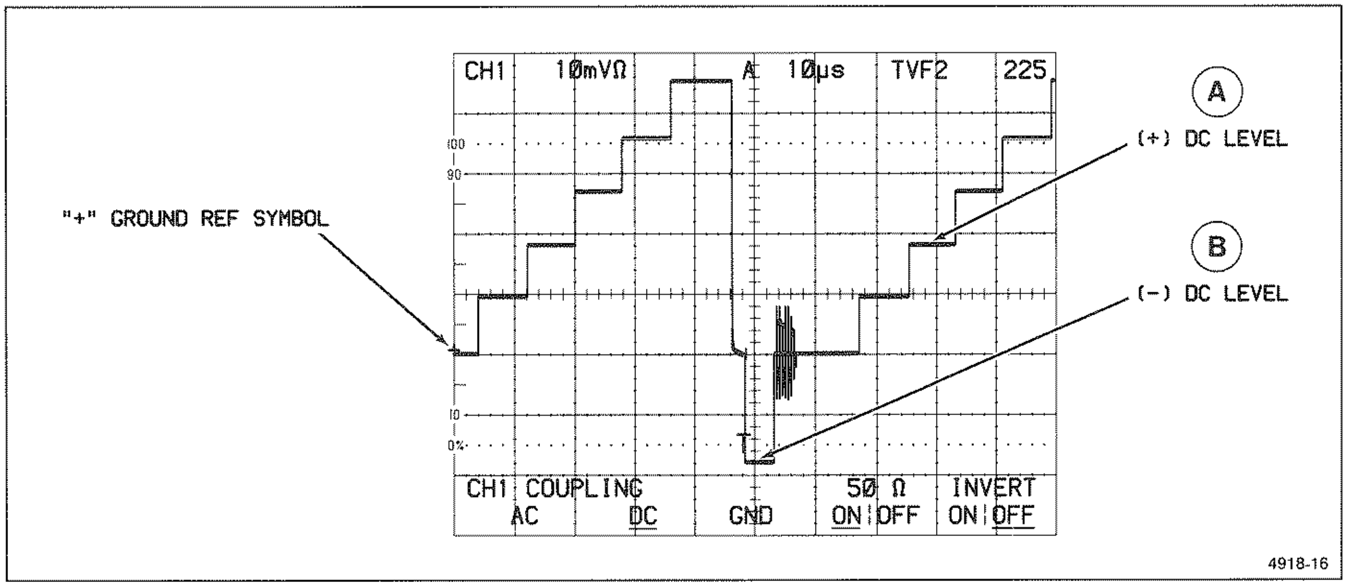


Figure 6-2. Instantaneous DC voltage levels on a waveform.

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 three 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 control to the setting that results in three 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 three 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 Cancelation

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 6-3 illustrates this method of noise reduction.

The second application referred to is unwanted signal cancelation. 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 6-4). 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.

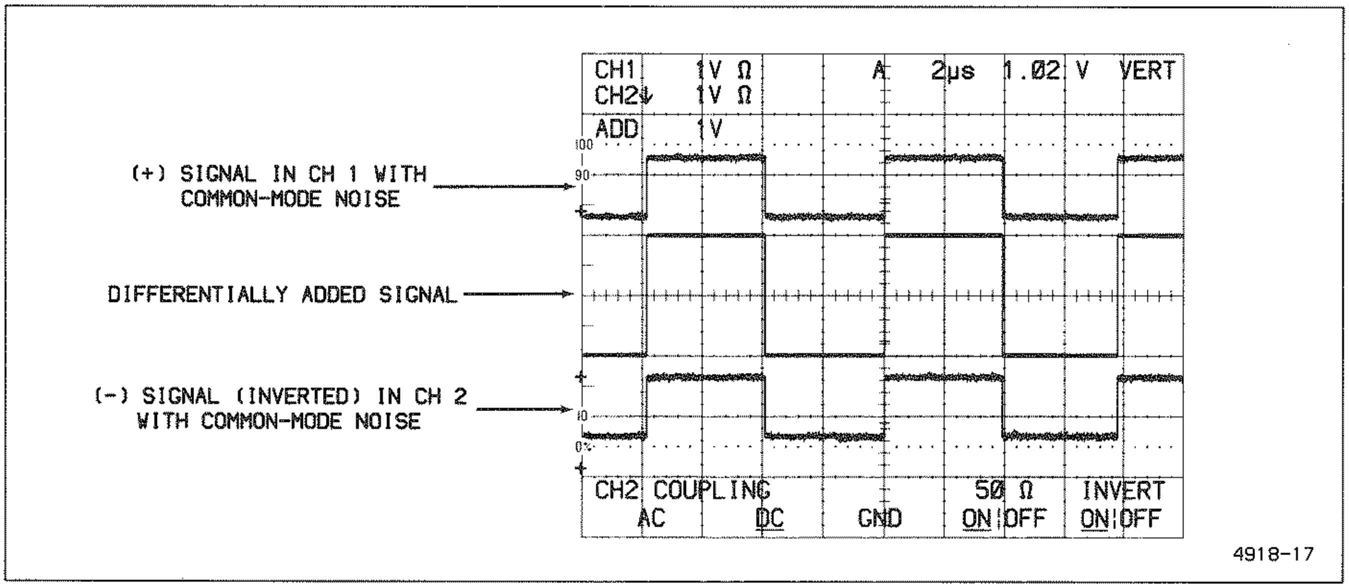
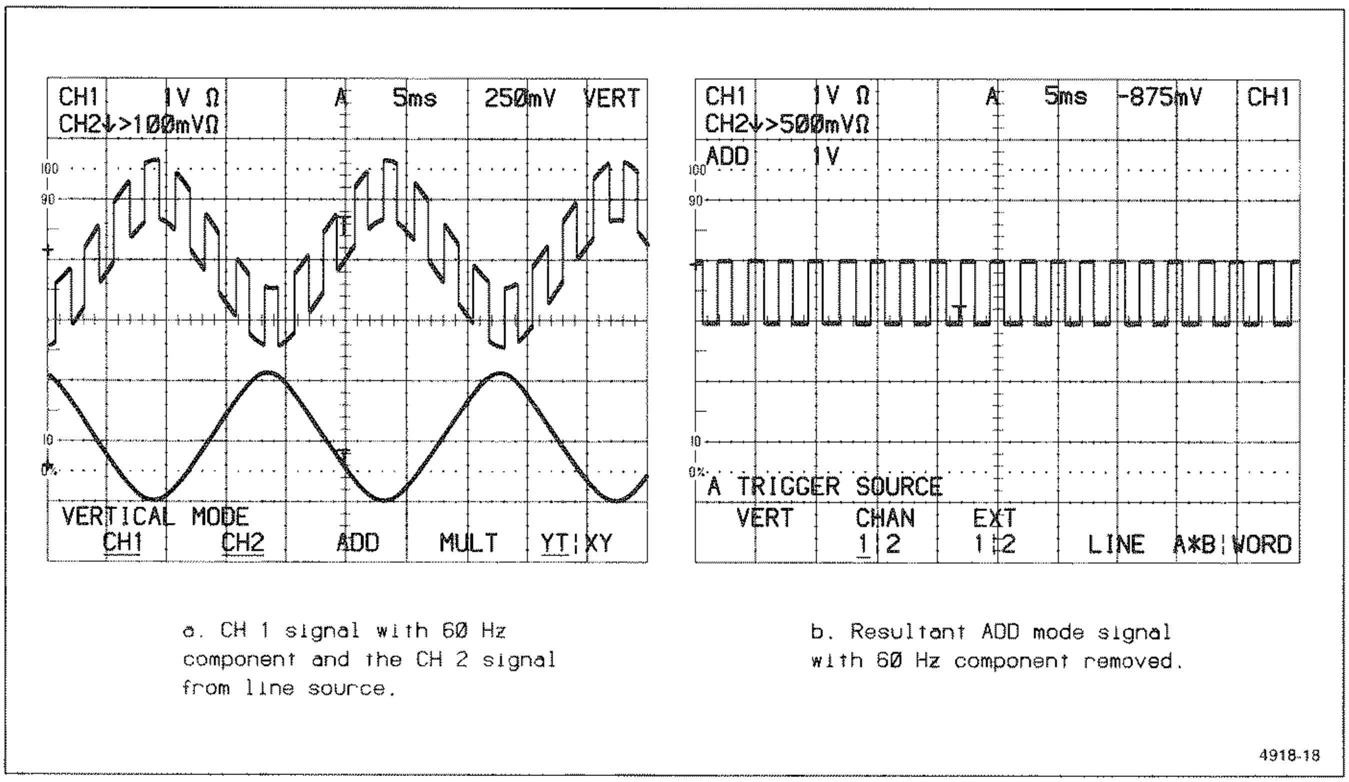


Figure 6-3. Cancelation of common-mode noise for differential signals.



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.

Figure 6-4 (a and b). Cancelation of an unwanted component in a signal.

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 display 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.

Note in the last procedure that 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 the CH 2 signal contributes to the ADD mode signal, but 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 be 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 6-4).

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 of 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 simultaneously with those two waveforms, 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:

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

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 they are displayed in) 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 the current amplifier requires to calibrate the 2430 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:

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

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:

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

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):

$$\text{Scale Factor (Power Waveforms)} = 0.1\text{ A/V} \times 102\text{ mV}^2\text{/div} = 10.2\text{ mW/div}$$

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, the cursor measurement values seen in the readout may be multiplied by the Scale Factor Multiplier obtained in Step 9 to obtain the acutal 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:

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

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

$$\text{Frequency (Hz)} = \frac{1}{\text{Time Duration}}$$

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 five divisions. Use the VARIABLE function to adjust the display for exactly five divisions.

3. Adjust the vertical positioning so 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 the 10% point on the waveform intersects a vertical graticule line near the left side of the screen (see point A of Figure 6-5).

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

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

EXAMPLE: Figure 6-5 gives the SEC/DIV control setting as 1 μs for the A time base. Counting the number of divisions between the 10% and 90% (marked as A and B in diagram) yields 2.2 divisions. Substituting into the formula:

$$\text{Rise Time} = \text{Time Duration} = 2.2\ \text{div} \times 5\ \mu\text{s/div} = 11\ \mu\text{s}$$

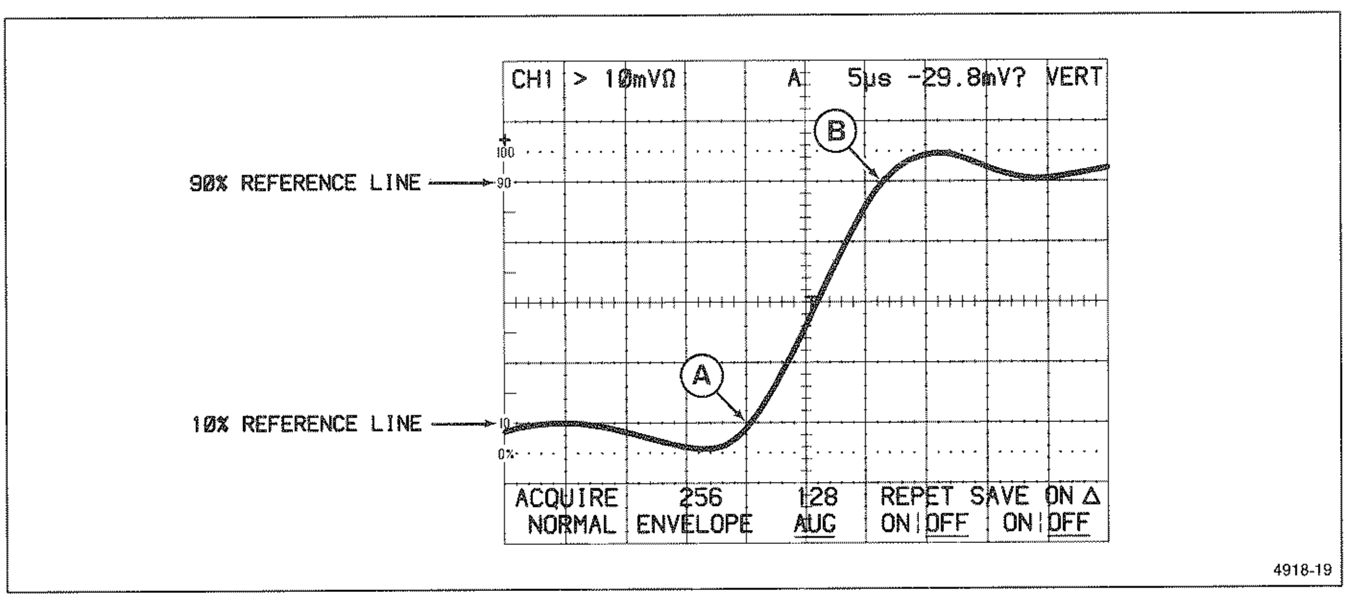


Figure 6-5. Rise time of a square wave (time duration).

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 for 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 the INTENS did not result in a visible intensified zone, pre-set the DELAY TIME setting 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 6-6a).

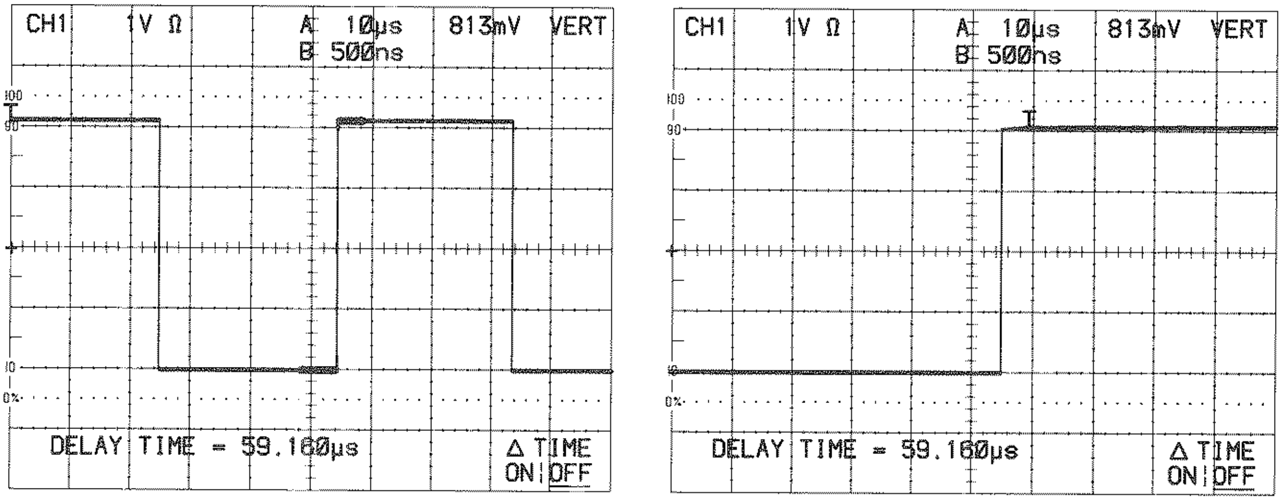
7. Change the HORIZONTAL MODE to B. The intensified portion of the display will be displayed at the SEC/DIV setting of the B time base (see Figure 6-6b).

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

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

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 6-6 (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.

The user is 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 the user 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. The operator 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 2430 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 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, adjusting the A SEC/DIV control (in Step 2) so both points to be measured are displayed (see Figure 6-7a).

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 6-7b.

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

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 6-1 and Figure 6-8 indicate where the main delay and Δ delay B acquisitions are obtained and displayed for the various VERTICAL MODE settings.

Table 6-1
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.

Delay By Events Measurements

The 2430 provides a third feature for delaying acquisitons—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.

The user sets 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.

The user also sets 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.

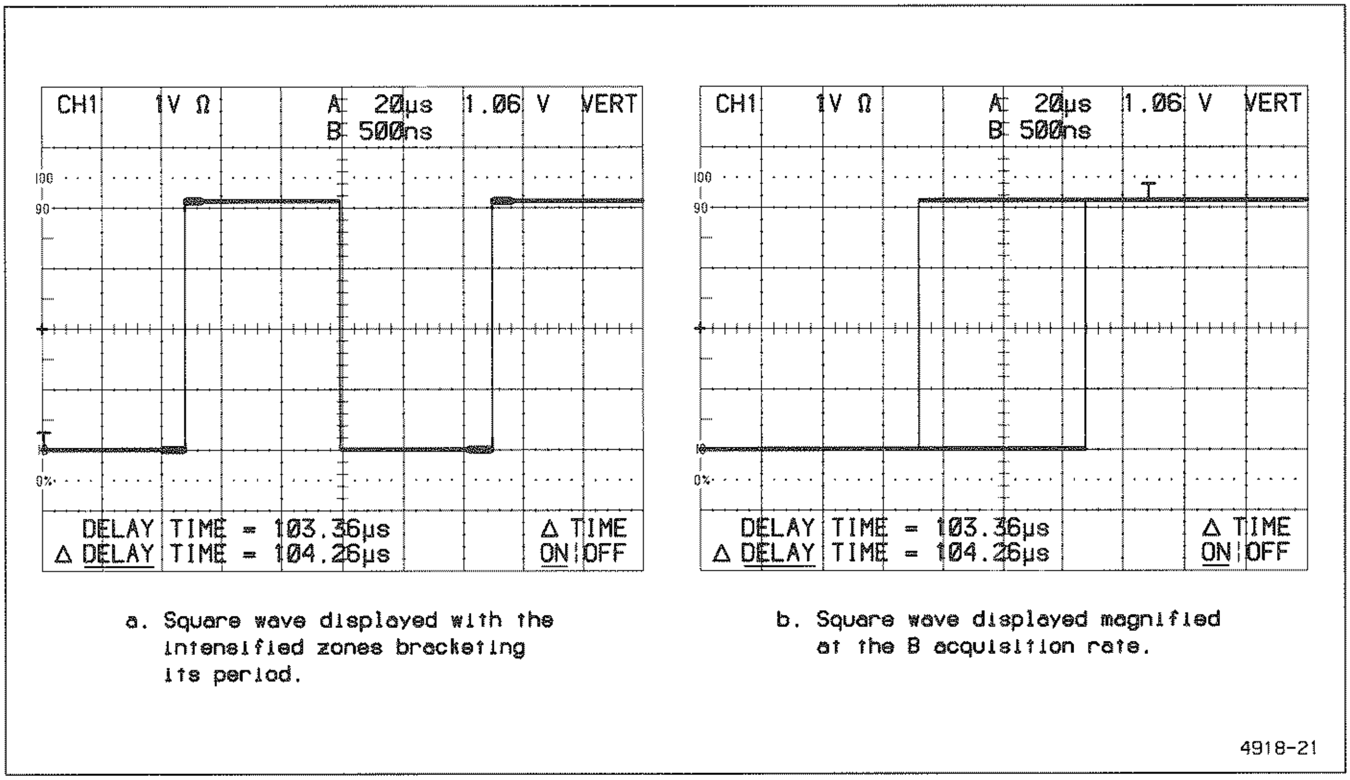


Figure 6-7 (a and b). Δ DELAY TIME used to measure the period of a square wave.

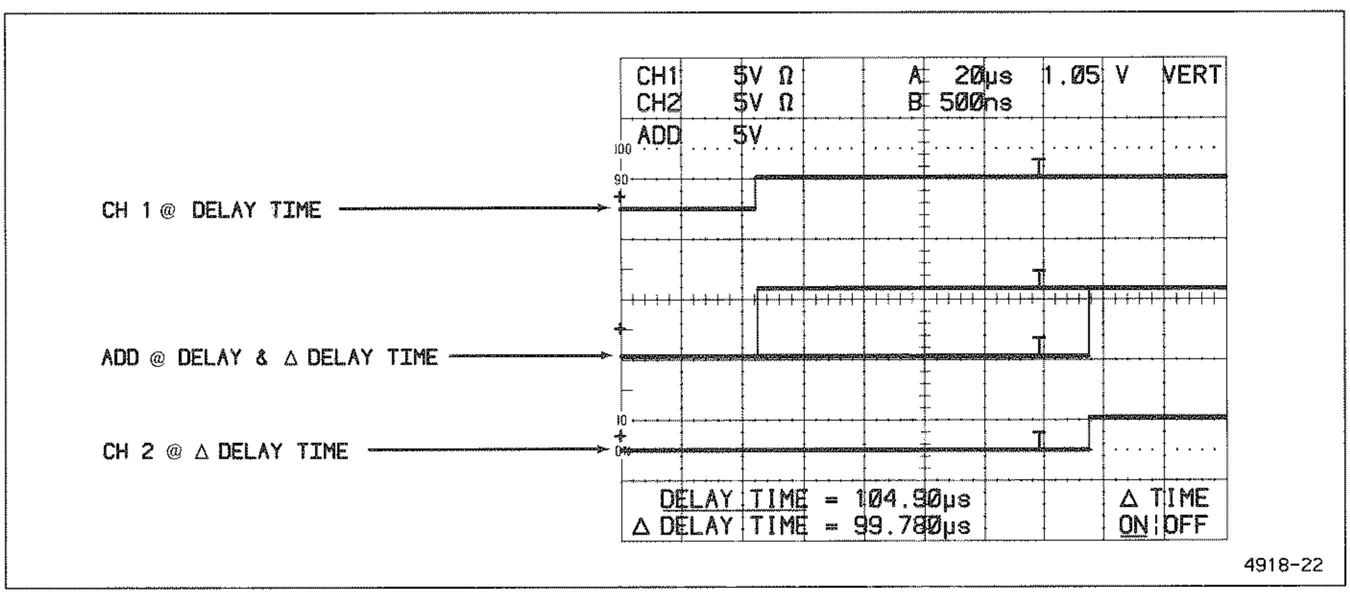


Figure 6-8. Delay and Δ Delay acquisitions as displayed for CH1, CH2, and ADD (or MULT) VERTICAL MODE.

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 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. Increasing the B SEC/DIV setting to acquisition rates which have maximum delays less than the delays set at a lower rate, will cause the delay setting(s) to be limited (change). It will 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 2641.4 × 10 μs = 26.414 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 2641.4 × 5 μs = 13.212 ms. The event is no longer displayed; return the B SEC/DIV to 10 μs and set the DELAY TIME back to 26.414 ms to see the event.

SPECIAL APPLICATIONS

CURSOR MEASUREMENTS

The CURSOR FUNCTION for the 2430 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. They are also quicker to use than interpolating for 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 measurements—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. Usage 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 6-9):

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.

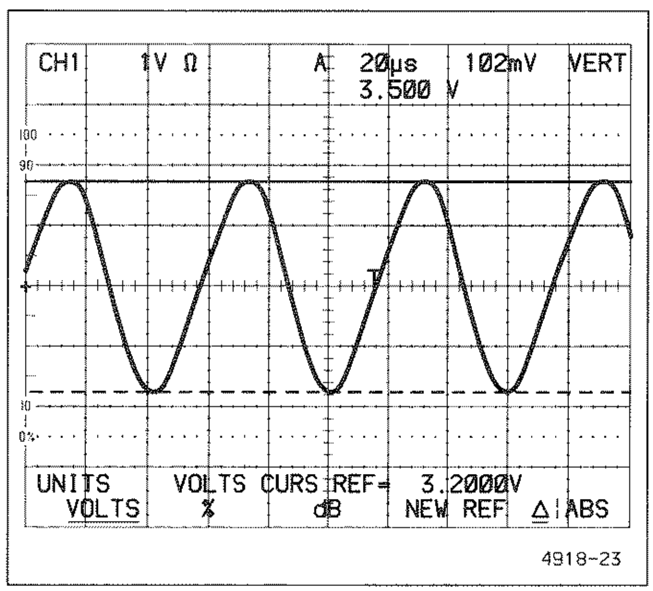


Figure 6-9. Measuring a 3.5 V sine-wave signal using VOLTS cursors.

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.

Ratio Between Two Voltages

The special units will generally be used when making comparison (ratio) measurements 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 Measurements" to set up the cursor measurement and to align the cursors to the reference signal peaks (see Figure 6-10a). Attach the cursor to the channel in which the reference signal is displayed for Steps 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 6-10a.

4. Align the cursors to the peaks of the signal to be compared to the reference. See Figure 6-10b.

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 6-10b.

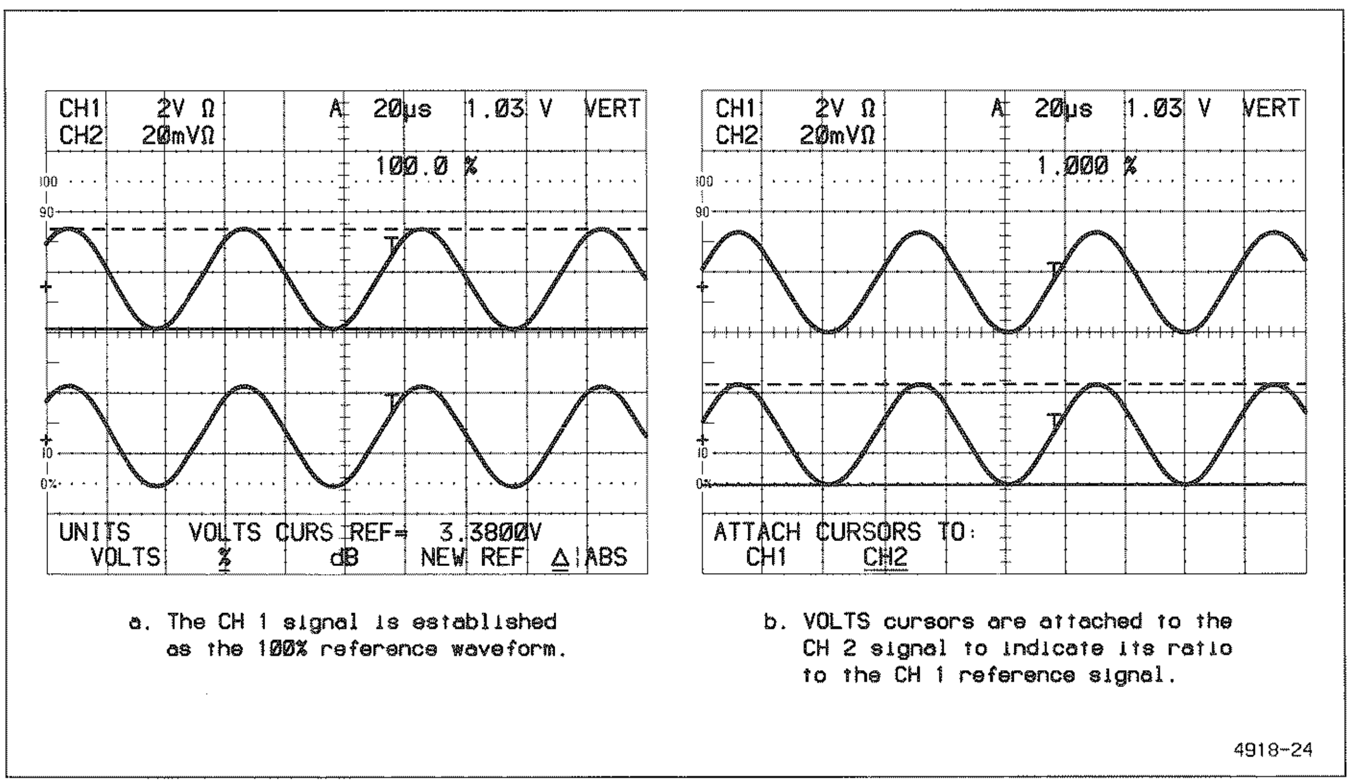


Figure 6-10 (a and b). Measuring the ratio between the amplitudes of two sine-wave signals.

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

Ratio 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 vs 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, attach 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. Press 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 6-11).

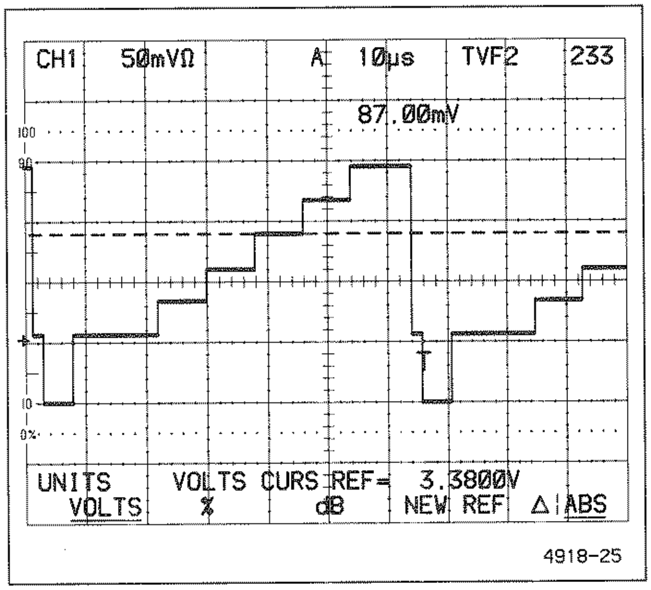


Figure 6-11. Voltage measurement of a step on a stair-case signal using the VOLTS cursor function in the ABS mode.

Ratio measurements can be made by similar methods to those outlined in the "Delta Voltage Measurement" procedure 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 decibel is the special unit used, the readout will indicate the number of decibels the noise level (with respect to ground) is below the pulse level (again, with respect to ground). Generally, apply the method outlined for performing ratio 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, increased accuracy for time measurements is obtained by using cursors. The accuracy of the time cursors is determined by an internal crystal-controlled clock circuit and is specified as 0.01% over two divisions. Since 0.01% of two divisions is less than one-thousandth of one 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; while for the ABS cursor 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 waveform 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 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 6-12a.

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 6-12a) the readout now indicates the frequency in Hz.

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 in the measurement of the duty cycle of a periodic rectangular pulse.

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

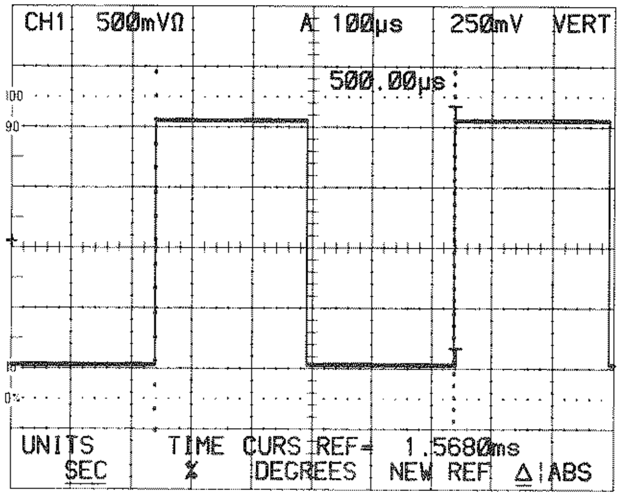
2. Set the SEC/DIV to display one or two cycles of the pulse.

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 6-12a).

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 6-12b).



a. Measurement of the period of a square wave.

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

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Figure 6-12 (a and b). Time measurements using TIME Cursor function and modes.

7. Read the ratio of the presently bracketed time period to the time period established as a reference in Step 5. For Figure 6-12b 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 ratio 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 either with 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 the SEC/DIV control allows.

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 setting 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 ΔV/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 is desired to be measured. Adjust the SEC/DIV as required.

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

4. Read the time difference between the cursor-aligned point and the Record Trigger point directly from the cursor readout (see Figure 6-13).

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.

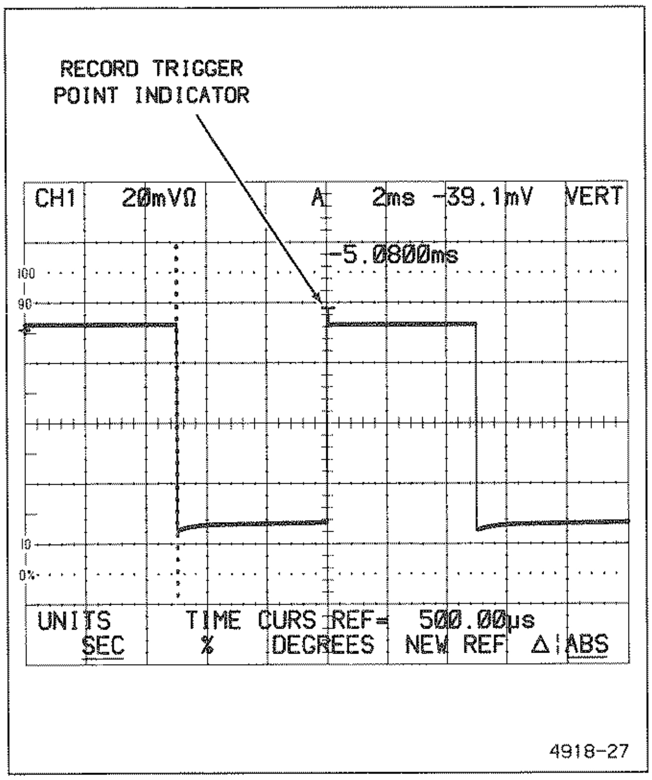


Figure 6-13. Time measurement of an event relative to when the record trigger occurred.

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 6-14 the first TIME cursor has been aligned to a time coincident with the peak of the displayed triangle wave. The VOLTS cursor coupled to that TIME cursor is also aligned to that peak. The second TIME cursor is set to a time where the amplitude is half way 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 was 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:

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

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

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

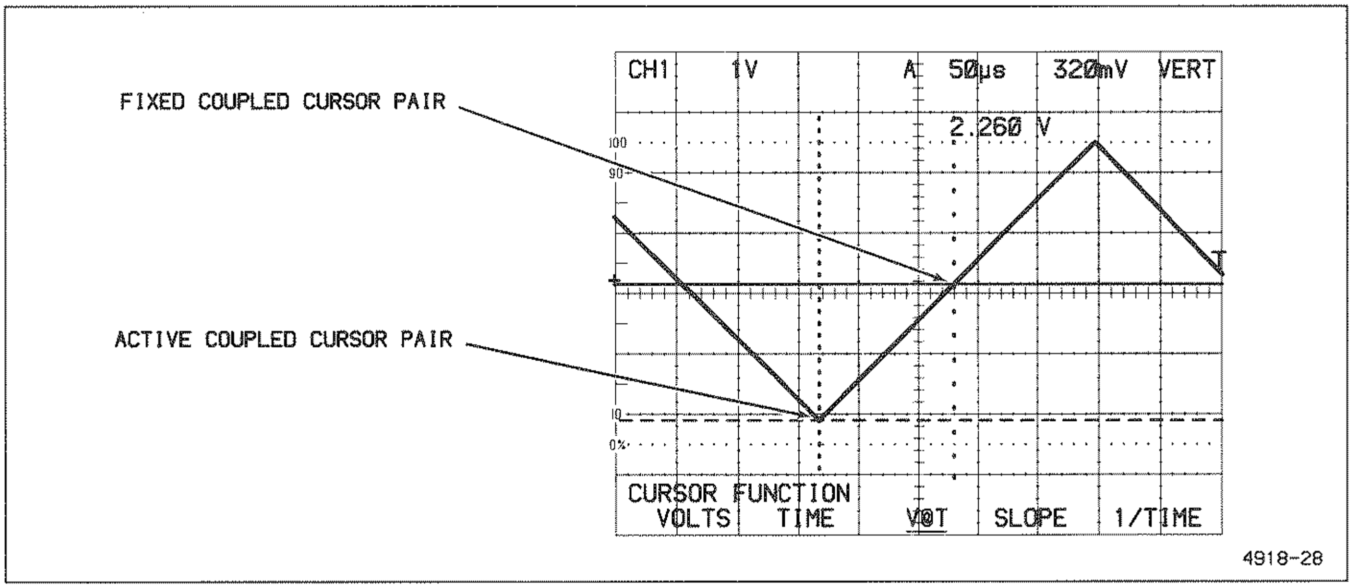


Figure 6-14. VOLTS coupled to TIME cursors displayed on a triangle wave.

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 difference 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 6-15 (a and b) for examples of V@T measurements for both the ABS and Δ cursor modes.

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 accuracy of such measurements is the uncertainty of cursor placement. Step 3 in the following procedure aids the user in 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 6-16a.

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 6-16b.

Slope Measurements

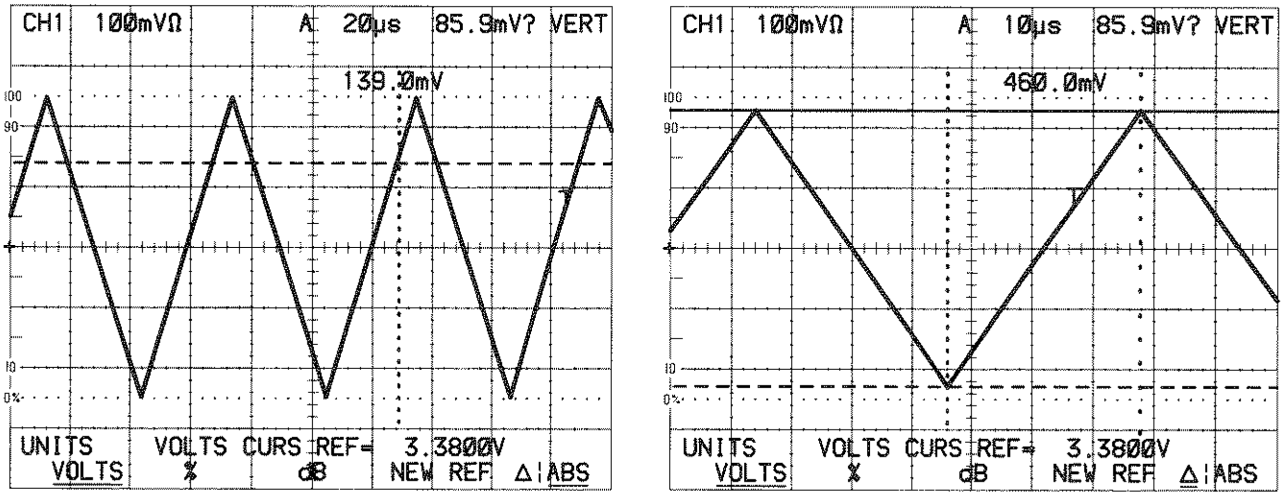
Use the following procedure to measure the average slope of a displayed waveform. The portion of the waveform to be measured is defined by the SLOPE cursors.

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 6-17).



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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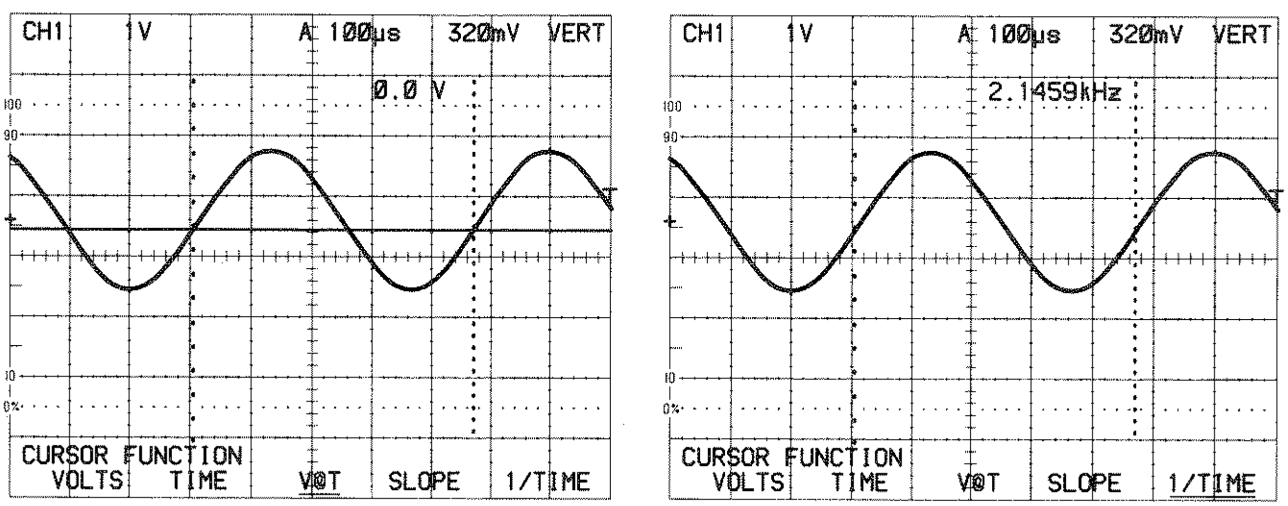
Figure 6-15 (a and b). V@T measurements on triangle-wave signals.



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.

4918-30

Figure 6-16 (a and b). High resolution measurement of the frequency of a sine-wave signal.

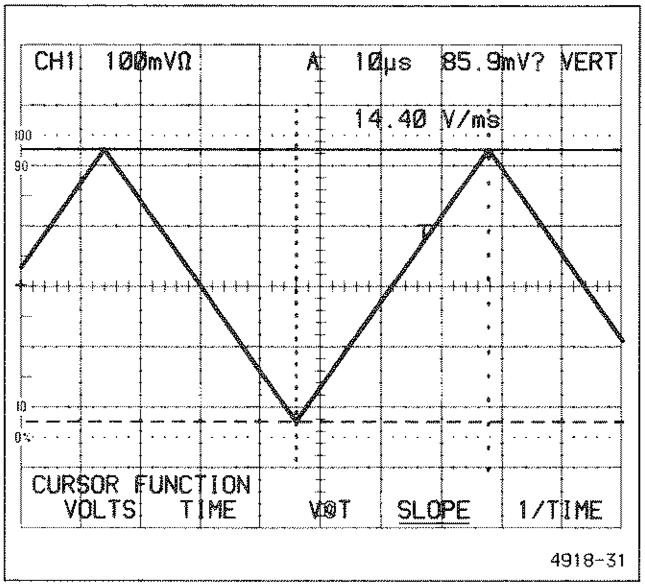


Figure 6-17. Slope measurement on a triangle-waveform.

Special Units for Coupled Cursors

The special units for both types of coupled cursors are percentage and decibels. References can be established and comparison 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 Function Application

The 2430 provides a composite trigger function which allows the use of a combination of two different sources for triggering acquisitions. With the A TRIGGER SOURCE menu set to A*B on, the user can select a trigger source for 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 combines the two sources in a logical AND manner. In other words, the triggering conditions set up by the user (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 the user wants 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 $\overline{CS}$ (Chip Select) and $\overline{WE}$ (Write Enable) inputs to write data to a particular RAM IC. With the $\overline{WR}$ pin held at the logic low state, a WRITE data function will occur when the $\overline{CS}$ pin transitions to the low state. If a sample of each signal is applied to the 2430 inputs and one source is selected for the A TRIGGER SOURCE and the other is selected for the B TRIGGER SOURCE, the user can set the controls of each trigger system (LEVEL, SLOPE to detect whenever the conditions necessary for a WRITE occur for the particular pin the trigger system is monitoring. The user 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 a 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 2430 is 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 and applications on 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

The 2430 Digital Oscilloscope 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. The "Operators Familiarization" section of this manual details the control setup required to make NORMAL mode acquisitions. This mode should be used 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, the user may change how much the signal-to-noise ratio is improved over a NORMAL signal acquisition. Table 6-2 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 6-2.

Table 6-2
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 with the 2430.

1. When certain controls or menu selections are changed, a new series of acquisitions begins for the signal averaging sequence. If the user specified number of acquisitions is not acquired before one of the listed controls is changed, the 2430 will quit averaging that series of acquisitions and begin 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.

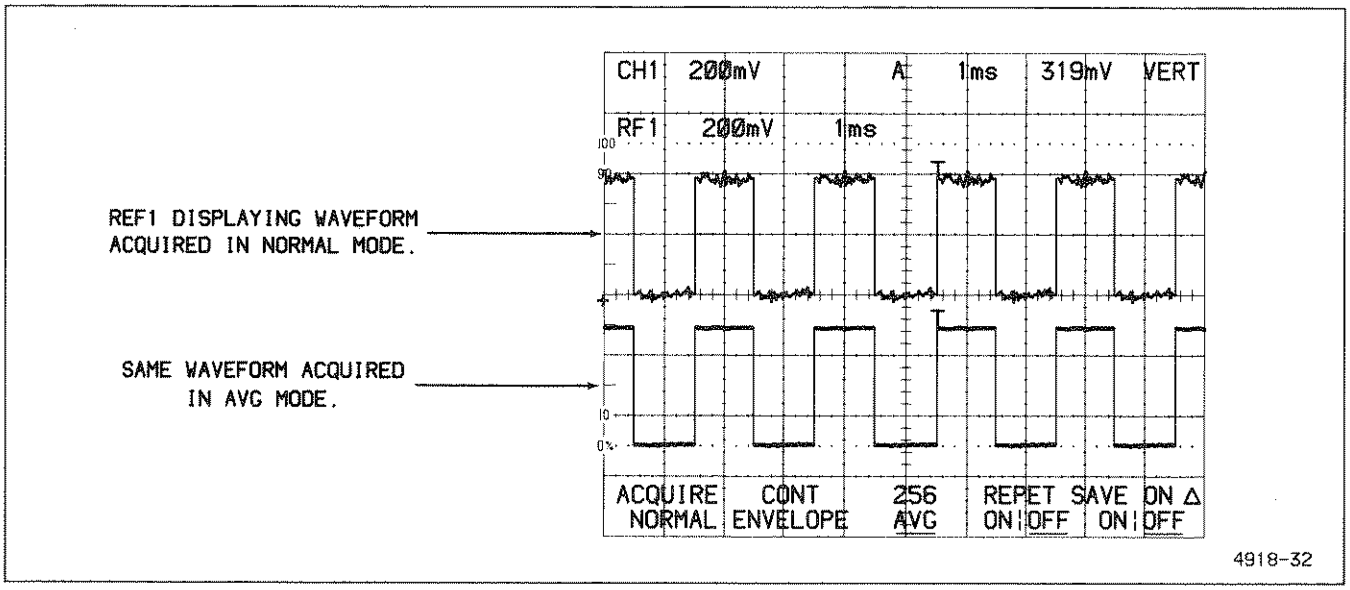


Figure 6-18. Effect of signal averaging on a noisy square wave.

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 the user has specified 256 acquisitions at a SEC/DIV setting of 5 s/div, the total time required to complete the averaging sequence is over 7 hours. The user must 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.

ENVELOPE Mode

The ENVELOPE acquisition mode is a repetitive process. The user specified number of acquisitions 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 the user is interested in, for example, a trigger-related amplitude change or switching transient, the envelope mode may be used to capture such an event. The operator 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 constant acquisitions being stored and displayed, the operator's constant attention is not required.

Several factors should be considered when using ENVELOPE mode for signal acquisitions.

1. The user 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 user specified number of acquisitions are not acquired before one of the affecting controls are changed, the 2430 will quit displaying the envelope waveform it has acquired, discarding the stored minimum and maximum values, and begin 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 that 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 many user specified acquisitions per envelope sequence are specified. Using NORMAL, the user avoids capturing the minimum and maximum data points caused by manipulation of the front panel controls.

ROLL Mode

ROLL mode allows the user to continuously view a slowly changing signal. When in ROLL mode, the 2430 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" towards 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.

The operator may use ROLL mode when it is desired to view the slowly changing signal in a continuous fashion. When ROLL mode is not used, the 2430 must be triggered on an appropriate event relative to the events which the operator wishes 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, the user may not know the trigger parameters required for the events to be viewed. Since ROLL mode is an untriggered mode, with acquisitions displayed continuously as described above, the user can view, as well as save on screen or REF memories, the events of interest.

Consider the following factors when using the 2430 in ROLL mode.

1. To enter ROLL mode the 2430 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 2430 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 2430 will begin making triggered acquisitions.

4. The 2430 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 the operator 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 the operator changes 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 allow the user to extend the usable vertical bandwidth for displaying high frequency-waveforms. The maximum sample rate of the 2430 (100 megasample per second) limits the bandwidth to 40 MHz for waveforms acquired during a single acquisition. For acquisition rates faster than 500 ns per division, the 2430 must interpolate between sampling points when not in REPET mode. For periodic, repetitive waveforms, REPET mode will equivalent-time sample 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 (100 MHz at 2 mV VOLTS/DIV setting).

REPET mode is available for use 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 2430 will automatically equivalent-time sample at SEC/DIV settings of 200 ns and faster.

SAVE Storage Mode

Any display acquired, regardless of which of the various acquisition modes was used, can be saved on screen. When the STORAGE SAVE button is pushed, the 2430 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 ten-times vertical expansion, as well as expanded up to six SEC/DIV setting for one-hundred times 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 VERTICAL MODE(s) desired.

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 signal 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 6-3.

Table 6-3
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 Cancelation" 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 6-4.

Table 6-4
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, the user should leave the HORIZONTAL MODE set to the same setting that was 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 user-specified acquisitions occurred before the sequence was stopped and saved. The menu is important because it allows the user to store away the saved waveform(s) as a reference(s).

SAVEREF SOURCE and DISPLAY REF

The SAVEREF SOURCE menu allows the user to 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 at the time 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 sub-menu 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 C-14 in Appendix C 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 C-14; 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 is 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. 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" and/or SAVE waveform(s) as before.

Several factors should be considered when storing and displaying SAVE waveforms with the 2430.

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. Re-positioning the waveforms so that their Trigger Point Indicators ("T") are aligned will restore the phase relationship.

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 2430 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), the user can create a 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 2430 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 C-15 in Appendix C 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 is dependent on the equipment used to generate the waveform and control the GPIB interface of the 2430; however, a general outline of a procedure is given in "USING THE GPIB" following "FROM THE FRONT PANEL." Table A-11 of Appendix A of this manual gives the various commands the 2430 uses in waveform transfer. Using Appendix A, 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 comparision envelope by positioning a baseline trace to the positive and negative limits desired. For example, positioning the baseline trace two divisions above, and then two 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 2430 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 displayed. The 2430 is left in B Horizontal Mode for acquiring the live waveforms and making the SAVE ON Δ comparison (see Figure 6-19).

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%. The user should use this procedure as a guide for developing his 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 1/2 division to the left of the waveform.

10. Vertically position the square wave up 1/4 division, then down 1/4 to begin creating the ±1/4 (0.5 V) division vertical envelope.

11. Rotate the Cursor/Delay control knob counter-clockwise until the readout indicates 0.1000 ms less than the value note in Step 8. Note that the envelope increases 1/2 division to the right of the waveform.

12. Position the waveform up 1/2 division (it was left at the −1/4 position in Step 10) to complete the envelope waveform (see Figure 6-19a).

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 C-15 in Appendix C 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 2430 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 2430 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.

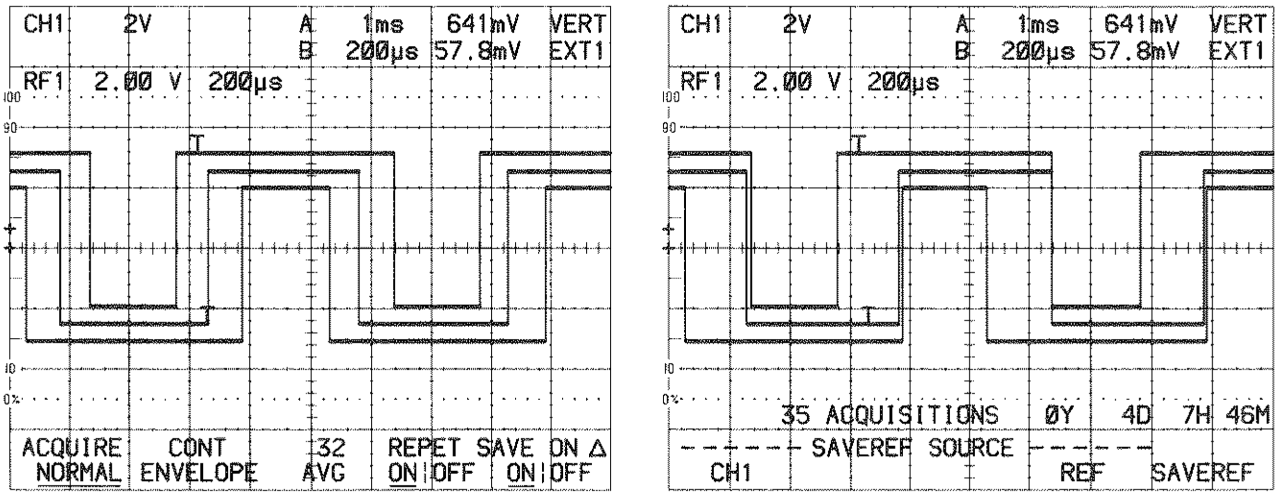
4. Adjust any of the 512 envelope data point MAX-MIN pairs stored in the waveform data array as necessary to create the comparison limits wanted. Fast rising edges need some horizontal width to widen the envelope for jitter. How this is done depends on what you want your comparison envelope to look like, 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 2430 expects waveform data to be sent in two's-complement format (RIBINary).

6. Set DATa TARget for the reference memory to be stored into. Remember that waveforms are compared against designated reference memories. See Table C-15 in Appendix C 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 2430 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 6-19 (a and b). Using the SAVEREF function with ENVELOPE mode to monitor and save a square wave.

OPTIONS AND ACCESSORIES

OPTIONS DESCRIPTION

This section contains a general description of available options for the 2430 Digital Storage Oscilloscope at time of manual publication. The options are:

Options A1-A5	International Power Cords
Option 1R	Rackmounting
Option 05	Video Option
Option 11	Probe Power

Operating instructions for the Video Option and the Word Recognizer Probe 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 2430

When the 2430 Digital Oscilloscope 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 2430 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 2430. Using this rear-support kit enables the rackmounted instrument to meet all electrical and environmental specifications of the standard 2430.

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 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.

OPTIONAL WORD RECOGNIZER PROBE ACCESSORY

The Word Recognizer Probe optional accessory is used to obtain triggering on a selected parallel TTL data word. A word length of 16-bits plus a 17th qualifier bit is recognizable, (with each bit selectable as 0, 1, or X (don't care). Recognition may be either synchronous with an external clock signal (rising or falling edge) or asynchronous. All the required hardware and firmware for using the Word Recognizer Probe is included in the standard 2430 Digital Oscilloscope; it is only necessary to purchase the Word Recognizer Probe optional accessory. More specific information on the Word Recognizer Probe, including electrical specification, is provided in the Instruction Sheet supplied with the probe.

OPTION OPERATING INFORMATION

VIDEO OPTION

Introduction

The TEKTRONIX 2430 oscilloscope with the Video Trigger (Option 05) 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 Appendix A, Table A-3 (Trigger Commands).

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 2430, 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 1-4 of Section 1 in this manual. All other electrical, environmental, and mechanical characteristics remain as for the standard 2430.

General Operation

Selecting the TV menu choice from the A TRIGGER COUPLING (CPLG) control menu enables the sync separator circuitry of the Video Option. Pressing the front-panel button labeled SET TV 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 waveform. 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 to trigger on. 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 TV 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 TV front-panel button calls up the following menu (see Section 3, Item 38).

A TV 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 line-number setting reaches the maximum (or minimum) number of lines in a field with either FIELD1 or FIELD2 triggering selected, continued turning of the control in the same direction changes the line number to the beginning (or end) of the opposite field. In these cases, the underscored FIELD choice in the SET TV control menu and the field number (TVF1 or TVF2) readout preceding the line number readout also switch to reflect the correct field. If alternate (ALT) field triggering is selected, 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 (maximum line count common to both fields).

System-M/Nonsystem-M Protocol 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 3-1 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. Under TV SYS, the menu button toggles between M and NON-M, with the selected protocol underscored.

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

The 2430 instrument with the TV Option circuitry provides 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)	1/2
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 ccw 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 cw 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 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 2430 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).

OPTIONAL WORD RECOGNIZER PROBE ACCESSORY

The Word Recognizer Probe is used to obtain triggering on a selected parallel TTL data word. General operating information is given in the following text.

Electrical connection from the Word Recognizer Probe to the 2430 is made by means of the rear-panel connector labeled P6407 WORD RECOG INPUT. The instrument has one Word Recognizer Probe connector, but the trigger output from the probe may be selected as the source for the A Trigger signal or the B Trigger signal, or for both using the A an B TRIG SOURCE menus. The system identifies whether the WORD trigger is the selected trigger Source for A or B Trigger, or both, by displaying the appropriate letter(s) on the TRIG WORD menu title line (displayed when the SET WORD front-panel button is pressed).

Attempting to select WORD as a trigger source or program the probe operation without a Word Recognizer Probe connected will ring the warning bell, and the error message "WORD PROBE FAULT" will be displayed. 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 2430 is acquiring. Disconnecting the probe will not be detected while the 2430 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 as 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.

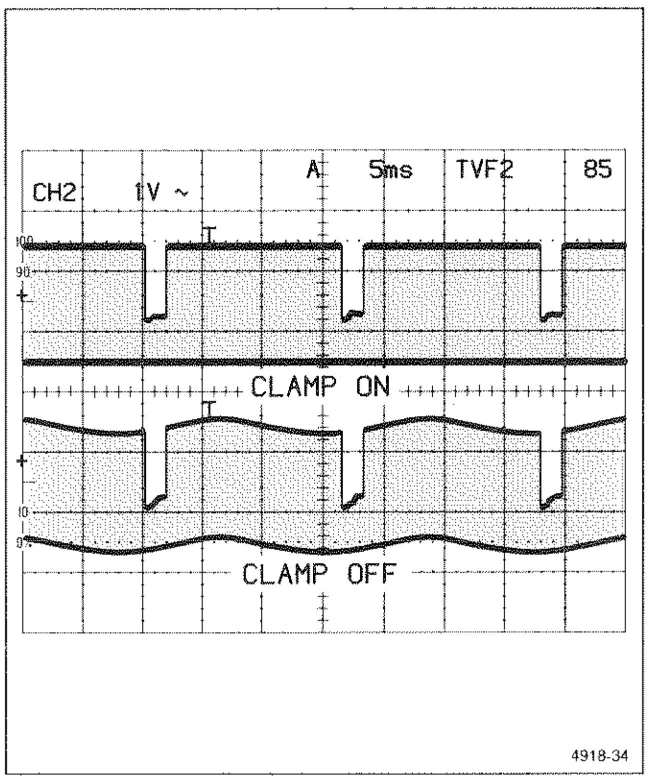


Figure 7-1. Composite Video Signal with and without TV clamping.

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 permits the user to display the selected word in either octal or hexadecimal. Under the CLOCK selection, a choice of rising-edge clock, falling-edge clock, and ASYNC (asynchronous) permits the selection of either clock edge or ignoring the clock for determining the time that 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 underscore 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.

ACCESSORIES

STANDARD ACCESSORIES

The following standard accessories are provided with each instrument.

	Part Number
2 Probes, 10X, 1.3 meter, with accessories	010-6131-01
1 Accessory pouch, snap	016-0692-00
1 Accessory pouch, ziploc	016-0537-00
1 Operators manual	070-4918-00
1 Instrument Interfacing guide	070-5705-00
1 User Reference guide	070-5497-00
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 configured as a 1R option.

	Part Number
Rackmounting conversion kit	016-0825-00
Rackmounting rear-support kit (included in conversion kit)	016-0096-00

OPTIONAL ACCESSORIES

The following optional accessories are recommended for use with the 2430 Digital Oscilloscope.

	Part Number
Service manual	070-4917-00
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

APPENDIX A

GPIB INTERFACE

Appendix A provides the 2430 GPIB communication protocol; including the definition and description of all commands, format and header structure, status bytes, and interface specifications.

The GPIB commands control the instrument operating mode, query the results of measurements made, query the state of the oscilloscope, and send or receive waveform data. Commands sent must have the proper syntax to be understood, but the format is flexible in that many abbreviated variations are acceptable as long as they are unambiguous.

COMMAND FORMAT

The 2430 commands follow the conventions established in the Tektronix GPIB Codes and Format Standards. Commands are specified in mnemonics similar to the name of the front-panel control that performs the identical function as the command. That likeness, plus the standard syntax of the commands, makes their use much easier in writing system programs to control the 2430.

The special characters in the 2430 character set that are available to the programmer, for use in command strings and messages to be displayed, include underlined alphanumeric characters and scientific symbols. These special characters are accessed using a backslash ("\") before the ascii code character normally found in a standard ascii chart. Carriage returns, line feeds, and tabs may all be used as formatting characters to improve the readability of command sequences. Figure A-1 illustrates the complete 2430 character set.

COMMAND STRUCTURE

The 2430 command structure is formed from a header followed by a main argument and then link arguments to implement a command string.

Example:

CH1 COUPLING:AC

The Header is CH1, and COUPLING:AC is an argument list made up of the main argument "COUPLING" and the link argument "AC."

In the command description tables, A-2 through A-12, Headers, Arguments, and Link Arguments are listed in uppercase and lowercase character combinations. The instrument will accept any abbreviated Header or Argument which contains at least the characters indicated in uppercase. Lowercase command characters added for readability are normalized to uppercase by the 2430 before interpretation. However, any characters added to the uppercase short form must be those characters shown in lowercase.

For a "query," a question mark (?) must follow the Header. Any of these example query formats is acceptable:

Example:

VMO? VMOd? VMOde?

All commands may be queried to any argument level, except the lowest, by attaching a question mark (?) to the Header. An argument may be attached to a query for specifying at which level it should respond. However, if the complete command path is used down to the lowest argument, the query will be ignored and an error SRQ will be issued.

Examples of good queries:

CH1? COUpling
CURSOR? VPOS:ONE

Examples of bad queries:

VMOde? CH1:ON
ATRigger? SOUrce:CH1

B7 B6 B5 BITS / B4 B3 B2 B1	Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
	SPECIAL		NUMBERS SYMBOLS		UPPER CASE		UNDERLINED	
Ø Ø Ø Ø	0 \0 _ 0 0	20 \@ Ø̲ 10 16	40 SP 20 32	60 Ø 30 48	100 @ 40 64	120 P 50 80	140 \\` @̲ 60 96	160 \p P̲ 70 112
Ø Ø Ø 1	1 \1 ⨯ (crossed symbol) 1 1	21 \A 1̲ 11 17	41 \\! 2 21 33	61 1 31 49	101 A 41 65	121 Q 51 81	141 \a A̲ 61 97	161 \q Q̲ 71 113
Ø Ø 1 Ø	2 \2 ▯ 2 2	22 \B 2̲ 12 18	42 " 22 34	62 2 32 50	102 B 42 66	122 R 52 82	142 \b B̲ 62 98	162 \r R̲ 72 114
Ø Ø 1 1	3 \3 d̲ 3 3	23 \C 3̲ 13 19	43 \\# d 23 35	63 3 33 51	103 C 43 67	123 S 53 83	143 \c C̲ 63 99	163 \s S̲ 73 115
Ø 1 Ø Ø	4 \4 k 4 4	24 \D 4̲ 14 20	44 \\$ (blank) 24 36	64 4 34 52	104 D 44 68	124 T 54 84	144 \d D̲ 64 100	164 \t T̲ 74 116
Ø 1 Ø 1	5 \5 %̲ 5 5	25 \E 5̲ 15 21	45 % 25 37	65 5 35 53	105 E 45 69	125 U 55 85	145 \e E̲ 65 101	165 \u U̲ 75 117
Ø 1 1 Ø	6 \6 z̲ 6 6	26 \F 6̲ 16 22	46 \\& z 26 38	66 6 36 54	106 F 46 70	126 V 56 86	146 \f F̲ 66 102	166 \v V̲ 76 118
Ø 1 1 1	7 \7 s 7 7	27 \G 7̲ 17 23	47 ' 27 39	67 7 37 55	107 G 47 71	127 W 57 87	147 \g G̲ 67 103	167 \w W̲ 77 119
1 Ø Ø Ø	10 \8 Δ̲ 8 8	30 \H 8̲ 18 24	50 \\(Δ 28 40	70 8 38 56	110 H 48 72	130 X 58 88	150 \h H̲ 68 104	170 \x X̲ 78 120
1 Ø Ø 1	11 \9 ÷̲ 9 9	31 \I 9̲ 19 25	51 \\) ÷ 29 41	71 9 39 57	111 I 49 73	131 Y 59 89	151 \i I̲ 69 105	171 \y Y̲ 79 121
1 Ø 1 Ø	12 \\: *̲ A 10	32 \J Ω 1A 26	52 * 2A 42	72 : 3A 58	112 J 4A 74	132 Z 5A 90	152 \j J̲ 6A 106	172 \z Z̲ 7A 122
1 Ø 1 1	13 \\; m B 11	33 \K ⏚ 1B 27	53 + 2B 43	73 ; 3B 59	113 K 4B 75	133 \\[ʃ 5B 91	153 \k K̲ 6B 107	173 \\{ ʃ̲ 7B 123
1 1 Ø Ø	14 \\< μ C 12	34 \L B LW 1C 28	54 , 2C 44	74 < 3C 60	114 L 4C 76	134 \\\\ \\ 5C 92	154 \l L̲ 6C 108	174 \\\| | 7C 124
1 1 Ø 1	15 \\= n D 13	35 \M ° 1D 29	55 − 2D 45	75 = 3D 61	115 M 4D 77	135 \\] ʅ 5D 93	155 \m M̲ 6D 109	175 \\} ʅ̲ 7D 125
1 1 1 Ø	16 \\> p E 14	36 \N → 1E 30	56 . 2E 46	76 > 3E 62	116 N 4E 78	136 \\^ ↑ 5E 94	156 \n N̲ 6E 110	176 \\~ ~ 7E 126
1 1 1 1	17 \\? /̲ F 15	37 \O ← 1F 31	57 / 2F 47	77 ? 3F 63	117 O 4F 79	137 _ ↓ 5F 95	157 \o O̲ 6F 111	177 \DEL[a] H O 7F 127

[a] \DEL = \RUBOUT

KEY TO CHART

octal —	32 \J	— GPIB code
	Ω	— 2430 character
hex —	1A 26	— decimal

4918-35

Figure A-1. The 2430 character set codes.

Query only arguments need to be explicitly queried to receive the wanted information.

Example: ACQuire? by itself does not return the number of acquisitions made. The query command sent must be:

ACQuire? NUMACq

to receive the number of acquisitions.

HEADERS

A Header represents a major logical grouping of control functions used in the instrument, such as CH1, TRIGGER, and HORIZONTAL. All GPIB commands are composed of at least a Header that by itself may meet the requirements for a GPIB command to the 2430. An example of a command formed by a single Header is "MANtrig."

ARGUMENTS

Some commands require arguments with the Headers to describe the exact task to be performed. The Header must be followed by at least one space before the first argument.

Example:

BWLimit TWEnty
Header Argument

If a second argument is required, a colon must separate the two arguments.

Example:

CH1 VOLts : 10
ATRigger MODe : AUTOLEVEL

In Header with multiple arguments, the arguments must be separated by commas.

Example:

CH1 VOLts:10 , COUpling:DC , POSition:1.2
VMOde CH1:OFF , CH2:ON , ADD:ON

COMMAND SEPARATOR

If multiple commands are put in one message, each individual command must be separated with a semicolon.

Example:

CH1 VOLTS:10,COUPLING:DC,POSITION:1.2 ;
VMODE CH1:OFF,CH2:ON,ADD:ON

NUMERIC ARGUMENTS

Numeric arguments in the command set may contain both signed and unsigned numbers, with the unsigned value being interpreted as positive. Numbers returned as the result of a query will always be the form specified in the command. Table A-1 illustrates the number formats for numeric arguments in the GPIB command set.

Table A-1

Numeric Argument Format for Commands

Symbol of Numeric Argument	Number Format	Examples
<NR1>	Integers	+1, 2, −1, −10
<NR2>	Explicit Decimal Points	−3.2, +5.1, 1.2
<NR3>	Floating Point In Scientific Notation	+1.36E−2, 1E+2, 1E−2, 1.02E+3

NOTE

All scientific notation numbers having the exponential "E" must have a plus sign preceding the positive exponents, just as the minus sign must precede the negative exponents.

GPIB TABLES

Of the following tables, A-2 through A-14 describe all GPIB commands available for the 2430, including those relating to options. Table A-15 describes the GPIB interface specifications, Table A-16 defines the 2430 status bytes, and Table A-17 defines the Event Codes sent in answer to an EVEnt? query.

The first column lists the name (or header) of a command. The second column lists the arguments that can be associated with a command. The third column lists any further "link" arguments associated with the first argument. And finally, descriptions of each command and its arguments are contained in the last column.

The capitalized letters must always be present to identify the command, while those shown in lowercase are optional. The Command format is as follows:

COMMAND ARGUMENT:LINK1:LINK2

When making command queries, one or more arguments, separated by commas, may be given to request only the information wanted.

Example:

CH1? COUpling,VARiable

This query returns only the coupling and variable information about the CH1 setup.

Instrument commands, divided into functional groups, are presented in the following tables:

Table A-2

Vertical Commands

Header	Argument	Link Argument	Description
CH1 (or CH2)	VOLts	<NR3>	Sets the "screen" VOLTS/DIV in a 1-2-5 sequence to the value of the argument. The screen VOLTS/DIV takes attached probes into account. For example, sending a 50 V/div setting in over the bus while a 100X probe is attached will result in setting the actual hardware gain to 0.5 V/div. <NR3> will be rounded and limited to a legal hardware setting. If EXW is on and rounding or limiting occurs, a warning SRQ will be issued. Live expansion of non-Average waveforms is not allowed. A command to change to 1 mV, 500 μV and 200 μV will be rejected unless acquiring in Average mode. Also, if expanding in SAVE mode with VOLTS/DIV setting less than 2 mV, it will be reset to 2 mV when ACQUIRE is selected. Each of these events causes a warning SRQ to be issued if EXW is on.
	VARiable	<NR3>	<NR3> will range from 0 to 100 with a resolution of 0.125. Zero is fully calibrated and 100 is fully uncalibrated. <NR3> will be limited to legal values, and if EXW is on, a warning SRQ will be issued. This is not a calibrated feature and is meant to be used as a reference only.
	POSition	<NR3>	<NR3> ranges from −10 to +10 with a resolution of 0.01 and will set the position of ground (in divisions) with "0" being center screen. If <NR3> is limited to the valid range, and EXW is on, a warning SRQ will be issued.
	COUpling	AC DC GND	
	FIFty	[ON] OFF	An SRQ will be issued whenever a 50 Ω overload is detected if INR is on. If EXR is on, an error SRQ will be issued if an attempt is made to set the COUpling to FIFty with an overload still present. If coupling is AC and FIFty is turned on, COUpling will be set to DC. Similarly, if FIFty is on and COUpling is then set to AC, FIFty will be turned off.
	INVert	[ON] OFF	
PRObe?	CH1 CH2 EXT1 EXT2		Query only. Will return the probe value attached to the indicated input BNC connector. The values can be: 1, 10, 100, or 1000.
BWLimit	TWEnty FIFty FULl		

Table A-2 (cont)

Header	Argument	Link Argument	Description
VMOde	CH1	[ON] OFF	
	CH2	[ON] OFF	
	ADD	[ON] OFF	ADD and MULT are mutually exclusive. The selection of one causes the other to be turned off.
	MULt	[ON] OFF	
	DISplay	XY YT	

Examples:

CH1? VOLTS	→	CH1 VOLTS:5.0E−1;
CH1?	→	CH1 VOLTS:5.0E−1,VARIABLE:5.9E+1,POSITION:6.34, COUPLING:AC,FIFTY:OFF,INVERT:OFF;
VMODE?	→	VMODE CH1:ON,CH2:OFF,ADD:OFF,MULT:ON,DISPLAY:YT;
CH1? VOL	→	CH1 VOLTS:5.0E−3;
PRO?	→	PROBE CH1:1,CH2:10,EXT1:10,EXT2:1;

Table A-3

Trigger Commands

Header	Argument	Link Argument	Description
ATRigger	MODe	AUTOLevel	Sending an AUTOLevel command while AUTOLevel is selected forces a recalculation of the trigger level.
		AUTo	AUTO switches to ROLL at SEC/DIV settings of 100 ms and slower.
		NORmal SGLseq	A single sequence is started by issuing the RUN ACQUIRE command. An SRQ will be issued when the transition to SAVE is made if OPC is on. This is the way to do a hold next.
	SOUrce	CH1 CH2 LINe VERtical EXT1 EXT2	For any SOUrce selection, if LOGsrc is WORd, then LOGsrc is set to OFF, and a warning SRQ is issued if EXW is ON.
	LOGsrc	WORd A.B OFF	If WORD is selected and the word probe is not present, a warning SRQ will be issued if EXW is on, and LOGsrc will change to OFF. Likewise, if WORD is currently active and the probe is disconnected, the same SRQ will be issued and the source will change to VERT.
	COUpling	AC DC LFRej HFRej NOIserej TV	Choosing the TV selection turns on the Video Option using the coupling choices in the SETTv command. An SRQ is issued if the Video Option is not present and EXR is on. TV coupling and A.B/WORD logical sources are incompatible. Selecting TV coupling forces LOGsrc to OFF; selecting any LOGsrc argument forces COUpling to DC. If either is done, a warning SRQ will be issued if EXW is on.
	LEVel	<NR3>	Level is set in volts with no range limitations, but the actual effective level (which is based on the current trigger source) is limited to ±18 divisions in CH1 and CH2 and ±9 divisions otherwise. This allows the user to set, absolutely, the trigger level of interest and let the instrument determine what its hardware can supply at any given VOLTS/DIV setting. For purposes of LEVel, line SOUrce is considered to be 20 V per division.
	SLOpe	PLUs MINUs	

Table A-3 (cont)

Header	Argument	Link Argument	Description
ATRigger (cont)	POSition	<NR1>	Sets number of data points which will be acquired prior to the trigger with (1023−[NR1*32]) points acquired after the trigger. <NR1> can range from 1 to 31, with 1 meaning 32 pretrigger and 991 post-trigger points and 31 meaning 992 pretrigger and 31 post-trigger points. If necessary, <NR1> will be limited to the nearest legal setting and, if EXW is on, a warning SRQ will be issued.
	HOLdoff	<NR3>	<NR3> is settable with a resolution of 1/16 in the range 0 to 100, with 0 being the minimum holdoff (one screen) and 100 representing the maximum. Numbers outside these limits will be set equal to the value of the closest boundary and, if EXW is on, an SRQ will be issued. Holdoff will always change to the minimum value on an A SEC/DIV change.
	ABSElect	A B	Selects which trigger level the Trigger LEVEL pot controls. It also controls which trigger status is displayed on screen and on the front-panel Trigger Status indicators.
	MINImum		Query only. Returns the current minimum level of the A Trigger channel in volts. Data is only valid in AUTO LEVEL and immediately following completion of an auto-level cycle. An auto-level cycle is forced by sending in the command: ATRigger MODe:AUTOLevel while the mode is already AUTOLevel.
	MAXimum		Query only. Returns the current maximum level of the A Trigger channel in volts. Data is only valid in AUTO LEVEL and immediately following completion of an auto-level cycle.
	STATE		Query only. Shows the most "advanced" state the trigger system has reached since the last CLRstate command. These are the responses (in order of least to most advanced state): ARMED, READY, ATRIG, RTRIG, SAVE.
	CLRstate		Command only. Resets the trigger-state variable to "ARMed."

Examples:

ATR? → ATRIGGER MODE:AUTO,SOURCE:CH1,LOGSRC:WORD,COUPLING:AC,
LEVEL:2.06E+1,SLOPE:PLUS,POSITION:16,HOLDOFF:5.5E+1,ABSELECT:A;

ATRIG? MODE → ATR MOD:AUTOL;

ATR? HOL → ATRIGGER HOLDOFF:3.5E+1;

SETWORD? → SETWORD RADIX:HEX,CLOCK:ASYNC,WORD:#Y11000XX1100110011;

Table A-3 (cont)

Header	Argument	Link Argument	Description
BTRigger	MODe	RUNSAft TRIgaft	
	EXTCLk	[ON] OFF	
	SOUrce	CH1 CH2 WORd VERtical EXT1 EXT2	
	COUpling	AC DC LFRej HFRej NOIserej	
	LEVel	<NR3>	See ATRigger LEVel comments.
	SLOpe	PLUs MINUs	
	POSition	<NR1>	See ATRigger POSition comments.
SETTv	ICOupling	FLD1 FLD2 ALT TVLine	Shows the type of display when the video signal applied is an interlaced signal. If any SETTv selections are made and the Video option is not present, an SRQ will be issued, if EXR is on, and the command ignored.
	NICoupling	FLD1 TVLine	Shows the type of display when the video signal applied is a noninterlaced signal.
	INTERlaced		Query only. Returns "ON" if the Video Option detects that the applied video signal is interlaced and "OFF" if it detects that the signal is noninterlaced.
	TVClamp	[ON] OFF	

Table A-3 (cont)

Header	Argument	Link Argument	Description
SETTv (cont)	TVLine	<NR1>	<NR1> gives the line number to be triggered on in the selected field (selected in the COUPLING command). <NR1> can range from 1 to the current maximum number of lines for the field (in ALT, the field will be FLD2). If outside this range, a warning SRQ will be issued (if EXW is on) when TV Trigger is selected.
	LCNTStart	PREfld	Line count begins three lines before the field-sync pulse. This is the SYSTEM-M selection that will be made in the Extended Functions menu from the front panel.
		ATFld	Line count begins at the sync pulse (non-SYSTEM M).
	SYNc	PLUs MINUs	Shows direction of the sync pulse relative to the baseline.
SETWord	RADix	OCT HEX	Shows which numbering scheme will be used in the display.
	CLOck	ASYnc FALl RISe	
	WORd	<ascii binary data>	<ascii binary data> will be a #Y or #y followed by 17 characters, each one representing a bit in the trigger word plus the qualifier bit (the MS bit). The characters can be 0, 1, X, or x. Spaces will be ignored, but any other characters will cause an error to be generated. If an error occurs, the command will be ignored, and an SRQ will be sent if EXR is on.
	PRObe		Query only. Returns "ON" if the word probe is attached or "OFF" either if the probe is not connected or if the probe register bit that is checked to confirm attachment has not been set to the correct state (a defect).
MANtrig			Command only. If the 2430 is in the READY state (as an ATR? state query), meaning that the pretrigger data has been acquired, this command forces a trigger.
EXTGain	EXT1	DIV1 DIV5	
	EXT2	DIV1 DIV5	

Table A-4

Horizontal Commands

Header	Argument	Link Argument	Description
HORizontal	MODe	ASWeep AINtb BSWeep	If in ROLL mode (AUTO trigger at slow SEC/DIV settings), selecting AINtb or BSWeep causes A TRIG mode to become NORM. If EXW is on, a warning SRQ will be issued.
	POSition	<NR3>	Position will move point <NR3> of the waveform(s) to the center of the display. In order to account for expanded sweeps, the range for <NR3> will be from 0 to 1023 with a resolution of 0.01. If <NR3> requires rounding or limiting, a warning SRQ will be issued if EXW is on.
	ASEcdiv	<NR3>	<NR3> can range from 5E−9 to 5 in the standard 1-2-5 sequence. If <NR3> does not match a valid SEC/DIV setting, it will be set to the closest valid setting. If rounding or limiting is required, and EXW is on, an SRQ will be issued. If the A sweep is set faster than the B sweep, they will lock with an SRQ being sent if EXW is on.
	BSEcdiv	<NR3>	<NR3> range is the same as for ASEcdiv. The B SEC/DIV setting can be set whether being used or not. If an attempt is made to set B slower than the A SEC/DIV setting, it will be set equal to A, and an SRQ will be issued if EXW is on. During subsequent changes in the A SEC/DIV setting, the B SEC/DIV setting will be locked to the A SEC/DIV setting.
	EXTExp	<NR1>	<NR1> can be any of the following: 1, 2, 5, 10, 20, 50, or 100 and shows the expansion factor to be applied to any externally clocked A waveform in SAVE. The expansion factor is reset to 1 if not in SAVE mode or not working with externally clocked waveforms. Any <NR1> entered will be rounded and limited to one of the legal values and, if EXW is on, an SRQ will be issued.

Table A-4 (cont)

Header	Argument	Link Argument	Description
DLYTime	DELta	[ON] OFF	
	DLY1 DLY2	<NR3> <NR3>	DLY1 is set to <NR3> seconds with the range and effective resolution depending on the SEC/DIV setting. Both delays can be set at any time. With DELTa OFF, only DLY1 will be used. DLY2 sets the second delay relative to the first (it is the difference between the two). If the time base is being externally clocked, 1 sec/sample will be used to set the delay time. Delay time essentially becomes delay-by-events in external clock mode.
DLYEvts	MODe	[ON] OFF	
	VALue	<NR1>	<NR1> ranges from 1 to 65536 (2^{16}) and shows the number of events by which the A record trigger will be delayed. It will be limited to match a legitimate value. If limiting occurs and EXW is on, a warning SRQ will be issued.

Command (queried) examples:

HORIZONTAL?	→	HOR MOD:ASW,POS:5.11E+2,ASE:2E−4,BSE:1E+5,EXTE:1;
HOR? POS	→	HOR POS:5.21E+2;
DLYTIME?	→	DLYTIME DELTA:ON,DLY1:5.3E−7,DLY2:2.7E+2;
DLYE?	→	DLYEVTS MODE:OFF,VALUE:23451;

Table A-5

Acquisition Commands

Header	Argument	Link Argument	Description
ACQuire	MODe	NORmal ENV AVG	If set to AVG in DLYTime with DELta set to ON, only delay 1 will be displayed, and a warning SRQ will be issued if EXW is on.
	REPet	[ON] OFF	
	ERAse		Command only. Causes the acquisition sequence currently running to restart similarly to a single-sequence reset.
	NUMEnv	<NR1> CONT	<NR1> is the number of envelope sweeps done before resetting. It is settable to one of the following: 1, 2, 4, 8, 16, 32, 64, 128, or 256. If it does not match, the value will be rounded to coincide with one of the above and an SRQ will be issued if EXW is on. The number of envelopes is ignored in ROLL Mode.
	NUMAVg	<NR1>	<NR1> is the number of sweeps averaged before starting over. It is settable to any of these: 2, 4, 8, 16, 32, 64, 128, or 256 (handled similarly to NUMEnv).
	SAVDel	[ON] OFF	An OPC SRQ will be issued when the instrument has entered SAVE mode as a result of this command.
	NUMACq		Query only. It will indicate the number of acquisitions that took place before SAVE was activated. An error will be generated if the SAVDel function is not active with an SRQ being sent if EXR is on. An intermediate number will be returned if SAVE has not been entered yet. A controller must monitor OPC or the busy bit in the status byte to know when SAVDel has terminated.

Command (queried) examples:

ACQ? MOD	→	ACQ MOD:AVG;
ACQUIRE?	→	ACQUIRE MODE:AVG,REPET:OFF,NUMENV:CONT,NUMAVG:32,SAVDEL:OFF;
ACQ? NUMACQ	→	ACQUIRE NUMACQ:435;

Table A-6

Save and Saveref Commands

Header	Argument	Link Argument	Description
RUN	[ACQuire] SAVe		The ACQuire argument will cause the 2430 to start an acquisition. SAVe will cause an immediate transition to SAVE mode.
SAVERef	[STACk] REF1 REF2 REF3 REF4		Command only. If STACk is selected, an automatic reference transfer is done. For the others, the waveform indicated by the REFFRom pointer is put into the reference memory indicated by the argument. If the waveform pointed to by REFFRom is invalid, an error SRQ will be issued if EXR is on. Also, if the argument is REF4 and REF4Role is set to PANel, the command is ignored and an error SRQ issued if EXR is ON.
REFFrom	REF1 REF2 REF3 REF4 CH1Del CH2Del ADDDel MULTDel CH1 CH2 ADD MULT		
REFDisp	REF1	[ON] OFF	Because of display memory limitations, just turning on a reference does not guarantee that it will be displayed. If the reference is empty, an error results, and an SRQ is issued if EXR is on.
		EMPty	The EMPty command will erase the contents of the selected reference.
	REF2	[ON] OFF EMPty	
	REF3	[ON] OFF EMPty	
	REF4	[ON] OFF EMPty	If the argument is REF4 and REF4Role is set to PANel, the command is ignored and an error SRQ issued if EXR is on.

Table A-6 (cont)

Header	Argument	Link Argument	Description
REFPos	REF1 REF2 REF3 REF4	<NR1> <NR1> <NR1> <NR1>	<NR1> ranges between 0 and 1023 with a resolution of 1 and labels the point on the reference that will be at center screen. In XY display mode, REF1 and REF2 horizontal positions are "locked" (not independently selectable).

Examples:

REFD? REF1	→	REFDISP REF1:EMPTY;
REFFROM?	→	REFF CH1;
RUN?	→	RUN SAV;
REFPOS?	→	REFPOS REF1:512,REF2:614,REF3:37,REF4:981;

Table A-7

Cursor Commands

Header	Argument	Link Arguments	Description
CURSor	FUNction	VOLTs V.T SLOpe TIMe ONE/Time OFF	V.T and SLOpe will place cursors only on the waveform selected using the TARget argument. There are no ABSOlute cursors in SLOpe. If SLOpe is requested with ABSOlute cursors on, MODe will be changed to DELta, and a warning SRQ will be issued if EXW is on.
	TARget	CH1 CH2 ADD MULt REF1 REF2 REF3 REF4 CH1Del CH2Del ADDDel MULTDel	This command selects which waveform the user would like the cursors to appear on. The target waveform needs to be displayed; if not, an error SRQ will be issued if EXR is on, and the current target will not change. Also, if the target is REF4 and REF4Role is set to PANel, the command is ignored and an error SRQ issued if EXR is ON.
	UNIts	TIMe BASe PERcent DEGrees	BASe units are SEC.
		SLOpe BASe PERcent DB	BASe units are V/S.
		VOLTs BASe PERcent DB	BASe units are VOLTS.
	REFVolts	UNIts V VV DIV	
		VALue <NR3>	
	REFSlope	XUNit SEC CLKs V VV DIV	
		YUNit V VV DIV	
		VALue <NR3>	

Table A-7 (cont)

Header	Argument	Link Arguments	Description
	REFTime	UNIts SEC CLKs VALue <NR3>	
	NEWRef		Command only. Uses the current position of the cursors to set up the new reference for making percentage, dB, and degree measurements.
CURSor (cont)	XPOs	ONE <NR3> TWO <NR3>	The <NR3> argument will range over ±5.1 divisions for XPOs cursors and over ±4.1 divisions for YPOs cursors, both with a resolution of 0.01 (0 is center screen). Values will be limited and, if EXW is on, a warning SRQ will be issued.
	YPOs	ONE <NR3> TWO <NR3>	
	TPOs	ONE <NR3> TWO <NR3>	The <NR3> argument can range from 0 to 1023, with a resolution of 0.01 and will determine where to put the cursor specified in the first argument. <NR3> values will be limited, and if EXW is on, a warning SRQ will be sent.
	MODe	DELta ABSOlute	
	DISplay	VALue UNIts	Query only. VALue will return the <NR3> number from the cursor readout field of the display. UNIts will return the symbolic "units" string associated with that <NR3> VALue. If the cursor function is off, the units returned will be "OFF."
	SELect	ONE TWO	Command selects which cursor is the active one.

Command (queried) examples:

CURSOR? XPOS:ONE	→	CURSOR XPOS:ONE:4.02;
CURSOR? FUN	→	CURS FUN:SLO;
CURS? UNITS	→	CURSOR UNITS:PERCENT;
CURSOR?	→	CURSOR FUNCTION:VOLTS,TARGET:MULT, UNITS:SPECIAL, REFVOLTS:UNITS:V,REFVOLTS:2800, REFSLOPE:UNITS:VV,REFSLOPE:2500, REFTIME:UNITS:SEC,REFTIME:325, XPOS:ONE:20.02,XPOS:TWO:3.23, YPOS:ONE:3.0,YPOS:TWO:7.33, TPOS:ONE:530,TPOS:TWO:5.35, MODE:RELATIVE,SELECT:ONE;

Table A-8

Display Commands

Header	Argument	Link Argument	Description
INTENSIty	DISplay REAdout GRAt INTENS	<NR3> <NR3> <NR3> <NR3>	<NR3> for all the Intensity controls (DIS, REA, GRA, and INTENS) will be a number from 0 to 100 with a resolution of 0.25; 0 being off and 100 being the brightest. <NR3> will be limited and, if EXW is on, a warning SRQ will be issued. INTENS sets the intensity of the intensified zone in A INTEN Horizontal Mode.
	VECtors	[ON] OFF	Determines whether the display is drawn using vectors (ON) or dots (OFF).
REAdout	[ON] OFF		Turns all readout on the screen on or off.
MENuoff			Command only. Clears the lower three lines of readout and prevents updates from occurring with each menu button push. A useful command for creating custom menus (see MESsage command).
REF4Role	PANel REF4		Defines what the REF4 memory is to be used for. If set to REF4, the memory is used to hold a reference waveform, and only one front panel SAVE/RECALL SETUP memory is available. When set to PANel, the memory location is used instead to provide four more front-panel setup memories, and REF4 is considered to be permanently empty.
SETUp	SAVE	ONE TWO THRee FOUr FIVe	Command only. Causes the current front-panel setup to be saved in the selected memory. If REF4Role is REF4, only PANel ONE save memory is available; an argument to SAVE into memories TWO through FIVe is ignored and an error SRQ is issued if EXR is on. In order to determine what has been saved in a particular front-panel memory location, the user can do a RECall and then a SET?.
	RECall	ONE TWO THRee FOUr FIVe	Command only. Causes the setup in the selected memory to become active. If an attempt is made to retrieve either an unset memory or PANels TWO through FIVe when REF4Roll is REF4, an error SRQ is issued if EXR is on and the command ignored.

Table A-8 (cont)

Header	Argument	Link Argument	Description
MESsage	<NR1>	"string"	<NR1> is settable in the range 1 to 16 and will designate which row in the readout the "string" will go (line 1 at bottom of screen). <NR1> values will be limited and, if EXW is on, an SRQ will be issued. The string will be left justified in the display and will be blank filled or truncated to equal 40 characters.
	CLRstate		Command only. Clears out all 16 lines of readout from the 2430 display. **NOTE** *The top two and bottom three lines of readout are used extensively by the scope. Even though the front panel is locked out (LOCKOUT ON), remote changes can still cause updates to rewrite any of the top two or bottom three lines. In addition, any of the following can cause an overwrite to occur:* *(1) 50 Ω overload* *(2) word probe is disconnected while word-trigger source is selected.* *(3) if cursors are on, line 14 is constantly overwritten.*
PLOt	STArt		Command only. When this command is decoded, the plot is started using previously set or power-up parameters. No commands or queries are handled until the plot is completed. A DCL interface message will abort the plot. An OPC SRQ will be issued when the plot completes.
	READout	[ON] OFF	
	GRAt	[ON] OFF	
	PENlift	OPEn CLOsed	Specifies relay polarity for the pen-up position.

Examples:

INTENSI? DISP → INTENSITY DISPLAY:5.0E+1;

MESSAGE? 16 → MESSAGE 16:"CH1 >500\;V\~ A 500
\<\ 7 31.2\;V VERT";

Table A-9

Miscellaneous Commands

Header	Argument	Link Argument	Description
ID?			Returns the message "ID TEK/2430, V81.1, <string>". Option(s) present will extend ID string to show the configuration. Example: "...,<string>,TVTRIG" The <string> will be composed of the firmware release date, the firmware version, and the waveform processor firmware version. Example of <string>: "10-APR-85 V1.00/1.0"
DEBug	[ON] OFF		Command controls the debug option which displays incoming symbols from a controller on the screen as they are processed by the 2430. Each new message will clear the text area before it is displayed. If an error occurs in the message, an error message is shown, and the display is frozen. Lower case characters are displayed as upper case, and normal ascii characters, overlaid by special 2430 characters, are displayed as the special characters. The message terminator is shown as a box character. Ascii waveforms are displayed; binary ones are not.
HELp?			Query only. Will return a list of all valid command headers available to the user.
INIt	PANel		Command only. Will cause the 2430 to go to a factory-preset front-panel setup.
	GPIb		Command only. Causes all bus-unique commands to be initialized to known states as follows: PATH ON; DEBUG OFF; LONG ON; RQS ON; OPC ON; CER ON; EXW ON; EXR ON; INR ON; DEVDEP ON; USER OFF; PID OFF; DATA ENCDG:RIBINARY, TARGET:REF1, SOURCE:CH1; FASTXMIT OFF,1; START 256; STOP 512; LEVEL 0; WINDOW CH1. It also clears the event buffer.
	[BOTh]		Does both the PANel and GPIb initializations.
LONg	[ON] OFF		Command determines whether a response to a query is given with unabbreviated symbols (ON) or not.
SET?			Returns an ascii string that reflects the current instrument state and can be returned to the 2430 to recreate that state. The LONg command will affect the SET? query.
LLSet	<binary block>		<binary block> will consist of a low-level "readout" of the instrument state which will be shorter in length than a human readable version. The LLSet command is much fater than the SET? query.
PATh	[ON] OFF		When PATh is on, the full path name is returned for a query response. If PATh is off, just the last item is sent. For example, with PATh on, the query INTENSITY? DISPLAY would return: "INTENSITY DISPLAY:10.5;". With PATh off, just "10.5;" would be returned.
BELL			Command only. Rings the bell.

Table A-10

Service Request Commands

Header	Argument	Link Argument	Description
RQS	[ON] OFF		RQS causes the 2430 to assert SRQ when it has an event to report. If this feature is turned off, events are still accumulated as before and can be retrieved with an EVENT? query.
OPC	[ON] OFF		Enables SRQ upon the completion of a command. The 2430 will have several commands that will use the operation complete feature, including: SINGLE SEQ, SAVE ON Δ, plot complete, and self-test complete.
CER	[ON] OFF		If on, this mask will allow the 2430 to assert an SRQ whenever a command error is detected. Some examples of command errors are syntax errors or invalid characters in the input.
EXR	[ON] OFF		If on, this mask will allow the 2430 to assert an SRQ whenever an execution error is detected. Some examples of execution errors are illegal characters sent to set up the word trigger or trying to retrieve an unset front-panel recall memory.
EXW	[ON] OFF		If on, this mask will allow the 2430 to assert an SRQ whenever a warning condition is detected. Some examples of warning conditions are parameter rounding or limiting and trying to set B SEC/DIV setting slower than the A SEC/DIV setting.
INR	[ON] OFF		If on, this mask will allow the 2430 to assert an SRQ whenever an internal error is detected. An example of an internal error is a self-test failure.
USEr	[ON] OFF		Enables/disables an SRQ generated by a menu switch being pushed. Each switch will have a unique event code associated with it, allowing a controller to create special menus and react to user feedback. The USEr command must be preceded by a MENuoff command (or a press of the MENU OFF button) to tell the 2430 to ignore the bezel buttons for its normal operation. An SRQ will not be sent for normal scope menu displays.
DEVdep	[ON] OFF		Enables/disables a device dependent SRQ such as one generated from a TRANSMIT or ABORT button push.
PID	[ON] OFF		Enables/disables an SRQ generated by a probe identify button being pushed.
EVEnt?			Returns the most recent event held by the 2430 or a 0 if none exists. (See Table A-17 for EVEnt codes.)

Table A-10 (cont)

Header	Argument	Link Argument	Description
FAStxmit	<NR1> DELta NORmal OFF	 CH1 CH2 BOTh CH1 CH2 BOTh	Command only. Controls the fast transmit mode of the 2430. To use FAStxmit, it is necessary to set <NR1> to the desired number of waveforms only in the first command turning on the FAStxmit mode. <NR1> may be set from 1 to 65535 and is retained until reset by command or initialized again. <NR1> is set to 1 both at power-on and with the INIt GPIb command. The next argument of the command selects the waveforms of interest; either DELta (for the delta delay waveforms in Δ TIME mode) or NORmal (for either undelayed or main delayed waveforms) with the appropriate link argument for CH1, CH2, or BOTH. It is not necessary to set <NR1> on subsequent target waveform changes except to make a change in the number of waveforms wanted. If only the number of waveforms is to be changed, it is not necessary to send the waveform target arguments. The last argument of either DELta or NORmal received is the active waveform designator. **NOTE** *If DELta waveforms are asked for and Δ TIME is not ON, the asked for waveforms will never be acquired. If waveforms are being acquired in ROLL mode, the waveform transmission will not occur until SAVE mode is entered, and <NR1> must be set to 1 because more than one will not be acquired. If either of the above happens, the 2430 GPIB will "lock up," and there is no way to abort once <MTA> is received by the 2430, except power-off on the 2430.* Untalk the 2430, send the command line with terminator, then make the 2430 a talker again to initiate the transfer. Each subsequent transition from untalked (UNT) to talked (MTA) starts another sequence of <NR1> waveforms being sent. All waveforms are sent in Codes and Formats binary curve format, with the last binary byte of sequence being terminated by a LF with EOI set.

Example for FAStxmit command:

Send to 2430 → <UNT> FAStxmit 4,NORmal:CH1 <EOI> <MTA>

Reply from 2430 → [bin curve];[bin curve];
[bin curve];[bin curve] LF<EOI>

To change number of FAStxmit waveforms:

Send to 2430 → <UNT> FAStxmit 2 <EOI> <MTA>

NOTE

FAStxmit mode sends data in RIBINARY format regardless of the ENCDG setting.

Table A-11

Waveform Commands

Header	Argument	Link Argument	Description
WAVfrm?			A WAVFRM? query will cause both WFMPRE? and CURVE? queries to be generated for the waveform specified by the DATA SOURCE pointer.
CURVe	<wfm data>		The CURVe command or query is used to send or receive just waveform data. The DATa SOUrce pointer shows which data to send on a query, the DATa TARget pointer shows where to put data on a command, and the DATA ENCDG pointer shows which format to send it in. <wfm data> , as defined by Codes and Formats, can be either ascii or binary format. **NOTE** *The curve data sent is that which would go into a reference memory if SAVEREF were pressed.*
DATa	ENCdg	ASCii RPBinary RIBinary	At power-up, ENCdg is initialized to RIBinary. RPBinary is positive integer notation; RIBinary is twos-complement.
	TARget	REF1 REF2 REF3 REF4	Targets which reference memory will receive the next CURVe sent to the 2430. If the argument is REF4 and REF4Role is set to PANel, the command is ignored and an error SRQ issued if EXR is ON. At power-up the TARget is initialized to REF1.
	SOUrce	CH1 CH2 ADD MULT REF1 REF2 REF3 REF4 CH1Del CH2Del ADDDel MULTDel	Points to the waveform that a CURVe?, WFMpre?, or WAVfrm? query will return information on. If the waveform of interest is not valid (empty reference) an error will be returned when the information is requested if EXR is on. If the argument is REF4 and REF4Role is set to PANel, the command is ignored and an error SRQ issued if EXR is ON. At power-up, SOUrce is initialized to CH1.

Table A-12

Waveform Preamble Fields

Header	Argument	Link Argument	Description
WFMpre[a]	WFId	"ascii string"	The WFID field in the WFMPRE is left undefined by Codes and Formats to allow individual instruments the ability to communicate information not included elsewhere in the preamble. In the 2430 this section will include labeling information to help the user remember key features about the waveform and will include vertical mode, coupling, VOLTS/DIV, SEC/DIV, and what the particular acquisition mode was. The scaling information is the same as the preamble but is given in scope "units." See examples at the end for the form of this argument. This argument will be ignored if sent as a command.
	NR.Pt	1024	During waveform input, the 2430 will always expect waveforms with 1024 points. (All received waveforms are placed in reference memory.) Waveforms received with less than 1024 points will have the remainder filled with the last data point sent. All waveforms output by the 2430 will contain 1024 points. This argument will be ignored if sent as a command.
	PT.Fmt	Y	Point format defines how to interpret the curve data. Y format means that x information is implicit and the data points sent are the y values. Each point will be sequential in time (older to younger).
		ENV	Format used for envelope waveforms. The data is sent in the form: y1max,y1min,y2max.... Data sent to the 2430 with this format will be treated as an envelope waveform.
	XUNit	SEC CLKs	If the argument is SEC, the XINcr value has units of seconds. If it is CLKs, the scaling is for EXTCLk.
	XINcr	<NR3>	<NR3> will give the time interval between points (sampling rate). It is calculated by assuming 50 pts/div and dividing that into the sweep rate. It will range from 1.0E−1 (5 sec/div) to 1.0E-10 (5 ns/div). <NR3> *50 will be rounded and limited to match a legitimate SEC/DIV setting; and, if done, a warning SRQ will be issued if EXW is on. For a query response with an unknown sec/div (as for EXTCLk), <NR3> will be set to 1.

[a]Default values for the waveform preamble will not be sent or received, but they are needed when using the preamble information to associate waveform scaling with the waveform data in the message. The defaults are:

XZERO = 0
YZERO = 0
BIT/nr = 8
BYT/nr = 1
CRVchk = CHKsm0

Table A-12 (cont)

Header	Argument	Link Argument	Description
WFMpre (cont)	PT.Off[b]	<NR1>	Shows the location of RTRIG within the waveform. <NR1> can vary between 0 and 1023 in increments of 32. A number that does not fit the increments or limits will be rounded and limited to match. If rounding or limiting occurs, a warning SRQ will be issued if EXW is on. 0 means the trigger point is off the record to the left, and 1023 indicates that it is off the record to the right.
	YUNit	V VV DIV	Gives magnitude in volts when associated with YMUlt.
	YMUlt	<NR3>	This value gives the vertical "step" size of the digitizer (volts between points); computed from the VOLTS/DIV setting by assuming 25 points per division vertically.
	ENCdg	ASCii BINary	Shows the encoding type that will be used on the next CURVE query.
	YOFf	<NR3>	YOFF locates the ground in digitizing levels relative to data 00. (If the YOFF is positive, then ground is below data 00.) <NR3> can range from −2500 to 2500 with a resolution of 0.25. Incoming values will be limited to this range; and, should limiting occur, a warning SRQ will be issued if EXW is on.
	BN.Fmt	RI	Binary Integer format will be used by the 2430. This is essentially a two's complement representation with the MSB being interpreted as a sign bit. Digitized values being output will range from 80 (−128) to 0 to 7F (+127).
		RP	Binary data will be treated as positive integers (0 to 255). **NOTE** *The 2430 powers up expecting RI binary data. If RP is to be sent, first send a BN.Fmt command with RP as the argument to change the 2430.*

[b]Waveforms acquired in ROLL mode do not have a trigger point although the current trigger position will be sent. That trigger position defines the waveform window captured when a SAVE ON Δ operation is done.

Examples:

These are the fields and possible values for the WFID section of the preamble.

Channel	CPLG	VOLTS/DIV	SEC/DIV	STORE Mode
CH1	DC	0.2MV	5NS	NORMAL
CH1DEL	AC	to	to	AVG
CH2	GND	5000V	5S	ENV
CH2DEL	UNK[1]	UNCAL	EXTCLK	
ADD				
ADDDEL				
MULT				
MULTDEL				
REF1				
REF2				
REF3				
REF4				

Command (queried) examples:

WFMPRE? WFID → WFMPRE WFID:"CH1 DC 5MV UNCAL 200NS AVG";

WFMPRE? WFID → WFMPRE WFID:"CH2 AC 2V 5MS NORMAL";

WFMPRE? ENCDG → WFMPRE ENCDG:ASCII;

[1]UNKnown—CPLG (coupling) may be unknown when an ADD or MULT waveform has dissimilar couplings on the input channels. Likewise, a stored ADD or MULT reference waveform may have UNKnown coupling.

Table A-13

Waveform Data Commands

Header	Argument	Link Argument	Description
			NOTE *The DATa SOUrce variable shows which waveform will be looked at for all measurement queries.*
STARt	<NR1>		<NR1> varies between 1 and 1024 and sets the start of the interval for the actual measurement queries. STArt must be less than STOp; if they are not of the proper size relationship, they will be swapped. A warning SRQ will be issued if <NR1> is outside the allowable range and EXW is on.
STOp	<NR1>		<NR1> sets the end of the interval for the waveform measurement queries (see STARt).
LEVel	<NR1>		<NR1> varies between −127 and 126 and sets the vertical level for PCRoss and NCRoss.
MAXimum?			Query only. Returns an <NR1> number, from −127 to 126, which represents the maximum value of the acquired waveform between STARt and STOp.
MINimum?			Query only. Returns an <NR1> number, from −127 to 126, which represents the minimum value of the acquired waveform between STARt and STOp.
AVG?			Query only. Returns an <NR3> number that represents the average of the points between STARt and STOp. <NR3> will vary from −128 to 126, with −128 indicating that no valid points (−127 to 126) are in the requested interval.
PCRoss?			Query only. Returns an <NR1> number, from 0 to 1024, that represents the first waveform point (in the interval of STARt to STOp, but labeled from 1 to 1024) whose value is at or above LEVel when the previous point was below LEVel. If there is no positive crossing point, a value of 0 is returned.
NCRoss?			Query only. Returns an <NR1> number, from 0 to 1024, that represents the first waveform point (in the interval of STARt to STOp, but labeled from 1 to 1024) whose value is at or below LEVel when the previous point was above LEVel. If there is no negative crossing point, a value of 0 is returned.

Table A-14

Calibration and Diagnostic Commands

Header	Argument	Link Argument	Description
TESTType	SELFCal SELFDiag EXTCAl EXTDiag		Indicates which type of test will run upon receipt of an EXEcute command.
TESTNum	<NR1>		<NR1> indicates the test number within the TESTType (extended calibration or extended diagnostics) that is to be run. If SELFCal or SELFDiag is the TESTType, the TESTNum will be reset to 0000 when an EXEcute command is received.
EXEcute			Command only. Causes the test selected by TESTNum to execute. Any tests in the test hierarchy below the selected number will all be run. An SRQ will be sent upon successful completion of the test sequence if OPC is on. If a test was unsuccessful, an SRQ will be issued if INR is ON and the ERRor? query may then be used to return the test status.
ERRor?			Query only. ERRor? returns a string of error numbers (up to nine) resulting from the last EXEcute command (or 0 if no errors exist). Only those error numbers associated with the same level in the test hierarchy as that of TESTNum are returned. The exact test that failed in a hierarchy is found by moving TESTNum to a lower level and rerunning the test and reissuing the ERRor? query until the failure is isolated to a test at the lowest level.
STEp			Command only. Causes the current test to advance to the next step in the sequence and begin execution of the new step. An SRQ will be sent to indicate completion of the step if OPC is on.
LOOp	CONt FAIl PASs ONE		Command only. Causes the next test executed to run in a loop either until a HALt is received or the argument condition is met.
HALt			Command only. Stops any test being executed; specifically used to stop a looping test.

Table A-15 lists the GPIB subsets that the 2430 has in accordance with the IEEE-488 specification.

Table A-15

2430 GPIB Interface Specification

Function	Subset	Note
Source Handshake	SH1	Complete capability.
Accepter Handshake	AH1	Complete capability.
Talker	T5	Basic Talker, Serial Poll, Talk Only, Unaddress if MLA.
Listener	L3	Basic Listener, Listen Only, Unaddress if MTA.
Service Request	SR1	Complete capability.
Remote/Local	RL1	Complete capability.
Parallel Poll	PP0	No capability.
Device Clear	DC1	Complete capability.
Device Trigger	NDT0	No capability.
Controller	C0	No capability.

Table A-16 defines the status byte codes sent over the GPIB by the 2430.

Table A-16

2430 Status Bytes

Title	Binary[a]	Decimal				Priority	
		RQS Off		RQS On		RQS Off	RQS On
		Idle	Busy	Idle	Busy		
(System:)							
No Status To Report	000X 0000	0	16	0	16	2	1
Power On	010X 0001	1	17	65	81	2	9
Operation Complete	0R1X 0010	2	18	66	82	2	3
User Request	0R1X 0011	3	19	67	83	2	8
Command Error	0R1X 0001	33	49	97	113	2	7
Execution Error	0R1X 0010	34	50	98	114	2	6
Internal Error	0R1X 0011	35	51	99	115	2	5
Execution Warning	0R1X 0101	37	53	101	117	2	4
(Device Dependent:)							
Fatal Error	1R1X 0011			227	243		10
Transmit Request	1R0X 0011	131	147	195	211	2	8
Transmit Aborted	1R0X 0100	132	148	196	212	2	8

Device Dependent Bit
RQS Bit
Error Bit
Busy Bit

[a]"R" is set to 1 if the GPIB and RQS are on; otherwise, it is 0.

"X" is the busy bit and will be set if the 2430 is busy at the time the status byte is read. Any time the 2430 is doing something for which the OPC SRQ can be sent (calibration or self test, single sequence, SAVE on Δ, plotting), the bit will be sent true (1); otherwise, it will be a 0.

GPIB EVENT CODES

Table A-17 lists the possible event codes returned by the 2430 as a reply to an EVEnt? query. If there is no event to report on, the 2430 returns a zero.

Errors and warnings are broken into different types. The response to errors in each type differs. Warnings are issued either by the 2430 or the operating system when the user makes an error in entering a number or an event happens that is not fatal but which the user may want to know about. Mask status may be obtained using the STATUS choice in the GPIB OUTPUT menu (see Figure A-2).

1. Command Errors—Cause the input to be dumped to the next EOI or semicolon (;). An SRQ is sent if CER mask is ON.

2. Execution Errors—Inform the user that although a valid command was sent, the 2430 could not execute it. An SRQ is sent if EXR mask is ON.

3. Internal Errors—Are the result of a self-calibration failure or a 50 ohm overload of the vertical inputs. An SRQ is sent if INR mask is ON.

4. System Events—Inform the user of certain operating events that have occurred in the GPIB interface or the 2430.

5. Execution Warning—Issued as a result of a user entering an invalid or out-or-range number in a command or query and when a nonfatal event occurs that the user may wish to know about. Sends an SRQ when the EXW mask is ON.

6. Device Dependent Error—A result of a waveform being solicited or a waveform transmission being aborted. SRQ is sent when DEVDEP mask is ON.

7. Fatal Error—No masks.

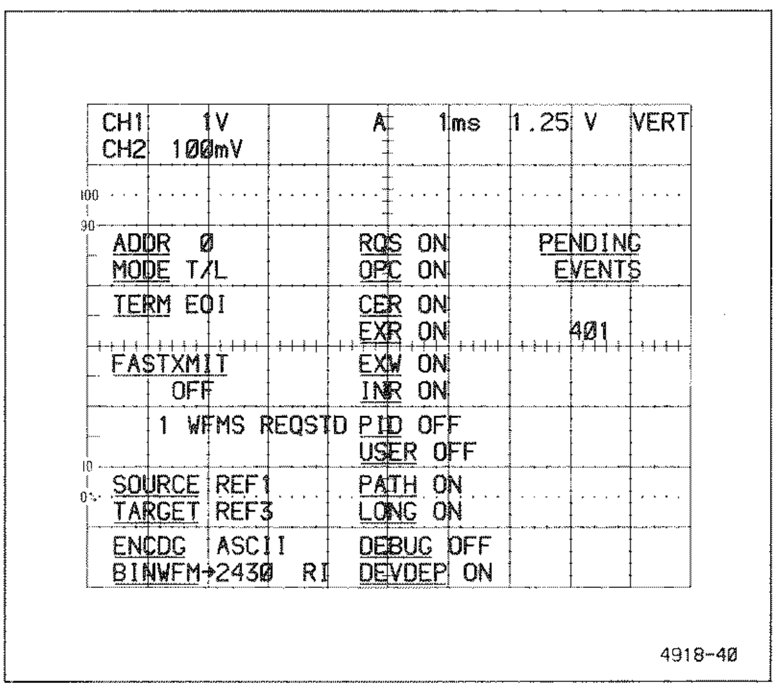


Figure A-2. GPIB STATUS display.

Table A-17

2430 Event Codes

Event Code	Event Description
	Command Error Events—CER Mask
108	Checksum error in CURVE transfers.
109	Count = 0 or EOI set on byte count.
151	Symbol or number too long.
152	Invalid character or control character input.
153	EOI set on back slash.
154	Invalid number input.
155	EOI set on string character before ending quote.
156	Symbol not found.
157	Command or query argument is illegal in this syntax.
158	Character should be a colon (:).
159	Valid symbol, but not a legal header.
160	Character should be a comma (,), a semicolon (;), or EOI.
161	Query argument stack overflow.
162	Command only. May not be sent as a query.
163	Query only. May not be sent as a command.
164	EOI asserted before waveform was completed.
165	Incorrect word string input.
166	Number expected on incoming ascii waveform.
167	Comma expected on incoming ascii waveform.
168	Incoming ascii waveform has more than 1024 data points.
169	Illegal LLSet string.
	Execution Error Events—EXR Mask
203	I/O buffers full, output dumped.
250	Selected recall memory is unset.
251	Selected reference memory is empty.
252	Waveform requested via GPIB is not valid or available.
253	Too many numbers were sent in (stack overflow).
254	No Video Option installed when SETTv commands issued via GPIB.
255	Target selected for cursors is not displayed.
256	Clear overload condition before changing to 50-ohm termination.
257	Waveform selected for reference source is not valid.
258	Use of REF4 memory incompatible with current setting of REF4Role.
	Internal Errors—INR Mask
330	Cal execute command returns with FAIL. Must use ERR? query to determine failure code.
331	A 50-ohm overload occurred and the Input Coupling switched to DC.

Table A-17 (cont)

Event Code	Event Description
	System Events
401	2430 Power on (no sub mask for this event).
450	Menu key #1 request (REM mask).
451	Menu key #2 request (REM mask).
452	Menu key #3 request (REM mask).
453	Menu key #4 request (REM mask).
454	Menu key #5 request (REM mask).
455	CH 1 Probe identify (PID mask).
456	CH 2 Probe identify (PID mask).
457	EXT 1 Probe identify (PID mask).
458	EXT 2 Probe identify (PID mask).
459	SRQ pending (no mask). This is in lieu of last event if SRQ is pending.
461	Single Sequence has completed (OPC mask).
462	Transition to SAVE has occurred in SAVE ON Δ (OPC mask).
463	XY Plot has completed (OPC mask).
464	Current Cal command or power-on self-check has finished execution (OPC mask).
465	Current STEP command is done (OPC mask).
	Execution Warning—EXW Mask
550	Only delay 1 will be displayed if in AVG.
551	Word Recognizer Probe is disconnected.
552	A and B SEC/DIV are locked together.
553	More than 1024 binary points were sent; excess discarded.
554	No ABSOlute cursors in SLOPE.
555	ATRIgger COUpling and LOGsrc changed.
556	ATRIgger SOUrce change forced LOGsrc to OFF.
557	No AVERAGE in ROLL. Acquisition mode or A Trigger mode changed.
558	No live vertical expansion unless averaging. Vertical gain changed.
560	VOLTS/DIV value requested was rounded or limited.
561	VARIABLE VOLTS/DIV value requested was limited.
562	Vertical POSITION value requested was limited.
564	Trigger HOLDOFF value requested was limited.
565	Horizontal POSITION value requested was limited. This event code is also used when Time Cursor horizontal position is limited.
566	A or B SEC/DIV setting requested was rounded.
567	Delay by Events events number was limited.
568	Delay by Time delay value was limited.
569	Number of Envelopes requested was rounded.
570	Number of Averages requested was rounded.

Table A-17 (cont)

Event Code	Event Description
Execution Warning—EXW Mask (cont)	
572	Cursor reference value requested was rounded.
573	Horizontal position value (XPOs) for cursors was limited.
574	Vertical position value (YPOs) for cursors was limited.
575	Intensity value requested was limited.
576	Line number of GPIB message was limited.
577	Setup memory number requested is invalid or unset.
578	The XINCR value was rounded or limited.
579	The PTOFF value was rounded or limited.
581	Video Option line number requested was limited.
582	Trigger position number requested was limited.
583	An ascii data point was rounded to fit into 127 to −128.
584	Waveform data LEVel value requested for data queries was invalid.
585	Waveform data STArt or STOp number requested for data queries was outside range.
586	The YOFF value was limited.
587	EXTExp value requested was limited.
Device Dependent Error—DEVDEP Mask	
650	Waveform was requested from front panel.
651	Waveform transmission was aborted from front panel.
Fatal Error—No Masks	
750	Fatal error.

APPENDIX B

EXTENDED FUNCTIONS

INTRODUCTION

The information in this section describes and defines the performance of the 2430 EXTENDED FUNCTIONS. Two types of EXTENDED FUNCTIONS are available for the user: SYSTEM and CAL/DIAG. A third choice of SPECIAL is used for special servicing only and performs no user functions. The control menus found under SYSTEM are ones that 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 FUNCTINS calls up the display "WARNING: SERVICE ONLY—SEE MANUAL" with the choice of COLD START and FORCE DAC. Both choices are special diagnostics functions that should not be called up the the user. 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. FORCE DAC is a special diagnostic tool that permits the service technician to change the value of selected constants as an aid in trouble shooting parts of the internal circuitry.

SYSTEM CONTROLS

Front-panel Controls at Power-On

Under SYSTEM, the choice of how the front-panel controls are set at power-on is selected by the user as either LAST (the control settings at power-off) or INIT (a factory setup of initialized front-panel settings). In general, powering up in INIT produces a simple setup with CH 1 only ON for display in SAVE acquisition mode, 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 C-16 of APPENDIX C). The INIT PANEL menu selection found on the front-panel SAVE/RECALL SETUP control menu produces exactly the same front-panel conditions as PWR ON INIT.

Warning Bell

The BELL ON/OFF feature is self explanatory. With the BELL ON, any warnings to the user regarding system operating errors (especially with the GPIB interface) can be signaled by an audible tone.

Prefilter

The usual setting for the PREFLT menu choice is ON. Its effect occurs only on interpolated data to reduce the filter overshoot in the sinx/x interpolator seen when viewing fast-rise and fast-fall signal. If viewing very narrow pulses, the user may wish to turn off the prefilter to eliminate its effects.

Selecting Use of REF4

The user has the choice under REF4 of selecting either to use some available memory space as the location of SAVEREF memory number 4 (REF) or to use it to save four additional front-panel setups (PANEL). If used for front-panel setups, the numbers 2 through 5 will appear in the front-panel SAVE/RECALL SETUP menu when that button is pressed. The memory location for front-panel 1 is long-term nonvolatile storage space; for numbers 2 through 5, the storage is short-term nonvolatile memory (three to five days).

TV System

Choice of operating the sync selection in System-M protocol or nonsystem-M protocol is set using the TV SYS M/NON-M menu button. Setting the choice for 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 in encountered. When nonsystem-M is selected, the line count begins coincident with the field-sync pulse.

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 2430 System μP. The Self Diagnostics routines may also be accessed from the instrument front-panel or by mean 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 B-1). Failure of a test number from 6000 to 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.

At power-on, the 2430 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 none of the VERTICAL MODE waveforms can be called up for display until valid data is obtained) and an INIT PANEL is done to set all the front-panel controls and GPIB states to their INIT values (see Table C-16 in Appendix C 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 2430 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. The SELF CAL routine must also be allowed to complete before the MENU OFF/EXTENDED FUNCTIONS button is pressed to obtain a valid calibration.

After SELF CAL has been done, the REPET cal 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 "UNCALD" message displayed for each following power-on. The ATTEN and TRIGGER choices in the EXTENDED CAL menu will also 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 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 C-16 in Appendix C 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 the waveform scaling factors (failure of WFM-HEADERS test 6300) causes all waveforms to be invalid. On power-on, invalid waveforms are turned off and not permitted to be called up for display and saveref memories are marked "EMPTY." Exiting EXTENDED DIAGNOSTICS by pressing the MENU OFF/EXTENDED FUNCTIONS button then pressing ACQUIRE to obtain valid waveform data permits continued normal operation of the scope.

Loss of individual waveforms from the SAVE memory, a short-term nonvolatile RAM, 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 or if the scope remains off beyond the nonvolatile time limit of the SAVE RAM (three to five days without powering on the scope). 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). Simply acquiring new waveform data in any affected memory restores the display to normal. If saveref memory REF4 has been set to store front-panels rather than the fourth reference waveform, those front-panel setups in RECALL SETUP locations 2-5 may be lost by a long-term power off. An attempt to recall an invalid front-panel setting will ring the warning bell, and no changes to the current front-panel settings will be made. New front-panel setups have to be saved to replace the ones lost.

Failure of diagnostic tests numbers 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 an "UNCALD" 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 2430 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 person to troubleshoot a fault in the 2430 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 2430 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 2430 instrument. Self Calibration routines calibrate the major portion of the analog system of the 2430 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 2430 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 B-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:

<mode>
↑ ↓ 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 B-1). In addition if the instrument is not fully calibrated the word UNCALD is displayed at the bottom of the screen.

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, and 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.

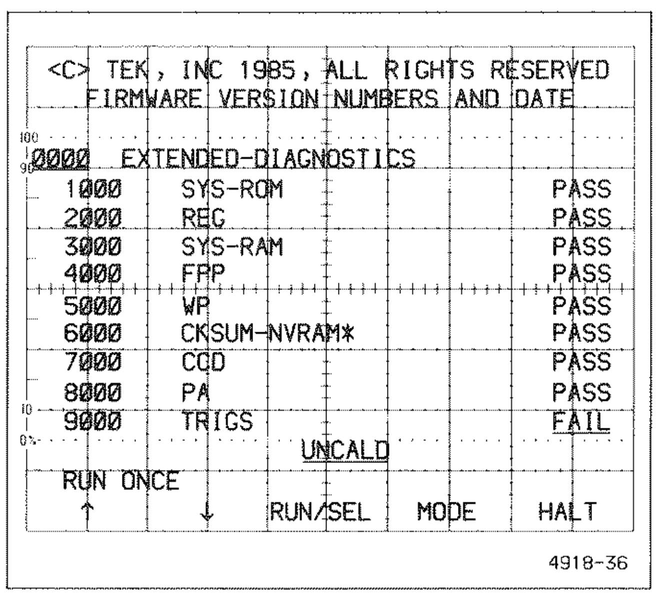


Figure B-1. EXTENDED DIAGNOSTICS Menu.

RUN/SEL. A press of RUN/SEL with the pointer at the title line, causes all the test 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 the manner in which a 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. The choice of RUN UNTIL PASS and RUN UNTIL FAIL may 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 Appendix A. 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 2430 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 Table A-14 in Appendix A 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 to 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 Table A-16 of Appendix A 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 reissued 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 2430 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 B-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 B-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
2300	TB-DSP
2310	VCURS
2311	1010 0101
2312	0100 1011
2313	1001 0110
2314	0010 1101

Table B-1 (cont)

Test Code	Test Name and Hierarchy
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
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

Table B-1 (cont)

Test Code	Test Name and Hierarchy
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
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

Table B-1 (cont)

Test Code	Test Name and Hierarchy
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
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

Table B-1 (cont)

Test Code	Test Name and Hierarchy
8140	ENV-FISO-SLOW
8141	CH1
8142	CH2
8150	ENV-FISO-FAST
8151	CH1
8152	CH2
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
8500	INV-GAIN
8510	50MV
8511	CH1
8512	CH2

Table B-1 (cont)

Test Code	Test Name and Hierarchy
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
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*

Table B-1 (cont)

Test Code	Test Name and Hierarchy
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*
9300	REPET*

APPENDIX C

TABLES

Appendix C contains reference tables and general information which may be useful for the operator in understanding the operation of the 2430.

LIST OF APPENDIX C TABLES

VOLTS/DIV Range with Attenuator Probes

The range of the VOLTS/DIV front-panel switch for all available probes is displayed in Table C-1.

Table C-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

Plotter Slew Rate

Plotter speed is controlled dynamically by computing the length of the stroke needed for each point, then waiting an appropriate time at the new position before continuing. Table C-2 shows the slew rates required to draw the usual maximum size plot for various paper sizes.

Table C-2

Plotter Slew Rate Versus Paper Size

Plot Size	Slew Rate (ips)
A (8 in x 8 in)	16
B (10 in x 10 in)	20
C (16 in x 16 in)	32

CALIBRATOR Frequency

Table C-3 shows the CALIBRATOR frequency and period for each A SEC/DIV setting.

AVERAGING SNIR

Table C-4 shows the signal-to-noise improvement ratio (SNIR) as the number of averages increases. The display is updated with each new waveform acquired, so the user sees the averaged waveform improve with each new acquisiton.

REPETITIVE Acquisition

Table C-5 illustrates the number of repetitive acquisitions required to fill a Single Seq waveform to 50%. Figure C-1 is a complete graph of Sweeps vs % Fill for all REPET Mode SEC/DIV settings.

Table C-3

Calibrator Frequency and Period for Each A SEC/DIV Setting

A SEC/DIV Setting	Calibrator Frequency	Calibrator Period	DIV/ Cycle
5 ns	5 MHz	200 ns	40
10 ns			20
20 ns			10
50 ns			4
100 ns			2
200 ns			1
500 ns	500 kHz	2 μs	4
1 μs			2
2 μs			1
5 μs	50 kHz	20 μs	4
10 μs			2
20 μs			1
50 μs	5 kHz	200 μs	4
100 μs			2
200 μs			1
500 μs	500 Hz	2 ms	4
1 ms			2
2 ms			1
5 ms	50 Hz	20 ms	4
10 ms			2
20 ms			1
50 ms			0.4
100 ms			0.2
200 ms			0.1
500 ms			0.04
1 s			0.02
2 s			0.01
5 s			0.004

Table C-4

Signal to Noise Improvement with Increasing 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

Table C-5

Repet Sweeps Aquired to Fill Single Seq Waveform to 50%

SEC/DIV (ns/div)	Number of Sweeps
200	2
100	6
50	11
20	25
10	45
5	83

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 C-6 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 C-6

Variable A Trigger Holdoff

A SEC/DIV	MIN HO	MAX HO
5 ns	2-3 μs	9-15 μs
10 ns		
20 ns		
50 ns		
100 ns		
200 ns		
500 ns	5-10 μs	
1 μs	10-20 μs	100-150 μs
2 μs	20-40 μs	
5 μs	50-100 μs	
10 μs	0.1-0.2 ms	1-1.5 ms
20 μs	0.2-0.4 ms	
50 μs	0.5-1.0 ms	
100 μs	1-2 ms	10-15 ms
200 μs	2-4 ms	
500 μs	5-10 ms	
1 ms	10-20 ms	90-150 ms
2 ms	20-40 ms	
5 ms	50-100 ms	
10 ms	0.1-0.2 s	0.9-1.5 s
20 ms	0.2-0.4 s	
50 ms	0.5-1.0 s	
100 ms	1-2 s	9-15 s
200 ms	2-4 s	
500 ms	5-10 s	
1 s		
2 s		
5 s		

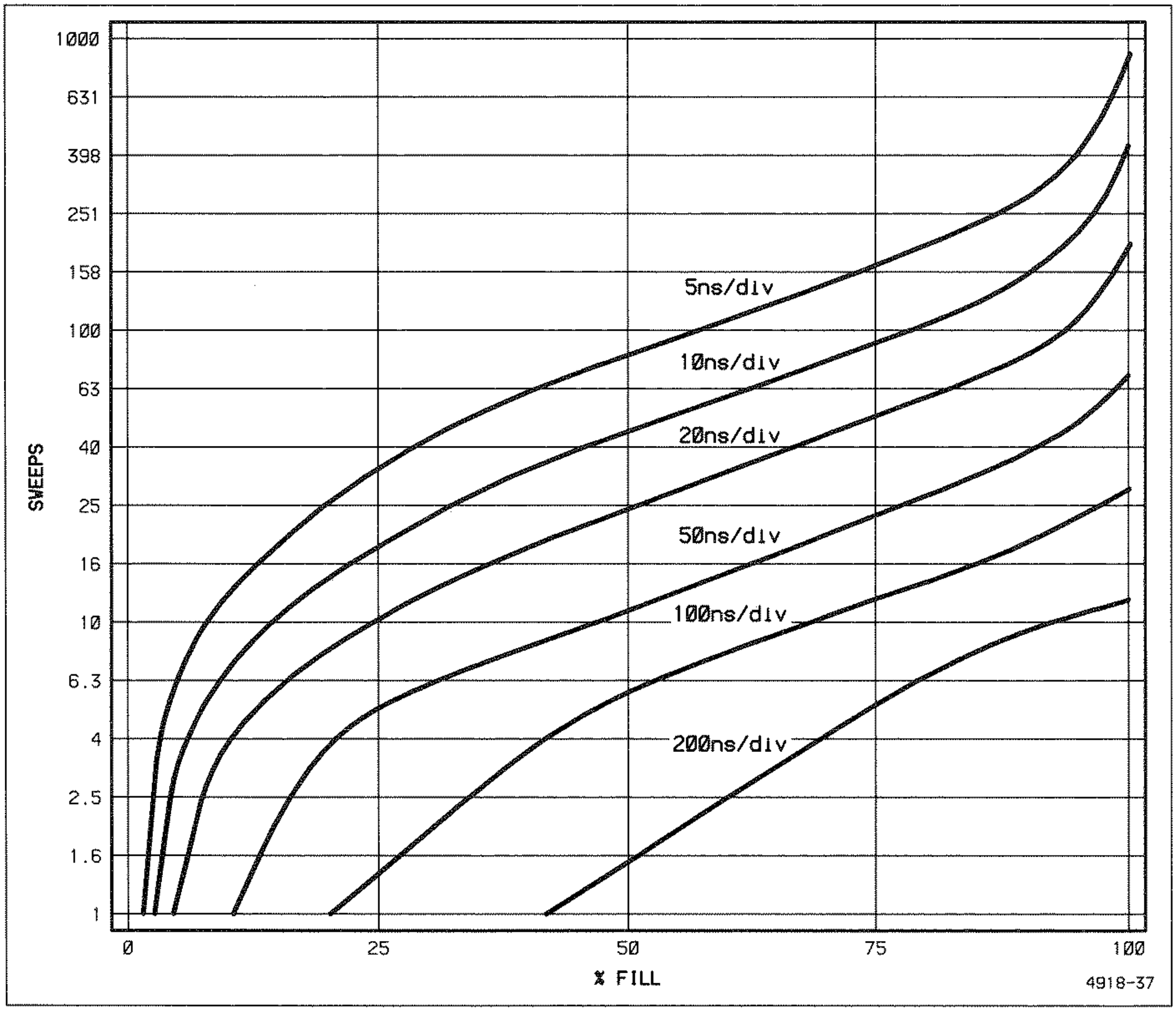


Figure C-1. REPET Mode sweeps required for % fill (99% confidence level).

Trigger LEVEL Range and Resolution

Table C-7 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 C-7

Trigger Level Range and Resolution

Trigger Gain (including probe)	Total Trigger Range		Trigger Resolution (1-point) 64 pt/div
	CH1 or CH2 (±18 div)	EXT1 or EXT2 (±9 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	9 V	4.5 V	7.8125 mV
200 mV/div	3.6 V	- - -	3.125 mV
100 mV/div	1.8 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 C-8 shows the approximate time interval (after the last trigger) until the system decides that either 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 C-8

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 the B Trigger is playing. Table C-9 shows the specific function.

Table C-9

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 C-10 indicates the selectable RTRIG position versus the data point at which it will be displayed in the next waveform acquisition.

Figure C-2 illustrates the A and 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 C-10

RTRIG Point Versus Trigger Position Menu Selection

Trigger Position Menu Entry	RTRIG Data Point In Display
1/8	128
1/4	256
1/2	516
3/4	768
7/8	896

Delay Time and Delay Time Resolution

Table C-11 shows the maximum delay time and delay time resolution for each 2430 B SEC/DIV setting. Maximum DELay time setting is 2621.4 times the B SEC/DIV setting, with a resolution of 1/25 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 is also constant.

Table C-11

Maximum B SEC/DIV Delay Time and Resolution

B SEC/DIV Setting	Maximum Delay	Delay Resolution
5 sec	3.64 hr	200 ms
2 sec	1.46 hr	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

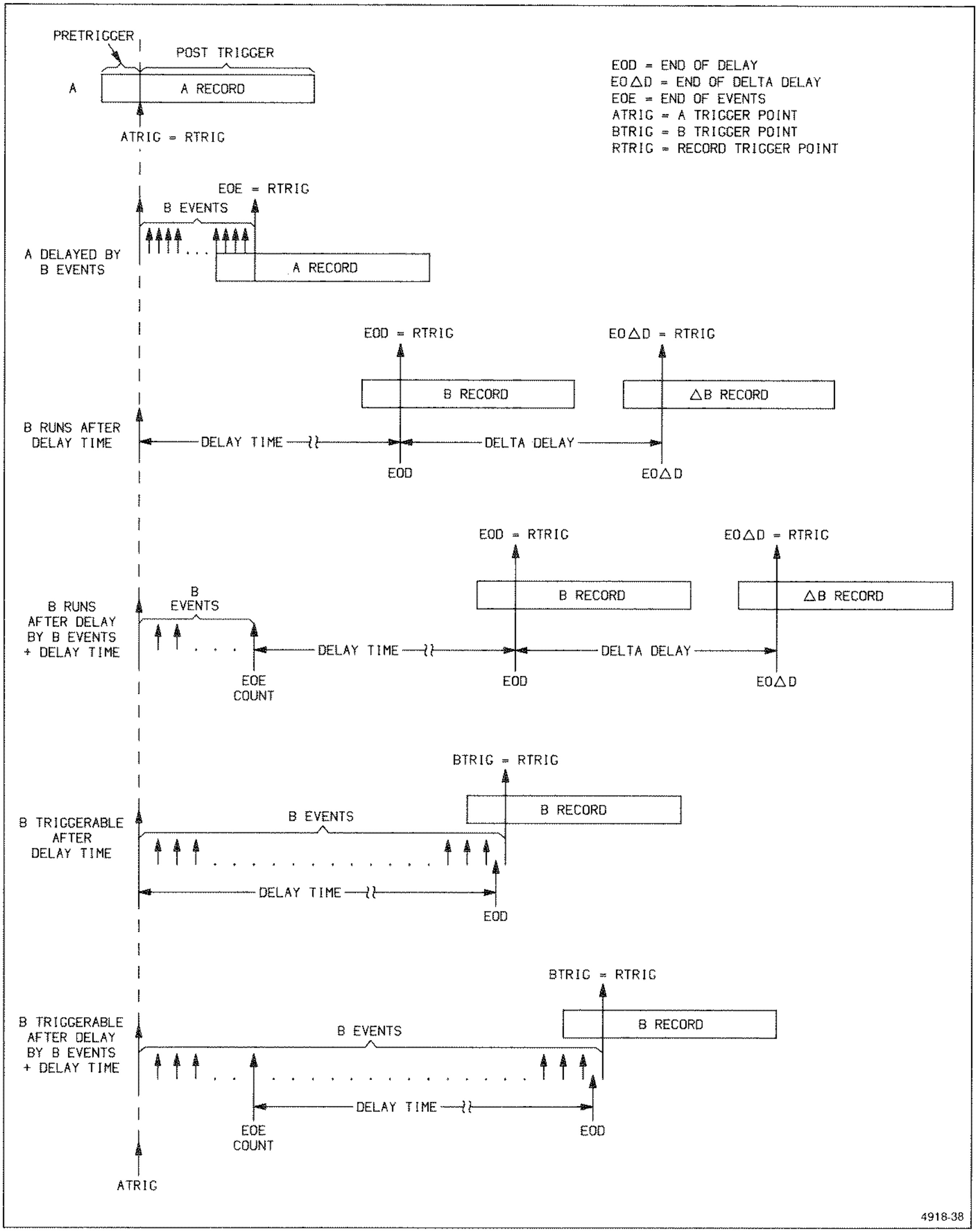


Figure C-2. RTRIG versus Horizontal Display Modes.

Trigger Status Indicators

The Trigger Status Indicators give visible evidence of what function is occurring within the system. At A SEC/DIV settings of 100 ms per division and slower, the switching occurs slowly enough to examine the state in detail. The only time during normal operation all trigger status lights are off is when the scope is in SAVE mode. Table C-12 is a summary of the switching states of the indicators.

TRIG'D—On at A TRIGGER; off when acquisition is done.

READY—On 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 ends.

ARMED—On at the start of each acquisition while pretrigger data is being acquired. During this time, no triggers are accepted. Off at the end of pretrigger holdoff.

NOTE

For an acquisition involving both A and B triggers, the READY and TRIG'D lights will both be on during the time between the occurrence of A trigger and the final B trigger.

Table C-12

TRIG'D, READY, and ARM Indicator Status

LIGHT	STATE				
	Armed	Ready	Atrig	Rtrig	Save
TRIG'D	off	off	on	on	off
READY	off	on	on	off	off
ARM	on	off	off	off	off

Waveform Display Summary

The 2430 is capable of drawing six waveforms, so when more than six waveforms are selected for display, the system uses a priority scheme. Table C-13 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 C-13

Display Priority Versus Display Mode

YT			XY
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 C-14.

In Table C-14, 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.

NOTE

If REF4 in EXTENDED FUNCTIONS is set for PNL additional front-panel SAVE/RECALL SETUPS, then REF4 will not be available to store reference displays and will not appear in the SAVE or DISPLAY REF control menus. In that case, REF4 will not be overwritten by the STACK REF function, and all reference to REF4 in Table C-14 should be ignored.

SAVE ON Δ Operation

The comparison channel for the SAVE ON Δ feature is given in Table C-15. 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 C-14

STACK REF 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 R2	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

Table C-15

SAVE ON Δ 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	

SAVE/RECALL SETUP Operation

A choice of either one or five front-panel memory locations is selectable using the EXTENDED FUNCTIONS menu. If the REF4 choice in the SYSTEMS control menu (under EXTENDED FUNCTIONS) is set to REF, only one front-panel memory location is available for saving setups and only "1" will be displayed in both the SAVE and RECALL second-level menus. Memory location 1 is long-term nonvolatile memory; memory locations 2 through 5 are shorter term nonvolatile memory (3 to 5 days).

Pressing the front-panel button labeled SAVE/RECALL SETUP calls up the following control menu:

```
SAVE/RECALL SETUP                  INIT
   SAVE      RECALL                PANEL
```

Pressing the SAVE menu button calls up the following second-level menu:

```
SAVE SETUP
   1      2      3      4      5
```

Pressing one of the numbered menu buttons in the second level causes the current instrument setup to be saved in the specified setup memory.

Pressing the RECALL menu button calls up the following second-level menu:

```
RECALL SETUP
   1      2      3      4      5
```

Pressing one of the numbered menu buttons in this second-level menu recalls the setup conditions previously stored under that number using the SAVE SETUP menu.

Pressing the INIT PANEL button in the SAVE/RECALL SETUP control menu sets up all the front-panel controls and menu selection in the predefined states shown in Table C-16.

Table C-16

INIT PANEL States

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
REF4	REF
DELAY Controls	
DELAY by EVENTS	OFF
Δ TIME	OFF
DELAY TIME	40 μs
Δ DELAY Time	0.0
DELAY EVENTS Nr.	1

Table C-16 (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
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	Midscreen
Display Mode	YT
BANDWIDTH	FULL
INTENSITY Controls	
SELECT	DISP
READOUT Intensity	50%
DISP Intensity	40%
GRAT Illum	0%
INTENS Level	80%
VECTORS	ON
WORD RECOGNIZER (SET WORD)	
Word Match	Don't Care (all x)
RADIX	HEX
CLOCK	ASYNC
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

Table C-16 (cont)

GPIB SETUP (OUTPUT)	
DEBUG	OFF
LONG	ON
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	OFF
Data Encoding (ENCDG)	RPBINARY
Data Target	REF 1
Data Source	CH 1
FASTXMIT	OFF
CURVE ONLY	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
VIDEO OPTION Setup (SET TV)	
Interlaced Coupling	FIELD1
Noninterlaced Coupling	FIELD1
TV SYNC	− (minus)
CLAMP	OFF
Line Count	525
Line Start	PREFLD
X-Y PLOTTER Setup (OUTPUT)	
Plot Graticule	ON
Plot Readout	OFF
PENLIFT	OPEN

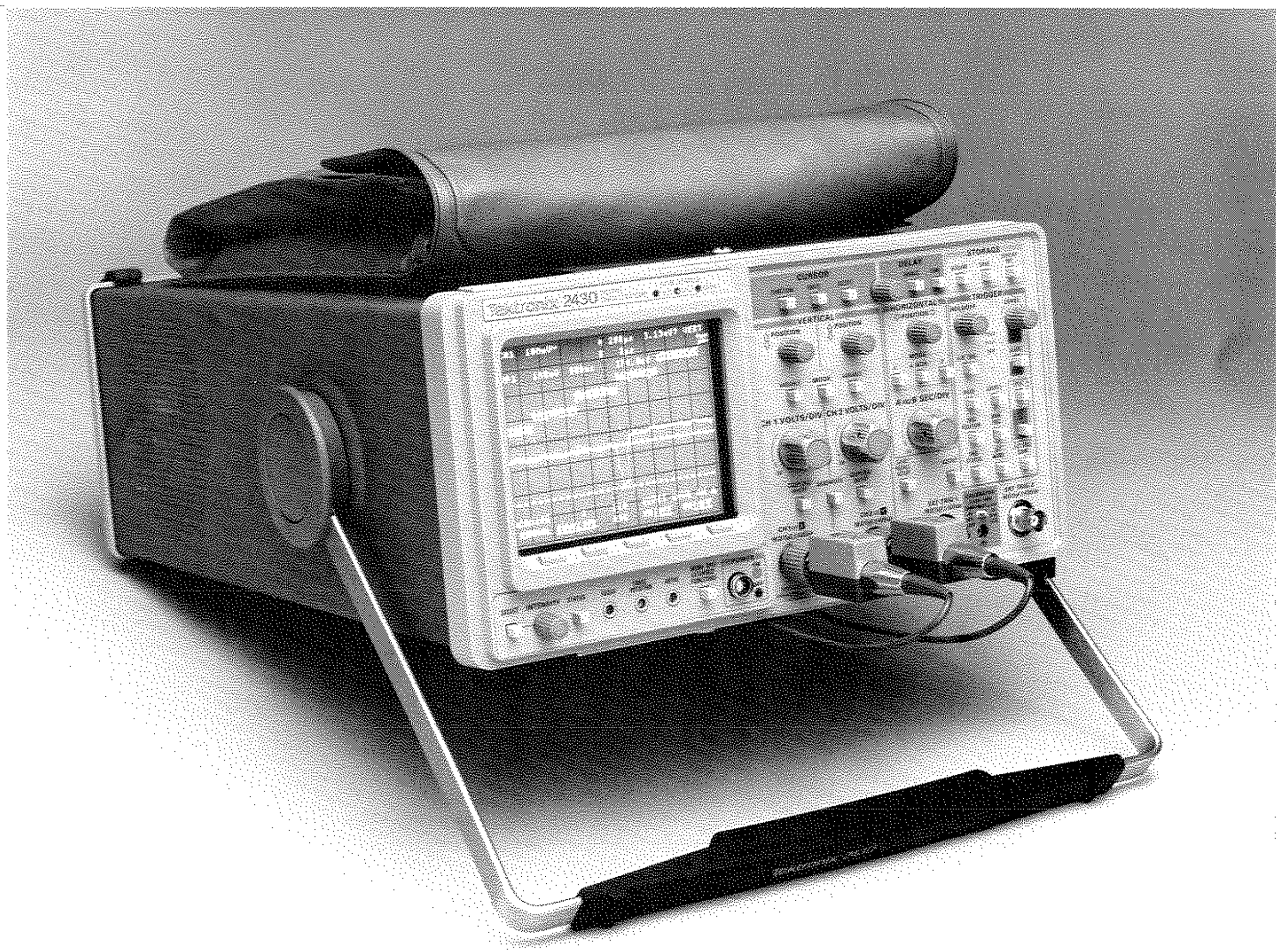
INDEX

TEK 2430 DIGITAL OSCILLOSCOPE

ENGINEERING NOTES
37W-6136

DIGITAL OSCILLOSCOPE CONCEPTS

- Calibration
- Effective Bits
- Averaging
- Save-on-Delta
- GPIB Fast Transmit



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CONTENTS

PREFACE

This document, made up of a series of five articles, is intended to promote greater understanding of several prominent features and design principles built into the 2430 Digital Oscilloscope. Each piece was written by a member of the engineering design team that developed the instrument and responds to an area where there have been requests for additional information.

CALIBRATION OF THE 2430 DIGITAL OSCILLOSCOPE

by Warren A. Finke

Calibration of the 2430 Digital Oscilloscope is as near to totally automatic as practical. This capability helps fulfill three major design objectives: (1) minimizing ownership costs for the end-user, (2) minimizing manufacturing costs for Tektronix, and (3) maximizing the instrument's "up time" at specified accuracy. The successful attainment of all these goals offers definite advantages to the user in terms of consistently high oscilloscope performance at significantly reduced life-cycle costs.

To accomplish this high degree of automatic calibration, the design team made wide use of digital calibration techniques. Instead of using a myriad of potentiometers and similar devices that depend on manual adjustment and, in many instances, require elaborate external test-signal references, the 2430 employs an extensive D-A converter subsystem. Together with built-in computer firmware, the subsystem is responsible for calculating and adjusting more than 100 voltages in the instrument.

Two Calibration Levels

The 2430 provides two levels of internal calibration: Self Calibration and Extended Calibration. Both levels can be initiated either locally from the front panel or remotely over the GPIB. Access is through the EXTENDED FUNCTIONS —CAL/DIAG menus, via menu entries titled SELF CAL and EXT CAL (see Figure 1).

When the SELF CAL routines are run, calibration adjustments to the instrument are made automatically by the subsystem. However, when running the EXT CAL routines, technicians themselves manually make additional calibration adjustments while interacting with the CRT readout.

Self Calibration. When the SELF CAL routines are selected, the D-A converter subsystem automatically calibrates virtually all of the analog measurement parameters within the 2430. Included are every gain and offset parameter for both the vertical acquisition system and the internal triggers. No adjustments are required in the horizontal subsystem (time base).

The entire self-calibration process takes less than 10 seconds to complete, even though it comprises a major portion of the instrument's total calibration requirements. No external equipment or stimuli are needed. The SELF CAL routines can be initiated at any time, thus guaranteeing accurate measurements in the current environment.

A user can ensure optimum instrument accuracy by performing a SELF CAL routine at three important times: (1) immediately before making critical measurements, (2) whenever the ambient temperature changes by more than 5°C since the last self calibration was completed, and (3) after the instrument warm-up period.

Figure 1. The CAL/DIAG menu showing PASS indications. These indicate that the SELF CAL and EXT CAL routines passed and parameters updated the last time they were run.

If all the parameters are within their specified tolerances at the end of the SELF CAL routines, a PASS message is displayed. However, if any parameter could not be properly calibrated, the subsystem automatically invokes the EXTENDED-DIAGNOSTICS menu. This menu in turn displays a FAIL indication opposite the label of each out-of-tolerance area (see Figure 2). At this point, the instrument operator can choose whether to make a measurement or not, depending on which parameter failed and how it would affect the measurement.

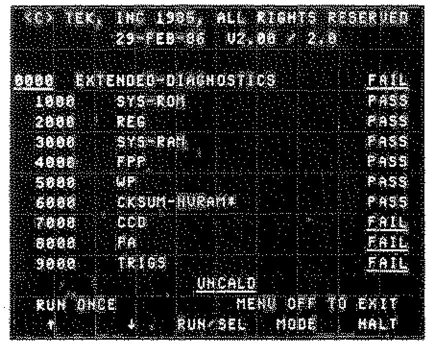

Figure 2. The EXTENDED-DIAGNOSTICS menu showing the 7000-, 8000-, and 9000-series tests are not within required limits.

Extended Calibration. The extended-calibration routines are for adjusting the remainder of the vertical acquisition and trigger system parameters. Four routines — accessed via the EXT CAL menu and labeled ATTEN, TRIGGER, REPET, and ADJUSTS — interactively guide the technician through the steps required for calibrating: (1) gain of the input thick-film attenuators, (2) gain and offset of the trigger amplifiers, (3) repetitive-mode ramps, and (4) the display system and Charge-coupled Device (CCD) amplifiers (see Figure 3).

All except the ADJUSTS routines can be accomplished without removing the instrument's cabinet; however, when these routines are run, external voltage references are needed.

During the EXT CAL routines, a FAIL display appears whenever there is an unsuccessful calibration attempt. When this occurs, the previous calibration constants are not overwritten and the instrument remains in its previously calibrated state. Also, when the EXTENDED-DIAGNOSTICS menu is invoked, an UNCALD message is displayed to warn the user that an attempted calibration has failed.

Two other conditions also can cause a FAIL message to be displayed: (1) a real hardware failure and (2) correct voltage levels are not connected as required.

Attenuator and external-trigger calibrations (ATTEN and TRIGGER) are recommended every 2000 hours, or once per year, if the instrument is used infrequently. On the other hand, repetitive-mode ramp and display calibrations (REPET and ADJUSTS) should only be performed whenever parts are replaced during instrument servicing. Unlike the SELF CAL routine, re-performing any portion of the EXT CAL procedure is not necessary to maintain maximum instrument accuracy over the ambient temperature range.

Manual Procedures. There are other manual adjustments in the 2430 for input capacitance, 50-MHz bandwidth limit, the CCD clock skew, the display system, and the CCD output amplifiers. Normally, these adjustments are made during the manufacturing process and should not require readjustment, unless parts are replaced during instrument servicing.

Dynamic Adjustments. During normal operation, the 2430 itself makes additional dynamic adjustments to the acquisition system and to the repetitive-mode ramps, which compensate for minor changes in offsets and repetitive-mode timing. These adjustments are both totally automatic and transparent to the user and require no service.

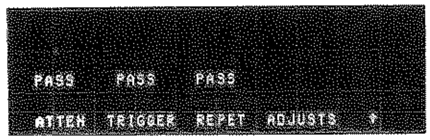

Figure 3. The EXT CAL menu showing that calibration routines for attenuator gain, trigger amplifier gain and offset, and repetitive mode ramps passed and parameters updated during the last time each routine was run.

NBS Traceability

Traceability to the National Bureau of Standards (NBS) means that an instrument's stated accuracy was established through calibration equipment whose own accuracies were fixed, either directly or indirectly, by NBS-certified references.

Before being packaged for shipment, the 2430 is calibrated with an external NBS-traceable source. Then, a jumper is installed inside the instrument to prevent an operator from accidentally running any extended calibration (EXT CAL) procedure that could void current calibration settings.

In the 2430, an external NBS-traceable voltage reference is used to calibrate the attenuators and external triggers via the EXT CAL menu (ATTEN and TRIGGER choices). When run, these calibrations not only make fine gain adjustments on the attenuators but also normalize the internal 10-V Calibration Reference to the external NBS-traceable source. This establishes the relative accuracy of the internal reference. The installed jumper disables the ATTEN and TRIGGER choices from the EXT CAL menu.

Once a complete sequence of the SELF CAL and the EXT CAL routines are performed successfully at the service center with an external NBS-traceable voltage reference, the 2430 and its internal 10-V Calibration Reference become traceable to NBS. Traceability is maintained, because subsequent SELF CAL routines use the internal (and unadjustable) 10-V Calibration Reference as the comparison source.

During a calibration attempt of the attenuators, should the external voltage reference and the internal 10-V Calibration Reference disagree by approximately two percent or more, a FAIL indication will appear. This indicates that one of the references is either faulty or incorrect. When a FAIL indication occurs, the previous attenuator calibration constants are retained and are not updated.

Failure Modes

If 2430 fails are detected that might affect instrument calibration, they are shown in the extended diagnostics (EXT DIAG) display. System, subsystem, and possibly device failures may be indicated, as well as the UNCALD calibration status. Failures can be of two types: (1) soft errors caused by drift in parameters (usually large operating temperature changes since the last self calibration) and (2) hard failures of 2430 components.

Potential soft errors are revealed to the user by: (1) failure of power-up diagnostic tests in the 7000 through 9000 range, (2) the word UNCALD displayed in the EXTENDED-DIAGNOSTICS menu, and (3) the word UNCALD displayed above the SELF CAL selection in the CAL/DIAG menu. These errors can be rectified by running SELF CAL and obtaining a PASS indication.

Hard failures are indicated by (1) a loss of the ability to run SELF CAL routines, (2) a FAIL indication when attempting to rerun SELF CAL, and (3) loss of EXT CAL (which points to a possible nonvolatile memory failure). In any of these cases calibration should be considered void, and the instrument serviced.

EFFECTIVE BITS—MEASURING DYNAMIC DIGITIZER ACCURACY

by Rolf Anderson

Specifications Determine Performance Limits

The desire of any test and measurement equipment user is to obtain an accurate picture of the signal under observation, with minimal distortion contributed by the test system. The user relies on specifications to determine what effect the test equipment will have on signal characteristics that are being measured.

In the analog oscilloscope realm, performance is stated in terms of widely known specifications such as bandwidth, rise time, aberrations, noise levels, linearity, and others. These limitations are also present in digital oscilloscopes, since they require analog front-end signal conditioning similar to analog scopes. In addition, digital scopes have performance considerations in the sampling circuit, and there is little industry consensus on testing methods or significance of the many popular digitizer specifications.

Common digitizer specifications include the number of bits, sampling rate, monotonicity, linearity, and aperture uncertainty. Although each of these has significance to the digital scope user, none gives an overall picture of digitizer performance. Effective bits combines all the other digitizer performance factors into a single specification that describes digitizer accuracy with respect to frequency. In essence, effective bits describes many specs rolled into one.

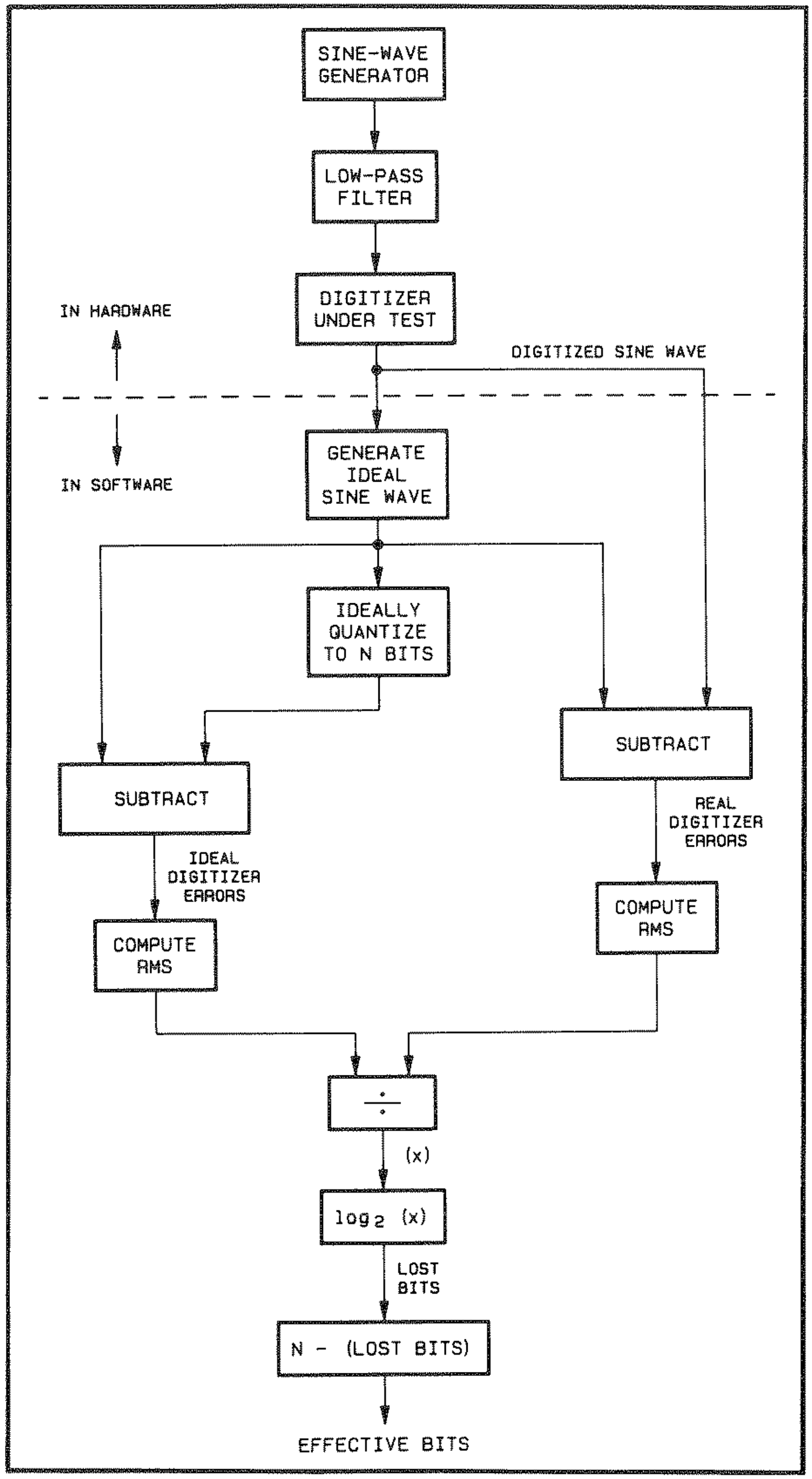

Figure 4. Procedure for measuring dynamic accuracy of an N-bit digitizer.

How Do We Measure Effective Bits?

The effective bits of a real digitizer are determined by comparing its output signal to the output of a theoretically perfect digitizer. An arbitrary input signal cannot be used, since obtaining a perfectly digitized version of the input signal would be impossible. Instead, sine waves are used, since high-frequency, high-quality sine waves are relatively easy to generate as the inputs to the real digitizer being tested. Also they are easily generated numerically as inputs to the perfect digitizer.

To perform the effective-bits test, a pure sine wave is fed into the real digitizer. Pure in this case means a sine wave whose harmonics are below the sensitivity of the digitizer. Harmonic distortion of the test waveform must be minimized, since it adversely affects the measurement of effective-bits. Typical leveled sine-wave generators are usable, provided their outputs are passed through an appropriate low-pass filter.

The sine wave is digitized, and the numerical data fed to a computer for analysis. During the analysis, numerical curve-fitting techniques are used to determine frequency, phase, amplitude, and dc offset parameters—which then are used to reconstruct the assumed-pure sine wave coming from the imperfect (real) digitizer output. Errors in these waveform parameters (frequency, phase, amplitude, and dc offset) that result from real digitization are not determined by the effective-bits analysis. The reconstructed sine wave is then numerically sampled in the computer— as though it were processed by a theoretically perfect digitizer.

The real digitizer's ouput is subtracted, sample by sample, from the computer-generated sine wave, leaving behind the digitizer errors. These real digitizer errors are then compared to the errors of an ideal digitizer with identical resolution. Using the error values, effective bits are determined by first computing the number of lost bits:

$$\text{Lost Bits} = \log_2\left(\frac{\text{Real Digitizer RMS Errors}}{\text{Ideal Digitizer RMS Errors}}\right)$$

Then subtract the lost bits from the available digitizer bits:

$$\text{Effective Bits} = (\text{Digitizer Bits Available}) - (\text{Lost Bits})$$

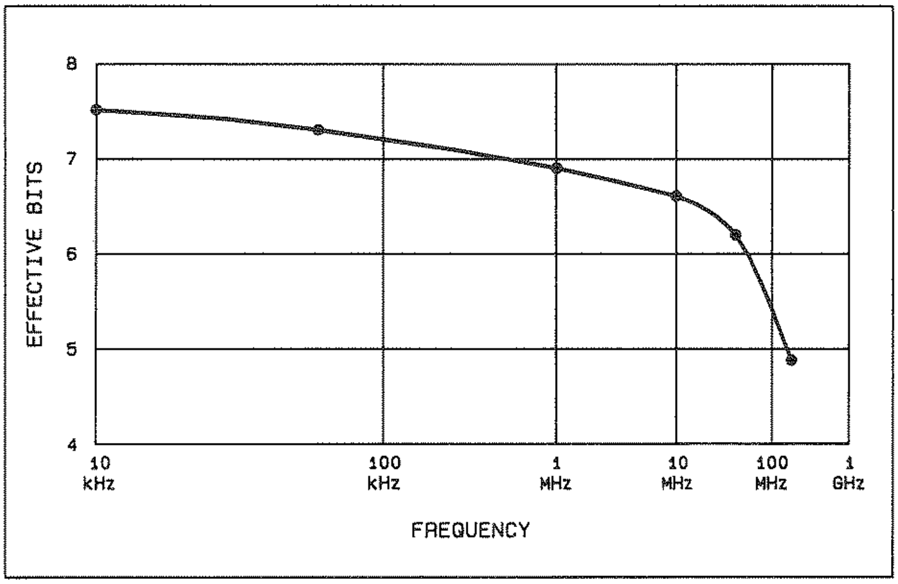

Figure 5. Dynamic performance of the 2430 Digital Oscilloscope. Measured with a five-division input signal and 50-ohm input coupling.

Frequency	Effective Bits
50 kHz	7.3
1 MHz	6.9
10 MHz	6.6
40 MHz	6.2
150 MHz	4.9[a]

[a]With 16 averages.

Effects of Input-signal Amplitude and Slew Rate

In terms of slew rate, a large input-signal amplitude places greater demands on both the front-end analog circuitry and the sampling circuits. Because of these greater demands, the effective bits are reduced as input-signal amplitude increases.

Well then, how should the input amplitude for an effective-bits test be determined? Most measurements are usually made with about five divisions amplitude, and specifications such as rise time and bandwidth also use a five-division input. Since a five-division input represents a typical measurement parameter, that is what was used for the 2430 effective-bits test.

The direct implication of effective bits for the user is that, for a given sine-wave measurement at a given frequency, the digitizer may be viewed as if it were an ideal digitizer whose dynamic vertical accuracy is specified by the effective bits at that frequency. Figure 5 and the accompanying table summarize effective-bits performance for the 2430 Digital Oscilloscope.

Vertical accuracy, when measuring other types of signals—for example, step functions—is not certain. This is due to the dependence of effective bits upon slew rate. It does mean, however, that signals with lesser slew rate—for example, a smaller-amplitude sine wave —will have greater vertical accuracy. And those with greater slew rate—such as a step input—will probably have less.

Additional References

DeWitt, Laurie, "Dynamic testing reveals overall digitizer performance," *HANDSHAKE*, Vol 10 No. 1 (Spring 1985): 8-11.

"Dynamic Performance Testing of A-to-D Converters," Hewlett-Packard Product Note 5180A-2.

IMPROVING MEASUREMENT SIGNAL-TO-NOISE RATIO AND RESOLUTION THROUGH AVERAGING

by Rolf Anderson

Why Averaging?

Noise pervades every electrical system, whether it's a piece of test equipment or a circuit under test. When viewed on a digitizing oscilloscope, a signal often can be completely obscured by noise and will sometimes appear to contain no useful information.

Because of its random nature, noise can be partially eliminated from the oscilloscope display. More importantly, its random qualities also can be used as the means to increase digitizer resolution. Recent developments in fast-waveform processing spurred the evolution of averaging techniques for efficiently reducing the noise seen on a display and improving the scope's measurement resolution.

The averaging process in a typical digital-storage oscilloscope uses the differences between signals of interest and random additive noise sources. Because of the time-locked positioning of samples relative to the trigger point in successive acquisitions, any given sample amplitude consists of two parts: a fixed signal component and a random-noise component.

The desired incoming signal contributes a fixed amplitude component to each given sample position in each triggered acquisition. Random noise, however, does not have a fixed time relationship to the trigger point. Because of this, noise may be viewed as numerous signals added together, with each noise signal being different in frequency from the desired signal. Noise signals move in time relative to the triggered signal, contributing positive and negative amplitudes equally to each sample in the acquisition record.

The amount of noise reduction increases with the number of acquisitions averaged, as the average of the noise amplitudes approaches zero.

The 2430 Combines Two Averaging Methods

The usual definition of averaging means that N numbers are added together, then their sum is divided by N. If only this algorithm were implemented in a digital storage oscilloscope, it would create an inconvenience for the user. Since the display would not be updated after each acquisition, the scope user would have to wait until the N acquisitions had taken place before seeing the averaged signal.

Another factor that the scope designer must consider when implementing an averaging function is that some signals may vary in amplitude, frequency, and phase over time. Normal averaging techniques would eventually "average away" most of these types of signals. For these reasons, the 2430 blends togeher two methods of averaging: stable and exponential.

Stable averaging is a variation on the usual meaning. It adds a correction term to the current acquisition value, which is based upon previous averages. This produces a display that not only is updated with each acquisition but also becomes less noisy after each update.

The stable averaging algorithm is:

$$A_n = A_{n-1} + \frac{x_n - A_{n-1}}{2^j},$$

for

$$2^{n-1} < j \leq 2^{n+1};$$

where

- A_n is the new data-point estimate,
- A_{n-1} is the previous data-point estimate,
- x_n is the current-acquisition value, and
- j is an integer value such that the resulting divisor, 2^j, is the first power of two greater than or equal to the current acquisition number (see Table 1).

Table 1
Relationship of Current Acquisition Number to the Divisor 2^j

Acquisition Number	j	2^j
1	0	1
2	1	2
3	2	4
4	2	4
5	3	8
6	3	8
7	3	8
8	3	8
↓	↓	↓
253	8	256
254	8	256
255	8	256
256	8	256

Stable averaging produces slightly less improvement—that is, a smaller signal-to-noise improvement ratio (SNIR) —than conventional averaging (see Table 2). In the 2430, stable averaging occurs on the first T acquisitions, where T is the number of user-selected averages. After T acquisitions are made, averaging automatically switches to the exponential method.

Table 2
Stable Averaging SNIR

Selected Averages (T)	Signal-to-Noise Improvement Ratio		% of Conventional
	Numeric	dB	
2	1.41	3.0	100
4	1.98	5.9	98.9
8	2.75	8.8	97.2
16	3.84	11.7	96.1
32	5.34	14.6	94.4
64	7.51	17.5	93.9
128	10.60	20.5	93.3
256	14.90	23.4	92.8

Exponential averaging gets its name from the fact that the averaging is exponentially weighted toward the newest samples. Its algorithm is identical to the stable-averaging algorithm, except that the divisor, 2^j, is replaced by T, the number of user-selected averages. Because the divisor now is a constant, the algorithm never ends. This means that each averaged update of the display tracks the incoming waveform with a time constant equal to T divided by the acquisition rate.

Table 3 lists, at each value of T, the expected time constant for 8-bit accuracy and 11.3-bit accuracy, which is needed when the waveform is expanded by a factor of 10. The effects of exponential averaging are most noticeably demonstrated on a slowly changing waveform.

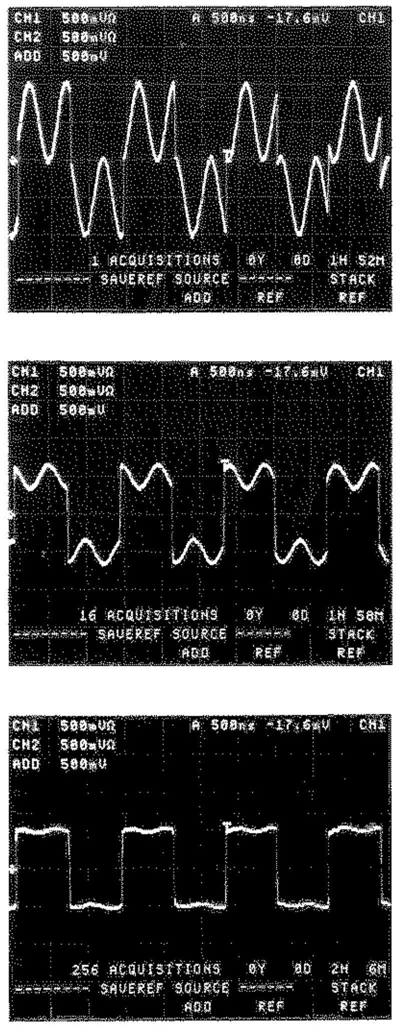

Figure 6. Averaging sequence of a square wave added to a slightly different frequency sine wave. Triggered on the square wave. Watch the sine wave average out.

Table 3
Time Constants to Achieve Accuracy

Selected Averages (T)	Time Constants	
	8-bit Accuracy	11.3-bit Accuracy
2	300 ms	410 ms
4	723 ms	988 ms
8	1.56 s	2.13 s
16	3.22 s	4.40 s
32	6.55 s	8.95 s
64	13.20 s	18.00 s
128	26.50 s	36.20 s
256	53.10 s	72.60 s

Obtainable Improvement is Not Unlimited

The achievable signal-to-noise ratio improvement is limited by other noise sources that are not random but are related in some way to the signal being digitized. For example, if a measurement has harmonics that are above the useful bandwidth of the digitizer at the selected sweep speed, the harmonics will be aliased onto the fundamental, thus producing errors.

Time jitter, when averaged, produces a low-pass filter characteristic. Also, within the oscilloscope, signals related to the sample rate by frequency produce errors that cannot be reduced through averaging. Another limitation on signal-to-noise ratio is the word length used in the averaging algorithm itself. As successive acquisitions are averaged, the least significant bits of the result must be rounded (because of finite word length used in the algorithm), thereby limiting resolution.

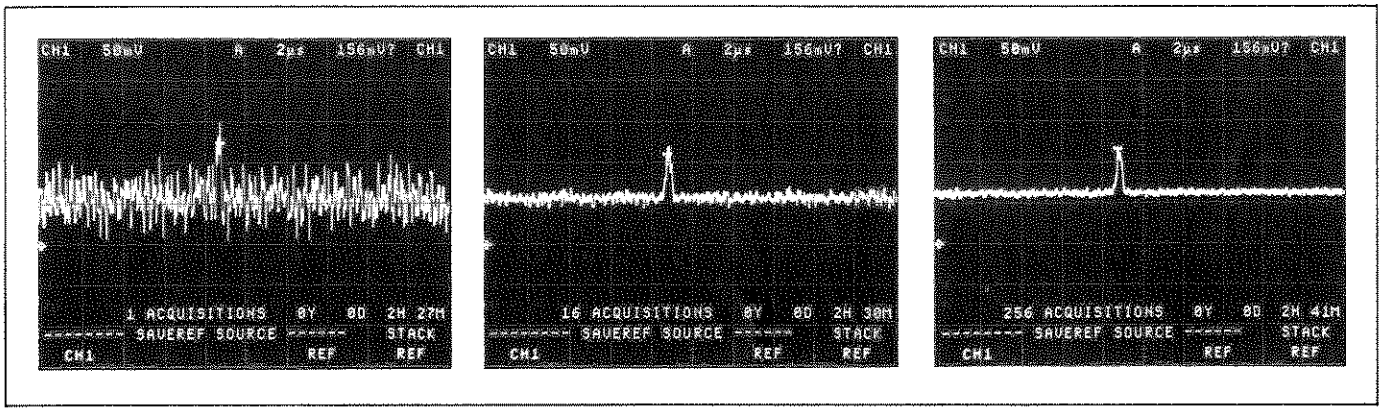

Figure 7. Averaging sequence of a very noisy signal.

Resolution is Increased

Averaging also increases the potential resolution of the digitizer. The increased resolution may be better understood by following the example of an eight-bit digitizer. The value of an eight-bit number ranges from 0 to 255. If you add two eight-bit numbers together, the range of values goes from 0 to 510. Thus the value of one count decreases from 1/255 to 1/510, giving increased resolution. This increased resolution will be obtained when dividing to obtain the average, provided the number of bits used in the calculation is sufficient to prevent round-off or truncation errors.

For example, the resolution for a sample of 128 and for a sample of 127 is 1. Their averaged value is 127.5, but now the resolution is 1/2. Resolution has doubled. In fact, the resolution increases by a factor of N, or $\log_2 N$ bits, when N acquisitions are averaged using stable averaging. Exponential averaging requires more acquisitions to obtain the same resolution improvement as stable averaging.

The presence of random noise in the digitizer is essential for producing this extra resolution. Assume for the moment that the system had no noise. Then, whenever an input signal is quantized to some number, say 10, at some sample point, every later acquisition would quantize that point to the same number (10), and the average would be 10, even though the signal may actually be 9.5. Now re-introduce the noise. The chosen sample point during one acquisition may now read 9, and at the next acquisition read 10, producing an average of 9.5. An extra digit of resolution has therefore been achieved.

Remember that resolution is not the same as accuracy. In spite of the fact that the extra resolution can be computed, the digitizer is still limited to the signal-to-noise limitations mentioned earlier.

Nonrepetitive Signals Can Be Made to Appear Repetitive

To be averageable, signals must be repetitive. Signals that are nonperiodic can sometimes be made to appear periodic to the scope for averaging purposes. For example, an infrequently occurring glitch may be made periodic by setting the scope to trigger on the glitch, then use averaging with NORM TRIGGER MODE selected.

Noise Reduction

A good portion of most measurements involve measuing repetitive signals. Thanks to the fast waveform processing of the 2430, the user may choose to constantly reduce noise through averaging, with no loss of display update rate.

Additional References

Oppenheim, Alan V., and Ronald W. Schafer. *Digital Signal Processing.* Englewood Cliffs: Prentice-Hall, 1975.

Trimble, Charles L. "What is Signal Averaging?" *Hewlett-Packard Journal* (1968).

Table 4
Display-Request List

Selected VERTICAL MODE	DELAY by TIME Δ TIME	Displayed Live Waveforms	Compared Against Selected DISPLAY REF		
			REF1	REF2	REF3
CH1	OFF	CH1	CH1	—	—
CH2	OFF	CH2	CH2	—	—
CH1 + CH2	OFF	CH1 + CH2	CH1	CH2	—
ADD	OFF	ADD	ADD	—	—
ADD + CH1	OFF	CH1 + ADD	CH1	ADD	—
ADD + CH2	OFF	ADD + CH2	ADD	CH2	—
ADD + CH1 + CH2	OFF	CH1 + CH2 + ADD	CH1	CH2	ADD
MULT	OFF	MULT	MULT	—	—
MULT + CH1	OFF	CH1 + MULT	CH1	MULT	—
MULT + CH2	OFF	MULT + CH2	MULT	CH2	—
MULT + CH1 + CH2	OFF	CH1 + CH2 + MULT	CH1	CH2	MULT
CH1	ON	CH1 + CH1/D2	CH1	CH1/D2	—
CH2	ON	CH2 + CH2/D2	CH2	CH2/D2	—
CH1 + CH2	ON	CH1 + CH2/D2	CH1	CH2/D2	—
ADD	ON	ADD + ADD/D2	ADD	ADD/D2	—
ADD + CH1	ON	ADD + ADD/D2 + CH1 + CH1/D2	ADD	ADD/D2	—
ADD + CH2	ON	ADD + ADD/D2 + CH2 + CH2/D2	ADD	ADD/D2	—
ADD + CH1 + CH2	ON	ADD + ADD/D2 + CH1 + CH2/D2	ADD	ADD/D2	—
MULT	ON	MULT + MULT/D2	MULT	MULT/D2	—
MULT + CH1	ON	MULT + MULT/D2 + CH1 + CH1/D2	MULT	MULT/D2	—
MULT + CH2	ON	MULT + MULT/D2 + CH2 + CH2/D2	MULT	MULT/D2	—
MULT + CH1 + CH2	ON	MULT + MULT/D2 + CH1 + CH1/D2	MULT	MULT/D2	—

SAVE-ON-DELTA OPERATION

by Fred Azinger

A powerful new capability was implemented in the 2430 Digital Oscilloscope—the ability for the instrument itself to make pass-fail measurement decisions for you! This feature, called Save-on-Delta, accords scope users an added dimension of efficiency in hunting and finding those infrequently occurring events. It offers them the freedom of unattended operation while tracking down circuit problems.

Essentially, the Save-on-Delta function compares incoming waveforms with a user-defined reference waveform or envelope, then automatically stores those incoming waveforms that exceed the limits set by the reference. Therefore, making the best use of this feature and correctly interpreting its results requires some knowledge about how Save-on-Delta comparisons are initially set up and how the instrument subsequently performs them.

From the user's standpoint, there are three basic steps involved in setting up the 2430 for Save-on-Delta operation: (1) establishing the waveform-comparison pairs, (2) establishing the comparison mode, and (3) generating the comparison waveform envelope. The first two are discussed in this note; the latter is the subject of a separate application note.

Setting Up the Comparison Pairs

When SAVE ON Δ is selected, the 2430 determines which reference waveforms—that is, those stored in the reference memories—can be compared against an incoming signal. It does this via an internally stored display-request list, which maintains a status of waveforms that have been selected for display. These include both incoming live waveforms and those saved in reference memories.

Updating the list occurs whenever any one of the following three parameters are changed using the front-panel controls and menus: VERTICAL MODE displays, DELAY (by) TIME Δ TIME status, and DISPLAY REF selections. Hence, the settings of these three parameters control which incoming live waveform will be compared against an appropriate stored reference waveform. In other words, they establish the waveform-comparison pairs.

It is important to note here that, although there can be more than six waveform-display requests active at any time, the inability of the display system to show more than six waveforms at a time does not affect the operation of the Save-on-Delta function.

The many waveforms available within the 2430 for display produce a great number of choices for Save-on-Delta comparison operations. To minimize the complexity of the human interface required for making all these choices and to avoid diminishing the host of useful capabilities in the Save-on-Delta function, we implemented a table-driven approach. It is similar to that used in the operation of the STACK REF feature.

When determining the particular live waveform that will be compared against a specific reference waveform, the oscilloscope looks at the selections made in the VERTICAL MODE menu. This information, along with the DELAY (by) TIME Δ TIME status, are used as indexes into the display-request list. It then looks at which DISPLAY REF memories are selected. If it sees that both the live waveform and the contents of a specific DISPLAY REF memory are both selected for display (refer to Table 4), then a Save-on-Delta comparison for this pair of waveforms is programmed-up for the waveform processor.

This method of deciding when to perform the comparisons gives a user the ability to "babysit" one node in a circuit while observing another node of interest. To determine which comparisons are considered, look at the line that corresponds to the selected VERTICAL MODE and DELAY by TIME Δ TIME status. Next, look into the table on that row to find the particular live waveforms that will be compared against specific references. Continue along the same row to find a matching waveform in the DISPLAY REF columns.

For example, suppose you have selected MULT and CH2 VERTICAL MODE, with DELAY (by) TIME Δ TIME toggled ON, and both REF 1 and REF 2 selected for display. In this instance, a Save-on-Delta comparison operation occurs between the incoming live multiplied waveform at the first delay (MULT) and the reference waveform stored in REF 1. A comparison also occurs between the live waveform display at the second delay (MULT/D2) and the waveform stored in REF 2.

Establishing the Comparison Mode

There are three comparison modes for the 2430 Save-on-Delta function — we'll call them Standard, Roll, and Repetitive. The criteria for differentiating between these three modes are: the SEC/DIV setting, the ACQUIRE REPET status, and the A TRIGGER MODE selection. Each mode (Standard, Roll, and Repetitive) causes the Save-on-Delta comparison operation to be performed in a different way. Collectively, they offer greater flexibility to the user in handling signals with a wide variety of characteristics. Table 5 summarizes the criteria for each comparison mode.

Table 5
Establishing Save-on-Delta Comparison Modes

Save-on-Delta Comparison Mode	If SEC/DIV Setting Is	Then Selected A TRIGGER MODE Should Be	And Selected ACQUIRE REPET Should Be
Standard	100 ms/div and slower	Any except ROLL	Either ON or OFF
	50 ms/div and faster	Any	OFF
Roll	100 ms/div and slower	ROLL	Either ON or OFF
Repetitive	200 ns/div and faster	Any	ON

Standard Mode. For the Standard Save-on-Delta comparison mode, any SEC/DIV setting can be used. If it is set at 50 ms/div or faster, the A TRIGGER MODE selection can be any of the four choices, but ACQUIRE REPET should be toggled OFF. When the SEC/DIV setting is slower than 50 ms/div, any A TRIGGER MODE except ROLL should be selected, and REPET acquisition can be either ON or OFF. Remember that if AUTO A TRIGGER MODE is active when the sweep speed is 50 ms/div or faster, it automatically changes to ROLL whenever the sweep speed is shifted to a setting slower than 50 ms/div.

In the Standard mode, the entire 1024-point live waveform record is compared against the reference record, which is assumed to be 512 maximum-minimum pairs. Each maximum-minimum pair of points on the incoming live waveform is compared with the corresponding pair of points on the reference waveform to determine whether either point exceeds its respective limit.

Roll Mode. In Roll mode, the SEC/DIV setting must be slower than 50 ms/div. The selected A TRIGGER MODE should be ROLL, and ACQUIRE REPET can be either ON or OFF.

If the Standard Save-on-Delta method of implementing comparisons were to be used also in the Roll mode, each incoming data point, given enough time, would be compared to every maximum-minimum pair in the reference waveform. This is due to the way data rolls through the record in Roll mode.

As a result, the Save-on-Delta comparison in fact is a DC level comparison. Its maximum limit is equal to the minimum of all the maximums, and its minimum limit is equal to the maximum of all the minimums. Accordingly, the usefulness of the Roll Save-on-Delta function is confined to monitoring DC levels. Moreover, if the reference is a DC window only, then the first incoming sample to exceed the window causes the 2430 to enter SAVE, and the errant sample will be at the very end of the record — at essentially 100% pretrigger.

To broaden the usefulness of the Roll Save-on-Delta mode, it was decided to only make comparisons around the trigger position. When ROLL TRIGGER MODE is selected and SAVE ON Δ acquisition is OFF, the trigger position is usually irrelevant. However, when ROLL is selected and SAVE ON Δ is ON, trigger position becomes important for controlling the amount of pretrigger samples that are preserved when an excursion outside the reference envelope is detected.

Therefore in the Roll Save-on-Delta mode, comparisons happen only on those sample occurring from about 20 sample points ahead of the trigger position through the sample at the trigger position. In the ideal situation, only the sample at the trigger position needs to be checked. But due to the batched nature of the way the comparison operation is implemented in the 2430, this window was enlarged.

Repetitive Mode. In this Save-on-Delta mode, REPET acquisition must be toggled ON, and the SEC/DIV SETTING should be 200 ns/div or faster. The A TRIGGER MODE can be any selection.

Now, since the waveform is built up using many acquisitions, there must be yet another way for Save-on-Delta comparisons to take place. At the start, all waveform data points are intitialized to −128, which indicates that a data sample has yet to be acquired for the current position in time within the record. Because of these yet-to-be-acquired samples, a Standard-mode comparison, if implemented, would cause the scope to enter SAVE immediately. Therefore, only the points in the live waveform (that were updated during a particular acquisition) are compared with the reference envelope. Since REPET does not operate in ENVELOPE mode, both the maximum and the minimum points of the reference envelope (that correspond with the live points sample period) are compared.

Other Operational Considerations

One scope parameter that does not affect Save-on-Delta operation is Horizontal Position. This parameter is germane only to the display system. It determines what points are displayed but has no effect on how or where the Save-on-Delta comparison is done. However, here's an important tip to remember when using the Save-on-Delta function. Lock the Horizontal Positions so that all reference waveforms will track the horizontal position of the live waveforms. Then when the 2430 enters SAVE, the event that caused the Save-on-Delta to occur will be centered on the screen, with its reference envelope appropriately positioned also.

Another significant aspect of using the Save-on-Delta function is the rearm dead time. This is the period during which the 2430 is busy processing its last acquisition. Throughout this interval, the scope is not ready to start acquiring data for the next acquisition. And while the scope is not acquiring data, it cannot be performing a Save-on-Delta comparison. However, it is important to note that although the Roll Save-on-Delta mode is effective only for monitoring DC levels, the combination of ROLL TRIGGER MODE and ENVELOPE acquisition (with the peak detectors) yields 100% coverage for a ⩾4-ns event.

USING THE GPIB-FAST-TRANSMIT MODE FOR WAVEFORM TRANSFER

by Steve Lyford

Transferring waveforms from a 2430 Digital Oscilloscope to another device in a GPIB-driven sytems environment can be speeded significantly by using the fast-transmit mode. This article describes the fast-transmit function, with several examples, and how it can be used to attain the highest waveform transfer rate available from the 2430 when it's used as part of a GPIB system.

Although the 2430 can send single waveforms at high rates, the real power of the fast-transmit mode (hereafter labeled FAStxmit to conform with its GPIB command header) becomes apparent in repetitive-transfer situations, where multiple waveforms must be acquired then sent to a controller.

Because of its high update rate, the 2430 can acquire a waveform, send it to the controller, and rearm itself for the next acquisition fast enough to capture and send up to 47 waveforms per second. In any measurement situation where the trigger rate is less than the transfer rate (for instance, video frame rate), FAStxmit delivers full coverage, with an acquisition and transfer occurring between every trigger.

In the 2430, the 9914A interface chip is still used for handshake control, but to speed things up, the system processor shuts down all unnecessary overhead and concentrates on sending bytes over the bus.

Memory Background

When data comes out of Acquisition memory, it goes into what is called the Save memory. If waveform expansion and positioning are selected, the waveform processor performs the required operations on the waveform in Save memory, then transfers it into Display memory. The ADD and the MULTIPLY waveforms also are created from waveforms in Save memory, then likewise placed into Display memory.

There are four slots available in Save memory—one each for the CH1 and CH2 main-sweep waveforms and one each for their respective delayed waveforms. Normally, when a waveform is requested using the CURVE? query (and not using FAStxmit), the requested waveform is built out of Save-memory contents, stored in another holding memory, then transmitted to the controller. Therefore, the waveform received at the controller is the same one displayed on screen.

But when FAStxmit is selected, a waveform transmitted to the controller comes directly from Save memory. In this transmission mode, there can be situations when the waveform received at the controller does not match the waveform being displayed on screen. This can happen when expansion or processing functions are selected (since the expanded, positioned, multiplied, and added waveforms are built from Save-memory contents, then placed into Display memory). Although the transmitted and displayed waveforms may not match, the waveform received at the controller is always the one that was acquired by the 2430.

How to Set Up FAStxmit

Let's see how we use the FAStxmit command to set up the 2430 for fast transfer of waveforms to a controller. First, the waveform of interest must be specified in the argument; the choices available are DELta and NORmal.

If DELAY by TIME Δ DELAY is OFF (use DLYTime? DELta), then NORmal is the selection you want. This will send to the controller the contents of the CH1 or the CH2 slot or BOTH slots in Save memory. Which waveforms are transmitted depends on the link argument selected to follow the NORmal argument.

If DELAY by TIME Δ DELAY is ON, and you are interested in the delay waveforms, then select the FAStxmit DELta argument. This will retrieve data from the delay slots in Save memory. Again, the chosen link argument (CH1, CH2, or BOTH) determines the waveforms that will be sent.

If the link argument BOTh is selected, then the specified number of waveforms from each channel are transmitted in the following sequence: CH1, CH2, CH1, CH2, CH1, . . ., CH2.

Examples:

FAStxmit NORmal:CH1	Sends Channel 1 main-sweep waveform(s).
FAStxmit DELta:CH2	Sends Channel 2 delay waveform(s).
FAStxmit NORmal:BOTh	Sends both Channel 1 and Channel 2 main-sweep waveform(s).

The next step is to specify the number of waveforms you want to send. This number can range from 1 to 65535, and it sets the quantity of acquire-send sequences that will be completed before the FAStxmit mode ends.

Examples:

FAStxmit 20000
FAStxmit 1
FAStxmit DELta:CH1,15

The last example sets up the 2430 to send 15 Channel 1 delay sweeps. If the 2430 were in an ACQUIRE mode, each waveform would be newly acquired before it's transmitted. And if a SAVE mode were selected, each transmitted waveform would be a copy of the one before it (since no new acquisitions would occur).

The final step starts the fast-transmission process. Waveforms begin transmission when the 2430 is addressed to talk—or more specifically, when a transition occurs from the untalk condition to being addressed to talk. Only when the controller issues the talk address for the 2430 and the user has requested FAStxmit waveforms will the fast-transmission sequence begin.

Before sending the talk address, the programmer should allow enough time for the 2430 to interpret and turn on the FAStxmit command. A minimum delay of 50 ms is necessary between sending a FAStxmit NORmal:CH1 command and requesting input from the 2430 (by addressing it to talk). This is needed to ensure that the 2430 recognizes the fact that FAStxmit is now active.

Sample Program

The following program example is one way that the fast-transmit mode can be implemented. This example was done in 4041 basic, and the 4041's Direct Memory Access (DMA) mode is used to maximize transfer speed. Using the DMA mode requires that Option 01 be installed in the 4041.

```
 10  !
 20  ! Fast Transmit Example
 30  !
 40  Scope=1
 50  Open#scope: "gpib1
       (pri=1,eom=<0>,
       tra=DMA,tim=2):"
 60  !
 70  Dim wave$ to 32000
 80  !
 90  Prin#scope: "fas 30 ,nor:ch1"
110  Wait .05
120  Inpu#scope:wave$
130  !
140  Prin#scope:"fas off"
150  End ! end of fast transmit
```

The program acquires 30 main-sweep waveforms from Channel 1 and stores them in a variable—wave$. Line 110 inserts the necessary delay to ensure that the 2430 knows it is in the fast-transmit mode before it is sent a transition command changing its condition from untalk to talk. The "print" statement in line 90 performs an untalk when it is finished, and the "input" statement in line 120 performs a talk when it begins. Line 140 is not executed until all of the fast-transmit waveforms have been sent. This example produced a transmittal rate of about 40 waveforms per second, with the A SEC/DIV set to 100 µs/div and the display turned off.

Potential Traps

Each succeeding FAStxmit waveform is transmitted right after the waveform processor finishes moving it from Acquisition memory to Save memory. The code for starting the FAStxmit sequence resides in the waveform-processor-done (wpdn) interrupt routine. It's important to realize that waveform acquisitions are what stimulate the wpdn interrupt—and subsequently cause the FAStxmit waveform transmissions. Because of this implemented sequence, there are two situations that should be avoided.

One exists if a user activates FAStxmit while the 2430 is acquiring in ROLL mode. In this case, since there is constant waveform acquisition during ROLL operation, no wpdn interrupts are generated; it takes a transition to SAVE mode to supply the necessary wpdn interrupt. The controller must be used to cause the 2430 to go into SAVE mode by sending it a RUN SAVE command before starting the FAStxmit sequence. If the programmer does not observe this step, bus operation will hang up.

The other situation occurs after a user requests FAStxmit DELta waveforms with the DELAY by TIME Δ DELAY mode OFF. In this case, the 2430 is prevented from ever acquiring a delay waveform, so the necessary wpdn interrupt will never be generated. Meanwhile, the FAStxmit sequence continues to wait for an interrupt—thus, it too suspends the GPIB.

In both of these situations, only the bus hangs up—the front-panel operation is not affected. The reason is that, when the 2430 recognizes it's been addressed as a talker, it turns off the interrupt coming out of the 9914A interface chip. This is done to reduce conflicts arising from polling information that possibly could be changed by the interrupt. Transfer of the waveform data is precluded by the handshake routine, which polls the interrupt bit and only looks to see whether the GPIB is ready for a new byte. At this point, the 2430 is in an output-only mode and will not pay attention to any bus command until all the requested waveforms have been sent.

To get out of this predicament, the operator can take one of two alternatives: (1) turn OFF the POWER switch to reset things, or (2) press the SAVE button on the front panel to stimulate the transition needed for generating the wpdn interrupt. Although both alternatives are extreme, the tradeoff is speed. And since FAStxmit is a special mode for users with a need for speed, it seems reasonable.

Speed is also a factor in the decision to ignore Device Clear, Interface Clear, and the Talk and Listen address changes until the FAStxmit sequence is complete. Because the interrupts are turned off, checks for these events would be made during the tight loop that is actually sending out new bytes. This increases the total loop time, as well as the time to send the entire waveform.

Speedy Transfer Rates

We've measured some waveform transfer rates for the FAStxmit mode (see Table 6). They were obtained using a very fast controller and a frequency counter attached to the RTRIG output on the rear panel to measure time between the occurrence of record triggers. The intervals measured include both the time to acquire the waveform and the time to send that waveform to the controller.

Because the waveform processor not only moves waveform data from Acquisition memory to Save memory but also from Save memory to the display, turning off all waveform displays (using the VMOde command) also speeds the transfer. Turning off the display eliminates the large data-moves going to it, which in turn accelerates the 2430's part in the transfer.

Table 6
Measured Waveform Transfer Rates

Sweep Speed or Mode	Transfer Rate
100 μs/div	47 wfm/s
50 μs/div to 500 ns/div	36 wfm/s
SAVE mode	65 wfm/s

The timing numbers were measured for sweep speeds of 100 μs and faster. At speeds slower than this, waveform baud rates are retarded, since data acquisition takes longer. And because sweep speeds faster than 500 ns require equivalent-time sampling to fill waveform points (which takes time), fast transmittal of waveform data becomes superfluous. But for sweep speeds from 50 μs to 500 ns, data is handled exactly the same way internally, so the transfer rates are the same.

User Tip: If a high transfer rate for one waveform is needed to reduce system overhead, then placing the 2430 into the SAVE mode (RUN SAVe) before initiating the FAStxmit sequence works well.

Command Timing

Tables 7 and 8 list various GPIB commands and queries available to the 2430 along with the respective times to execute them. These timing measurements were made with a Tektronix 4041 controller and an 8540 emulator station. Each measurement started when the header (for example, CH1 and HORizontal) was decoded. It stopped when the hardware was updated, with the 2430 ready to process the next command.

Table 7
Measured Command and Query Timing

Header	Arguments	Time
SET?	LONg ON OFF	0.93 s 0.79 s
SET	LONg ON OFF	4.94 s 4.60 s
LLSet?		0.14 s
LLSet		0.44 s
CURVe?	Binary Data ASCII Data	0.45 s 3.55 s
CURVE	Binary Data ASCII Data	1.19 s 7.33 s
CH1	VOLts:.2	0.11 s[a]
HORizontal	ASEcdiv:.001 .002	0.08 s 0.09 s
ACQuire	MODe:NORmal	0.07 s
ATRigger	LEVel:0 .1234	0.02 s 0.03 s

[a]Attenuators take time to change!

Table 8
Measured Query Timing

Query	Points Between STArt and STOp	Time
AVG?	128 1024	0.18 s 1.13 s
PCRoss?	128 1024	0.10 s 0.16 s
MINimum?	128 1024	0.10 s 0.17 s

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