2230
DIGITAL STORAGE OSCILLOSCOPE

Please Check for CHANGE INFORMATION at the Rear of This Manual

First Printing AUG 1985
Revised OCT 1985

Tektronix
COMMITTED TO EXCELLENCE

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INSTRUMENT SERIAL NUMBERS

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

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

Certificate of the Manufacturer/Importer

We hereby certify that the 2230 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 2230 OSCILLOSCOPE AND ALL INSTALLED OPTIONS in Ubereinstimmung mit den Bestimmungen der Amtsblatt-Verfugung 1046/1984 funkentstort ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerates angezeigt und die Berechtigung zur Uberprufung der Serie auf Einhalten der Bestimmungen eingeraumt.

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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 fur den Benutzer/Betreiber:

Die vom Betreiber zusammengestellte Anlage, innerhalb derer dies Gerat 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 fur den Benutzer/Betreiber:

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

OPERATORS SAFETY SUMMARY

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

Terms in This Manual

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

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

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 gound (earth) terminal.

ATTENTION — Refer to manual.

Power Source

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

Grounding the Product

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

Danger Arising from Loss of Ground

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

Use the Proper Power Cord

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

Use only a power cord that is in good condition.

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

Use the Proper Fuse

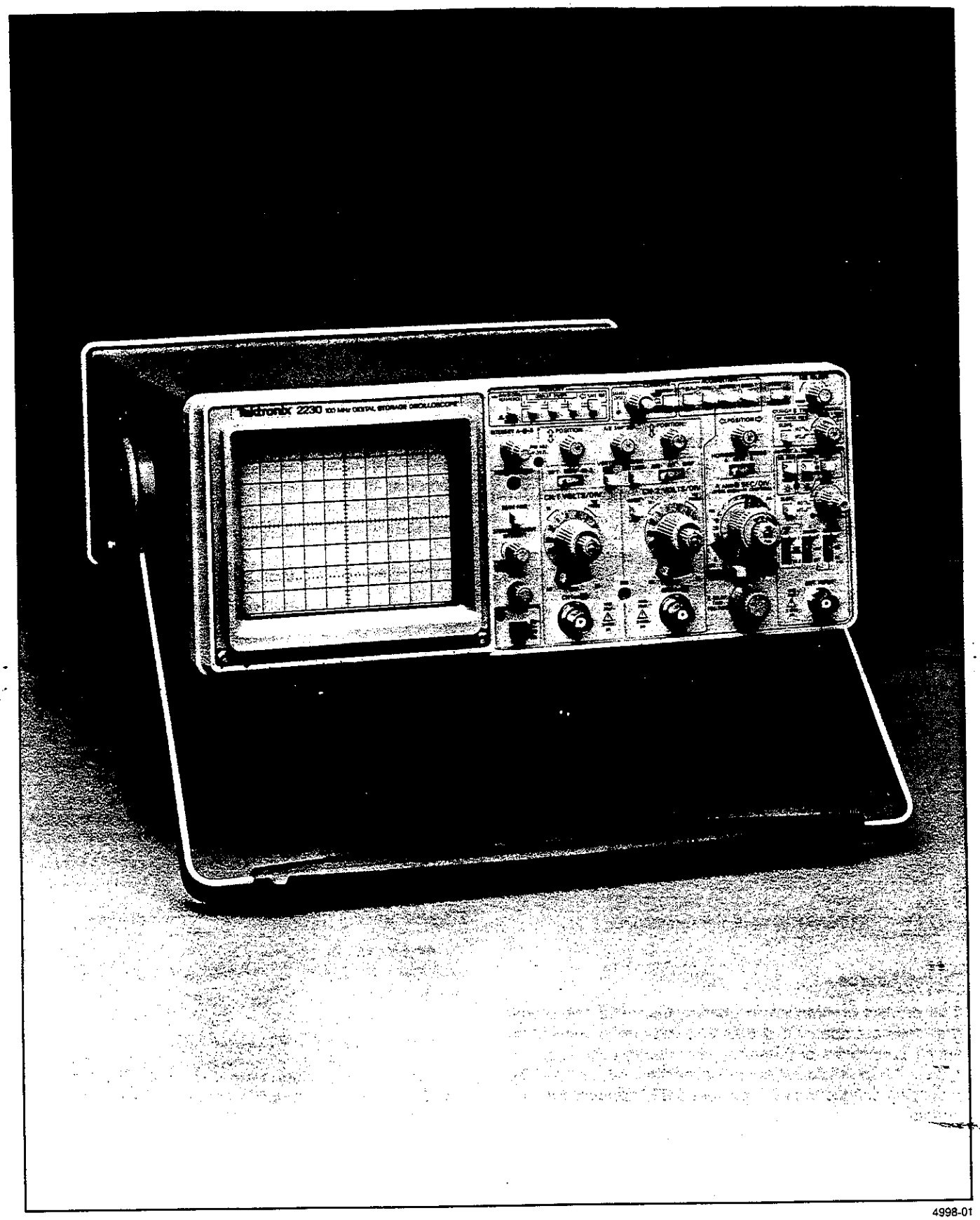
To avoid fire hazard, use only a fuse of the correct type, voltage rating and current rating as specified in the parts list for your product.

Do Not Operate in Explosive Atmospheres

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

Do Not Remove Covers or Panels

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



The 2230 Digital Storage Oscilloscope.

GENERAL INFORMATION

INTRODUCTION

The TEKTRONIX 2230 Oscilloscope is a combination nonstorage and digital storage dual-channel 100 MHz bandwidth instrument. It is a rugged, lightweight oscilloscope featuring microprocessor operation and alphanumeric crt readout of many of the front-panel controls. In the digital storage mode, up to three waveform sets (CH 1 and/or CH 2) may be stored in a SAVE REF memory and recalled for display at a later time. The vertical system provides calibrated deflection factors from 2 mV per division to 5 V per division. The horizontal system provides calibrated sweep speeds from 50 ns per division to 0.5 s per division for nonstorage mode with three slower sweep speeds (1 s, 2 s, and 5 s per division) added for store mode operation. A X10 magnifier extends the maximum sweep speed to 5 ns per division.

The digital storage sampling rate is 20 megasamples per second maximum, and the acquired record length is 4K samples (1K may also be selected) for a single channel or 2K samples for dual-channel (CHOP or ALT) displays. Any contiguous 1K sample of an acquired record is displayable. The fast sampling rate can capture a glitch with a pulse width of at least 100 ns. A 4K compress feature enables a 4K record length acquisition to be compressed to 1K in length for ease in viewing or storing in the SAVE REF memory. If compression is not desired, all 4K or any 1K portion of a 4K record may be stored in the SAVE REF memory. The SAVE store mode stops the waveform acquisition in progress, allowing a particular display to be stored or examined before further acquisitions cause a waveform update.

Cursors may be used to obtain voltage measurements, time difference measurements, and delay-time measurements on any of the store mode waveform displays. Delta volts, delay time, delta time, and 1/delta time (either delta time or 1/delta time is selectable via the MENU) are displayed in the crt readout for ease in obtaining precise measurement results. The cursors are positioned to any displayed store mode waveform to make measurements. An alternate use of the cursor-positioning control is to horizontally position the 1K display window to any location within a 4K record length waveform acquisition. The displayed portion of a 4K acquisition is stored when the SAVE REF feature is used.

The instrument is shipped with the following standard accessories:

1 Operators Manual
1 Users Reference Guide
2 Probe Packages
1 Front Panel Cover
1 Accessory Pouch
1 Power Cord
1 Fuse
1 DB-9 Female Connector
1 DB-9 Connector Shell
1 Loop Clamp
1 Flat Washer
1 Self-Tapping Screw

For part numbers and further information about both standard and optional accessories, refer to "Options and Accessories" (Section 7) of this manual. Your Tektronix representative, local Tektronix Field Office, or Tektronix products catalog can also provide additional accessories information.

SPECIFICATION

The following electrical characteristics (Table 1-1) are valid when the instrument has been adjusted at an ambient temperature between +20°C and +30°C, has had a warm-up period of at least 20 minutes, and is operating at an ambient temperature between 0°C and +50°C (unless otherwise noted).

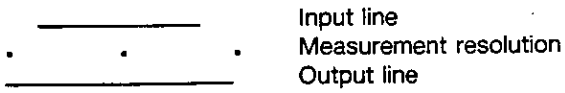
Items listed in the "Performance Requirements" column are verifiable qualitative or quantitative limits that define the measurement capabilities of the instrument.

Environmental characteristics are given in Table 1-2. This instrument meets the requirements of MIL-T-28800C for Type III, Class 5 equipment, except where noted otherwise.

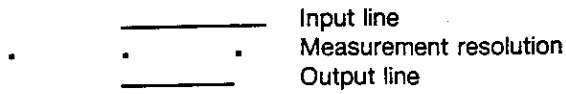
Physical characteristics of the instrument are listed in Table 1-3.

Finite resolution affects any measurement using discrete numbers. All digital storage stores amplitude values as discrete numbers and associates those amplitude numbers with discretely numbered times. Many measurements must be rounded or truncated. The size of the truncation or rounding becomes a part of the measurement error. For example, the following line is 1.5 units long. If it must be drawn as a line connecting points one unit apart, then it may be drawn as a line one unit long or two units long, depending on how it occurs relative to the points.

Case 1: Line approaches three points:



Case 2: Line approaches two points:



There are several places where measurements are quantified, and a one-count error in the measurement cannot be detected. The input channels are digitized to an 8-bit resolution, where one division is (ignoring expansion and compression) 25 counts. This means there is an inherent error of 1/25 of a division in any voltage measurement at acquisition time. Averaging can increase the resolution of a voltage measurement above the sampler's eight-bit limit. To use the increased resolution, the display has a 10-bit dynamic range in the vertical axis, as well as the horizontal axis. An averaged signal has a resolution of 100 points per division (ignoring expansion and compression). In addition, the averaged number is stored with up to twelve bits of resolution. Expansion is required to view the eleventh and twelfth bits of increased resolution.

Time is quantified to determine when each sample occurred and which display interval gets each sample. Time is resolved by storing, for example, 4K points. If 4K points are stored, 4K time intervals are represented. However, in 4K mode, not all of the 4K-point resolution may be displayed on the 10-bit (1K-point) screen. Therefore, if 4K COMPRESS is selected to present the whole picture on-screen at once, only 1K resolution remains in the display. When peak-detected information is acquired, events with high-frequency content such as fast steps, or short pulses, can only be located within the time interval from which the peaks came. Even though two display points result from the interval, the event cannot be tied with certainty to the first or second point in the interval.

Time is also quantified to determine where to put points in REPETITIVE acquisitions, where the points acquired at 50 ns intervals fill only part of the screen. A counting device produces a number to represent the portion of 50 ns between the samples acquired and the ones that would have included the trigger. This number ranges from 0 to about 205, which allows accurate placement into the display record. The display record will have at most 100 slots to choose from on the basis of the 0-205 number (this is where each slot represents 0.5 ns of acquisition time, and the counter's resolution is about 0.244 ns per count).

Table 1-1

Electrical Characteristics

Characteristics	Performance Requirements
VERTICAL DEFLECTION SYSTEM	
Deflection Factor	
Range	2 mV/div to 5 V/div in a 1-2-5 sequence.
DC Accuracy (NON STORE)	
+15°C to +35°C	Within ±2%.
0°C to +50°C	Within ±3%. For 5 mV/div to 5 V/div VOLTS/DIV switch settings, the gain is set at a VOLTS/DIV switch setting of 10 mV/div. 2 mV/div gain is set with the VOLTS/DIV switch set to 2 mV/div.
On Screen DC Accuracy (STORE)	
+15°C to +35°C	Within ±2%.
0°C to +50°C	Within ±3%. STORE Mode gain set with the VOLTS/DIV switch set to 5 mV/div.
Storage Acquisition Vertical Resolution	8 bits, 25 levels per division. 10.24 divisions dynamic range.
Range of VOLTS/DIV Variable Control	Continuously variable between settings. Increases deflection factor by at least 2.5 to 1.
Step Response (NON STORE)	
Rise Time	
0°C to +35°C	
5 mV/div to 5 V/div	3.5 ns or less.
2 mV/div	4.4 ns or less.
+35°C to +50°C	
5 mV/div to 5 V/div	3.9 ns or less.
2 mV/div	4.4 ns or less. Rise time is calculated from: $\text{Rise Time} = \frac{0.35}{\text{Bandwidth } (-3 \text{ dB})}$
Step Response (STORE Mode)	
Useful Storage Rise Time	**Single Trace** / **CHOP/ALT**
SAMPLE	$\frac{\text{SEC/DIV} \times 1.6}{100}$ s / $\frac{\text{SEC/DIV} \times 1.6}{50}$ s
PEAKDET or ACCPEAK with SMOOTH	$\frac{\text{SEC/DIV} \times 1.6}{50}$ s / $\frac{\text{SEC/DIV} \times 1.6}{25}$ s Rise time is limited to 3.5 ns minimum with derating over temperature (see NON STORE Rise Time).

Table 1-1 (cont)

Characteristics	Performance Requirements
Aberrations (NON STORE and STORE in SAMPLE Mode)	
2 mV/div to 0.5 V/div	+4%, −4%, 4% p-p.
1 V/div to 5 V/div	+12%, −12%, 12% p-p. Measured with a five-division reference signal, from a 50 Ω source driving a 50 Ω coaxial cable terminated in 50 Ω at the input connector with the VOLTS/DIV Variable control in the CAL detent. Vertically center the top of the reference signal.
NON STORE Bandwidth (−3 dB)	
0°C to +35°C	
5 mV/div to 5 V/div	DC to at least 100 MHz.
2 mV/div	DC to at least 80 MHz.
+35°C to +50°C	
5 mV/div to 5 V/div	DC to at leat 90 MHz.
2 mV/div	DC to at least 80 MHz. Measured with a vertically centered six-division reference signal, from a 50 Ω source driving a 50 Ω coaxial cable terminated in 50 Ω at the input connector; with the VOLTS/DIV Variable control in the CAL detent.
NON STORE BW LIMIT (−3 dB)	20 MHz ±10%.
AC Coupled Lower Cutoff Frequency	10 Hz or less at −3 dB.
Useful Storage Performance	
RECORD, SCAN and ROLL Store Modes	
SAMPLE Acquisition, no AVERAGE	**Single Trace** **CHOP/ALT**
5 μs/div to 5 s/div	$\frac{10}{\text{SEC/DIV}}$ Hz $\frac{5}{\text{SEC/DIV}}$ Hz
EXT CLOCK (up to 1 kHz)	$\frac{\text{EXT}}{10}$ Hz $\frac{\text{EXT}}{20}$ Hz
	Useful storage performance is limited to the frequency where there are 10 samples per sine wave signal period at the maximum sampling rate. (Maximum sampling rate is 20 MHz in Single trace and 10 MHz in CHOP or ALT at a SEC/DIV setting of 5 μs/div.) This yields a maximum amplitude uncertainty of 2%. Accuracy at the useful storage bandwidth limit is measured with respect to a six-division 50 kHz reference sine wave.
PEAK DETECT	**Single Trace and ALT** **CHOP**
Sine-Wave Amplitude Capture (2% p-p maximum amplitude uncertainty)	1 MHz 1 MHz
Pulse Width Amplitude Capture (50% p-p maximum amplitude uncertainty)	100 ns $\frac{\text{SEC/DIV}}{50}$

Table 1-1 (cont)

Characteristics	Performance Requirements
REPETITIVE Store Mode	
NORMAL and AVERAGE	**Single Trace** / **ALT**
0.05 μs/div	100 MHz (−3 dB)[a] / 100 MHz (−3 dB)[a]
0.1 μs/div	100 MHz (−3 dB)[a] / 50 MHz (−3 dB)
0.2 μs/div to 2 μs/div (2% maximum amplitude uncertainty)	$\frac{10}{\text{SEC/DIV}}$ Hz / $\frac{5}{\text{SEC/DIV}}$ Hz
ACCPEAK	
0.05 μs/div to 5 s/div	Same as NON STORE. Five-division reference signal, vertically centered; SEC/DIV switch set to 5 ms/div.
AVERAGE Mode	
Sweep Limit	Adjustable from 1 to 2047 or NO LIMIT.
Weight of Last Acquisition	1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, or 1/256 (MENU selections). AVERAGE mode default weight is 1/4.
Resolution	Assuming uncorrelated triggers and greater than 1 LSB of the 8-bit acquisition of vertical signal noise; the averaging weight for the first acquistion is 1, the averaging weight for the second acquisition is 1/2 and for n acquisitions is $1/2^{n-1}$. The MENU selects the least weight used. Maximum signal-to-noise improvement is achieved after 2 × (weight factor) × (expected acquisitions to fill).
Frequency Response	Frequency response of the AVERAGE Storage Mode is a function of the number of triggered acquisitions added to the weighted average. Time jitter of a signal with respect to the sample clock will produce a low-pass filter characteristic of an averaged waveform.
NON STORE CHOP Mode Switching Rate	500 kHz ±30%.
STORE Chop Rate	
SAMPLE	50/(SEC/DIV) for sweep speeds from 5 s per division to and including 10 μs per division.
PEAK DETECT	25/(SEC/DIV) for sweep speeds from 5 s per division to and including 20 μs per division.
5 μs/div through 0.05 μs/div	No CHOP mode; acts as in ALT.
A/D Converter Linearity	Monotonic with no missing codes.
STORE Mode Cross Talk	<1% measured in CHOP.

[a]One-hundred MHz bandwidth is derated for temperature outside 0°C to 35°C and at 2 mV/div VOLTS/DIV as for NON STORE.

Table 1-1 (cont)

Characteristics	Performance Requirements
NON STORE Common-Mode Rejection Ratio (CMRR)	At least 10 to 1 at 50 MHz. Checked at 10 mV per division for common-mode signals of six divisions or less with the VOLTS/DIV Variable control adjusted for the best CMRR at 50 kHz.
Input Current	1 nA or less (0.5 division or less trace shift when switching between DC and GND input coupling with the VOLTS/DIV switch set to 2 mV per division.
Input Characteristics	
Resistance	1 MΩ ±2%.
Capacitance	20 pF ±2 pF.
Maximum Safe Input Voltage (CH 1 and CH 2)	See Figure 1-1 for maximum input voltage vs frequency derating curve.
DC and AC Coupled ⚠	400 V (dc + peak ac) or 800 V ac p-p at 10 kHz or less.
NON STORE Channel Isolation	Greater than 100 to 1 at 50 MHz.
STORE Channel Isolation	100 to 1 at 50 MHz.
POSITION Control Range	At least ±11 divisions from graticule center.
A/B SWP SEP Control Range (NON STORE Mode Only)	±3.5 divisions or greater.
Trace Shift with VOLTS/DIV Switch Rotation	0.75 division or less; VOLTS/DIV Variable control in the CAL detent.
Trace Shift as the VOLTS/DIV Variable Control is Rotated	1 division or less.
Trace Shift with INVERT	1.5 divisions or less.

Table 1-1 (cont)

Characteristics	Performance Requirements
TRIGGERING SYSTEM	
A Trigger Sensitivity	
P-P AUTO and NORM	**10 MHz** **60 MHz** **100 MHz**
Internal	0.35 div 1.0 div 1.5 div
External	40 mV 120 mV 150 mV
	External trigger signal from a 50 Ω source driving a 50 Ω coaxial cable terminated in 50 Ω at the input connector.
HF REJ Coupling	Reduces trigger signal amplitude at high frequencies by about 20 dB with rolloff beginning at 40 kHz ±15 kHz. Should not trigger with a one-division peak-to-peak 250 kHz signal when HF REJ is ON.
P-P AUTO Lowest Usable Frequency	20 Hz with 1 division internal or 100 mV external.
TV LINE	
Internal	0.35 div.
External	35 mV p-p.
TV FIELD	⩾ 1 division of composite sync.
B Trigger Sensitivity (Internal Only)	**10 MHz** **60 MHz** **100 MHz** 0.35 div 1.0 div 1.5 div
EXT INPUT	
Maximum Input Voltage ⚠	400 V (dc + peak ac) or 800 V ac p-p at 10 kHz or less. See Figure 1-1 for maximum input voltage vs frequency derating curve.
Input Resistance	1 MΩ ±2%.
Input Capacitance	20 pF ±2.5 pF.
AC Coupled Lower Cutoff Frequency	10 Hz or less at −3 dB.
LEVEL Control Range	
A Trigger (NORM)	
INT	May be set at any voltage level of the trace that can be displayed.
EXT, DC	At least ±1.6 V, 3.2 V p-p.
EXT, DC÷10	At least ±16 V, 32 V p-p.
B Trigger (Internal)	May be set at any point of the trace that can be displayed.
VAR HOLDOFF Control (NON STORE Holdoff)	Increases NON STORE A Sweep holdoff time by at least a factor of 10. STORE holdoff is a function of microprocessor activity and the pretrigger acquisition. The VAR HOLDOFF control maintains some control over the STORE holdoff by preventing a new trigger from being accepted by the storage circuitry until the next (or current, if one is in progress) NON STORE holdoff has completed.
Acquisition Window Trigger Point	
PRETRIG	Seven-eighths of the waveform acquisition window is prior to the trigger (other trigger points are selectable via the MENU).
POST TRIG	One-eighth of the waveform acquisition window is prior to the trigger (other trigger points are selectable via the MENU).

Table 1-1 (cont)

Characteristics	Performance Requirements
HORIZONTAL DEFLECTION SYSTEM	
NON STORE Sweep Rates	
Calibrated Range	
A Sweep	0.5 sec per division to 0.05 μs per division in a 1-2-5 sequence of 22 steps.[b]
B Sweep	50 ms per division to 0.05 μs per division in a 1-2-5 sequence of 19 steps.[b]
STORE Mode Ranges	
REPETITIVE	0.05 μs per division to 2 μs per division.[c]
RECORD	5 μs per division to 50 ms per division.[c]
ROLL/SCAN	0.1 s per division to 5 s per division (A sweep only).[c]
NON STORE Accuracy	**Unmagnified** **Magnified**
+15°C to +35°C	Within ±2% Within ±3%
0°C to +50°C	Within ±3% Within ±4%
	Sweep accuracy applies over the center eight divisions. Exclude the first 25 ns of the sweep for magnified sweep speed and anything beyond the 100th magnified division.
STORE Accuracy	See Horizontal Differential Accuracy and Cursor Time Difference Accuracy.
NON STORE Sweep Linearity	±5%. Linearity measured over any two of the center eight divisions. Exclude the first 25 ns and anything past the 100th division of the X10 magnified sweeps.
Digital Sample Rate	**Single Trace** **CHOP/ALT**
SAMPLE (5 /div to 5 s/div)	$\frac{100}{\text{SEC/DIV}}$ Hz $\frac{50}{\text{SEC/DIV}}$ Hz
PEAKDET or ACCPEAK (20 μs/div to 5 s/div)	10 MHz 10 MHz (50% duty factor on each channel in CHOP)
REPETITIVE Store	
0.05 μs/div to 1 μs/div	20 MHz 20 MHz
2 μs/div	10 MHz 10 MHz.
External Clock	
Input Frequency	Up to 1 kHz.
Digital Sample Rate	10 MHz in ACCPEAK and PEAKDET, otherwise it is equal to the input frequency.
Store Rate	One data pair for every second falling edge.
Duty Cycle	10% or greater (100 μs minimum hold time).
Ext Clock Logic Thresholds	TTL compatible.
Maximum Safe Input Voltage ⚠	25 V (dc + peak ac) or 25 V p-p ac at 1 kHz or less.
Input Resistance	10 kΩ ±10%.

[b]**The X10 MAG control extends the maximum sweep speed to 5 ns per division.**

[c]**The X10 MAG control extends the maximum sweep speed to 5 ns per division. The 4K COMPRESS control multiplies the SEC/DIV by 4.**

Table 1-1 (cont)

Characteristics	Performance Requirements
STORE Mode Dynamic Range	10.24 divisions.
STORE Mode Resolution	
Acquisition Record Length	1024 or 4096 data points.
Single Waveform Acquisition Display	1024 data points (100 data points per division across the graticule area).
CHOP or ALT Acquisition Display	512 data points (50 data points per division across the graticule area).
Horizontal POSITION Control Range (NON STORE)	Start of the 10th division will position past the center vertical graticule line; 100th division in X10 magnified.
Horizontal Variable Sweep Control Range	
NON STORE	Continuously variable between calibrated settings of the SEC/DIV switch. Extends the A and the B Sweep speeds by at least a factor of 2.5 times over the calibrated SEC/DIV settings.
STORE	Horizontal Variable Sweep has no affect on the STORE Mode time base. Rotating the Variable SEC/DIV control out of the CAL detent position horizontally compresses a 4K point acquisition record to 1K points in length, so that the whole record length can be viewed on screen. Screen readout is altered accordingly.
Displayed Trace Length	
NON STORE	Greater than 10 divisions.
STORE	10.24 divisions.
Delay Time	
0.5 μs per division to 5 sec per division (A Sweep)	
Delay POSITION Range	Less than (0.5 div + 300 ns) to greater than 10 divisions. Delay Time is functional, but not calibrated, at A Sweep speeds faster than 0.5 μs per division.
Delay Jitter	One part or less in 5,000 (0.02%) of the maximum available delay time.
Delay Time Differential Measurement Accuracy (for Runs After Delay and B Sweep Triggers only)	
+15°C to +35°C	±1% of full scale.
0°C to +50°C	±2% of full scale. Exclude delayed operation when the A and B SEC/DIV knobs are locked together at any sweep speed or when the A SEC/DIV switch setting is 0.5 μs per division or faster. Accuracy applies over the B DELAY TIME POSITION control range.

Table 1-1 (cont)

Characteristics	Performance Requirements
DIGITAL STORAGE DISPLAY	
Vertical	
Resolution	10 bits (1 part in 1024). Display waveforms are calibrated for 100 data points per division.
Differential Accuracy	Graticule indication of the voltage cursor difference is within 2% of the readout value, measured over the center six divisions.
POSITION Range	Any portion of a stored waveform vertically magnified or compressed up to 10 times can be positioned to the top and to the bottom of the graticule area.
Position Registration	
NON STORE to STORE	Within ±0.5 division at graticule center at VOLTS/DIV switch settings from 2 mV per division to 5 V per division.
Acquisition to SAVE REF	Within ±0.2 division at VOLTS/DIV switch settings from 2 mV per division to 5 V per division.
SAVE Mode Expansion or Compression Range	Up to 10 times as determined by the remaining VOLTS/DIV switch positions up or down. 2 mV per division acquisitions cannot be expanded, and 5 V per division acquisitions cannot be compressed.
Storage Display Expansion Algorithm Error	±0.01% of full scale.
Storage Display Compression Algorithm Error	±0.16% of reading ±0.04% of full scale.
Horizontal	
Resolution	10 bits (1 part in 1024). Calibrated for 100 data points per division.
Differential Accuracy	Graticule indication of time cursor difference is within ±2% of the readout value, measured over the center eight divisions.
SAVE Mode Expansion Range	
Y-T Mode	Up to 10 times as determined by the X10 MAG switch and the remaining SEC/DIV switch positions faster. 0.05 μs/div acquisitions cannot be expanded.
X-Y Mode	In X-Y mode, Horizontal expansion and compression of the display is controlled by the CH 2 VOLTS/DIV switch in the same manner as Vertical expansion and compression.
Expansion Accuracy	Same as the Vertical.

Table 1-1 (cont)

Characteristics	Performance Requirements
DIGITAL READOUT DISPLAY	
CURSOR Accuracy	
Voltage Difference	Within ±3% of the ΔV readout value.
Time Difference	
RECORD, PEAKDET, AND SMOOTH Store	Within ±0.1% of the Δt readout value.
REPETITIVE Store	± (0.1% + 2 display intervals + [2 display intervals if SMOOTHed]).
X-Y OPERATION (X1 MAGNIFICATION ONLY)	
Deflection Factors	Same as vertical deflection system with the VOLTS/DIV Variable controls in the CAL detent position.
NON STORE Accuracy	Measured with a dc-coupled, five-division reference signal.
X-Axis	
+15°C to +35°C	Within ±3%.
0°C to +50°C	Within ±4%.
Y-Axis	Same as vertical deflection system.
NON STORE Bandwidth (−3 dB)	Measured with a five-division reference signal.
X-Axis	DC to at least 3 MHz.
Y-Axis	Same as vertical deflection system.
NON STORE Phase Difference Between X-Axis and Y-Axis Amplifiers	±3 degrees or less from dc to 150 kHz. Vertical Input Coupling set to DC.
STORE Accuracy	
X-Axis and Y-Axis	Same as digital storage vertical deflection system.
Useful Storage Bandwidth	
RECORD and REPETITIVE Store Modes	$\frac{5}{\text{SEC/DIV}}$ Hz
STORE Mode Time Difference Between Y-Axis and X-Axis Signals	
RECORD, SCAN, and ROLL Modes	100 ns. The X-Axis signal is sampled before the Y-Axis signal.
REPETITIVE Store	$\frac{\text{SEC/DIV}}{100} \times 4$

Table 1-1 (cont)

Characteristics	Performance Requirements
PROBE ADJUST	
Output Voltage on PRB ADJ Jack	0.5 V ±5%.
Probe Adjust Signal Repetition Rate	1 kHz ±20%.
Z-AXIS	
Sensitivity (NON STORE Only)	5 V causes noticeable modulation. Positive-going input decreases intensity. Usable frequency range is dc to 20 MHz.
Maximum Input Voltage ⚠	30 V (dc + peak ac) or 30 V p-p ac at 1 kHz or less.
Input Resistance	10 kΩ ±10%.
POWER SUPPLY	
Line Voltage Range	90 Vac to 250 Vac.
Line Frequency	48 Hz to 440 Hz.
Maximum Power Consumption	85 watts (150 VA).
Line Fuse	2 A, 250 V, slow blow.
Primary Circuit Dielectric Requirement	Routine test to 1500 Vrms, 60 Hz, for 10 seconds without breakdown.
CRT DISPLAY	
Display Area	8 cm x 10 cm.
Standard Phosphor	P31.
Nominal Accelerating Voltage	14 kV.
X-Y PLOTTER OUTPUT	
Maximum Safe Applied Voltage, Any Connector Pin ⚠	25 V (dc + peak ac) or 25 V p-p ac at 1 kHz or less.
External Clock Input	
Rate	Up to 1 kHz.
Duty Cycle	10% or greater (100 μs minimum pulse width).
Thresholds	TTL compatible.
Input Resistance	20 kΩ.
X and Y Plotter Outputs	
Pen Lift/Down	Fused relay contacts, 100 mA maximum.
Output Voltage Levels	500 mV per division ±5%. Center screen is 0 V ±0.2 division.
Series Resistance	2 kΩ ±10%.
4.2 V Output	4.2 V ±10% through 2 kΩ.

Table 1-2

Environmental Characteristics

Characteristics	Performance Requirements
Environmental Requirements	Instrument meets the requirements of Tektronix Standard 062-2853-00, Class 5, except EMI. The instrument meets the following MIL-T-28800C requirements for Type III, Class 5 equipment, except where noted otherwise.
Temperature	
Operating	0°C to +50°C (+32°F to +122°F).
Nonoperating	−55°C to +75°C (−67°F to +167°F). Tested to MIL-T-28800C, para 4.5.5.1.3 and 4.5.5.1.4, except that in para 4.5.5.1.3 steps 4 and 5 are performed before step 2 (−55°C nonoperating test). Equipment shall remain off upon return to room ambient temperature during step 6. Excessive condensation shall be removed before operating during step 7.
Altitude	
Operating	To 4,500 meters (15,000 feet). Maximum operating temperature decreases 1°C per 1,000 feet above 5,000 feet.
Nonoperating	To 15,000 meters (50,000 feet).
Humidity	
Operating and Nonoperating	5 cycles (120 hours) referenced to MIL-T-28800C para 4.5.5.1.2.2 for Type III, Class 5 instruments. Operating and nonoperating at 95%, −5% to +0%, relative humidity. Operating, +30°C to +50°C; nonoperating, +30°C to +60°C.
EMI (electromagnetic interference)	Meets radiated and conducted emission requirements per VDE 0871, Class B.
Vibration	
Operating	15 minutes along each of three major axes at a total displacement of 0.015 inch p-p (2.4 g at 55 Hz) with frequency varied from 10 Hz to 55 Hz to 10 Hz in one-minute sweeps. Hold for 10 minutes at 55 Hz in each of the three major axes. All major resonances are above 55 Hz.
Shock	
Operating and Nonoperating	30 g, half-sine, 11 ms duration, three shocks per axis each direction, for a total of 18 shocks.

Table 1-3

Physical Characteristics

Characteristics	Description
	See Figure 1-2 for dimensional drawing.
Weight	
With Power Cord, Cover, Probes, and Pouch	9.4 kg (20.7 lb).
With Power Cord Only	8.2 kg (18 lb).
Domestic Shipping Weight	12.2 kg (26.9 lb).
Height	137 mm (5.4 in).
Width	
With Handle	362 mm (14.3 in).
Without Handle	327 mm (12.9 in).
Depth	
With Front Cover	445 mm (17.5 in).
Without Front Cover	435 mm (17.1 in).
With Handle Extended	510 mm (20.1 in).

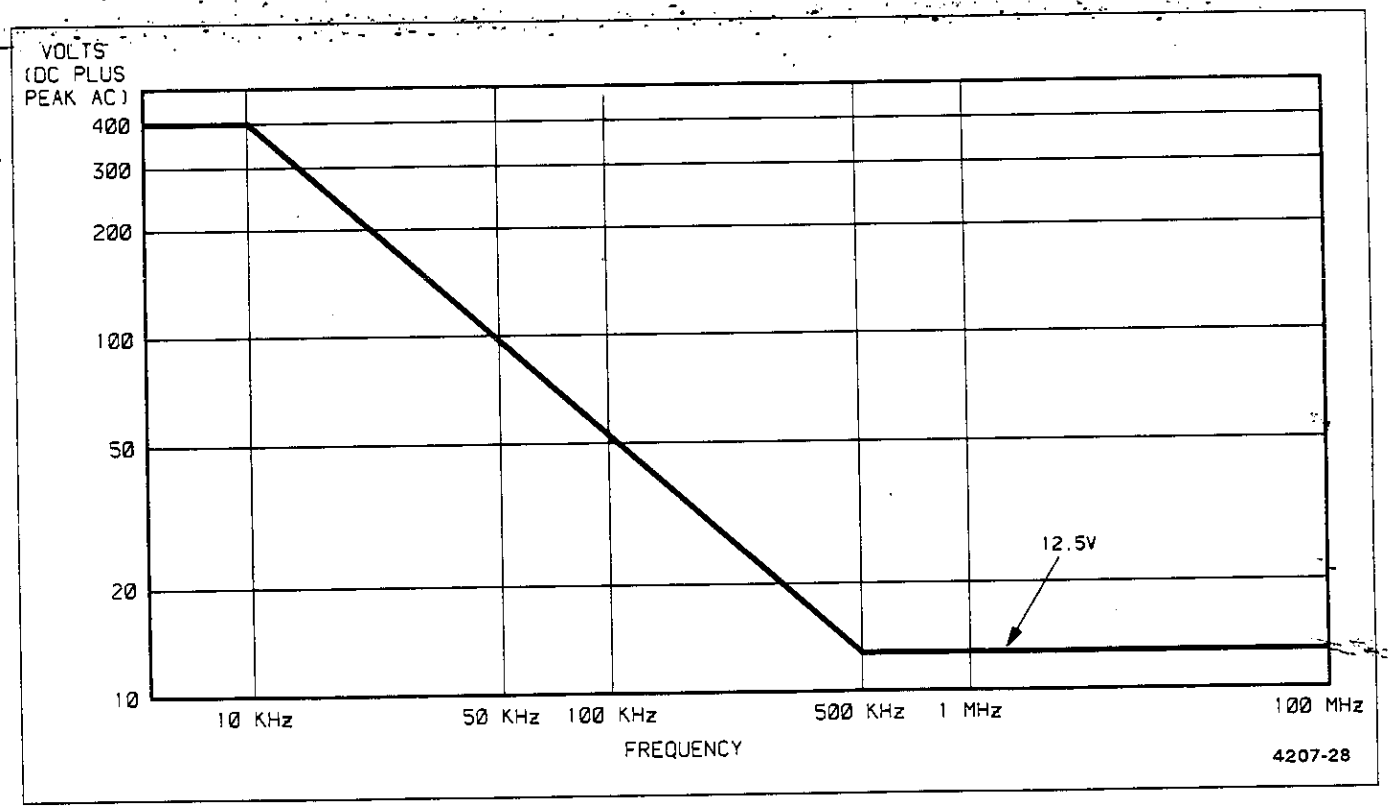


Figure 1-1. Maximum input voltage vs frequency derating curve for CH 1 OR X, CH 2 OR Y, and EXT INPUT connectors.

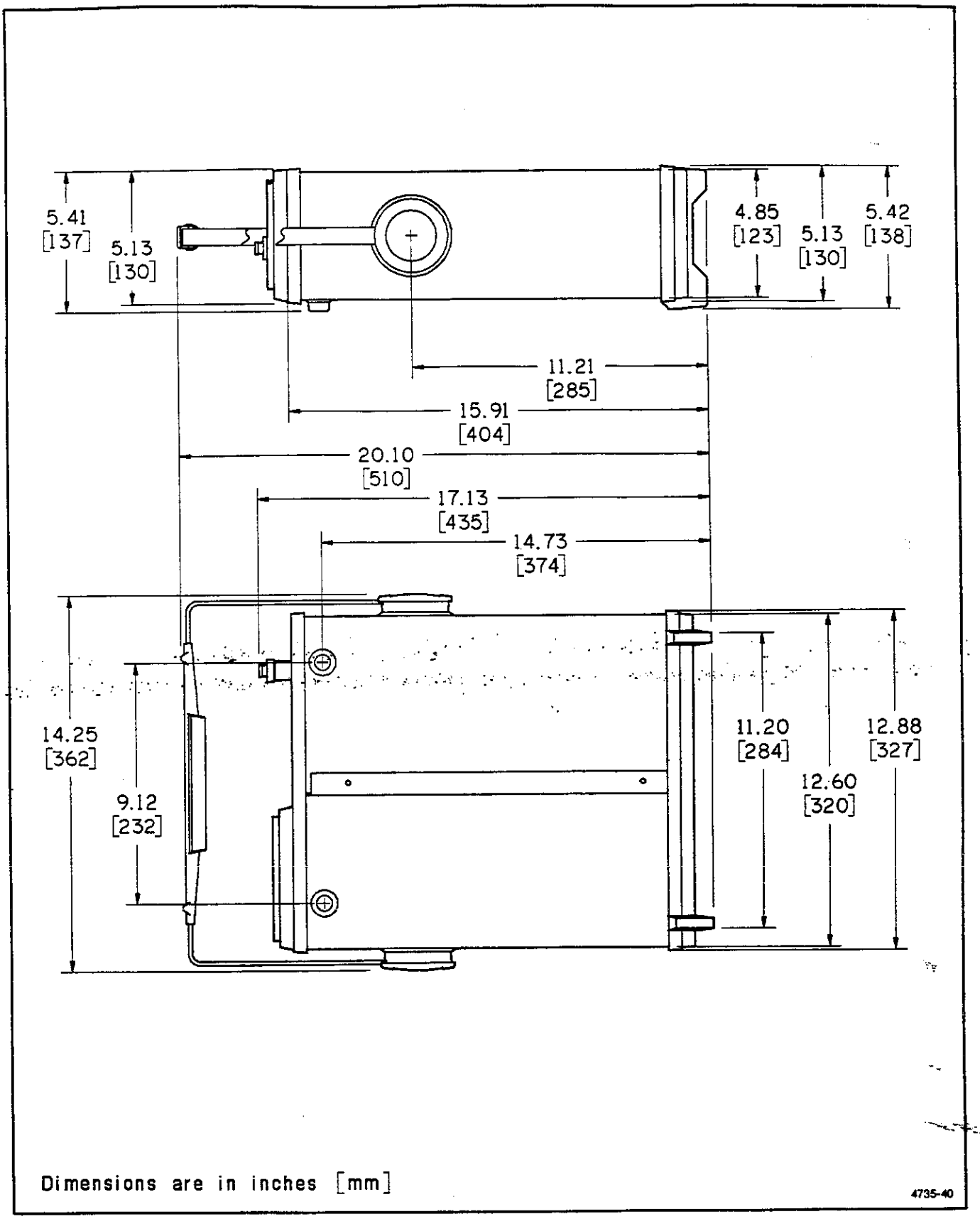


Figure 1-2. Physical dimensions of the 2230 Oscilloscope.

PREPARATION FOR USE

SAFETY

This part of the manual tells how to prepare for and to proceed with the initial start-up of the instrument.

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 entirely both this section and the Safety Summary.

LINE VOLTAGE

This instrument is capable of continuous operation with input voltages that range from 90 V to 250 V with source voltage frequencies from 48 Hz to 440 Hz.

POWER CORD

A detachable three-wire power cord with a three-contact plug is provided with each instrument for connecting to both the power source and protective ground. The power cord may be secured to the rear panel by a cord-set-securing clamp (see Figure 2-1). The protective-ground contact in the plug connects (through the protective-ground conductor) to the accessible metal parts of the instrument. For electrical-shock protection, insert this plug only into a power-source outlet that has a properly grounded protective-ground contact.

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

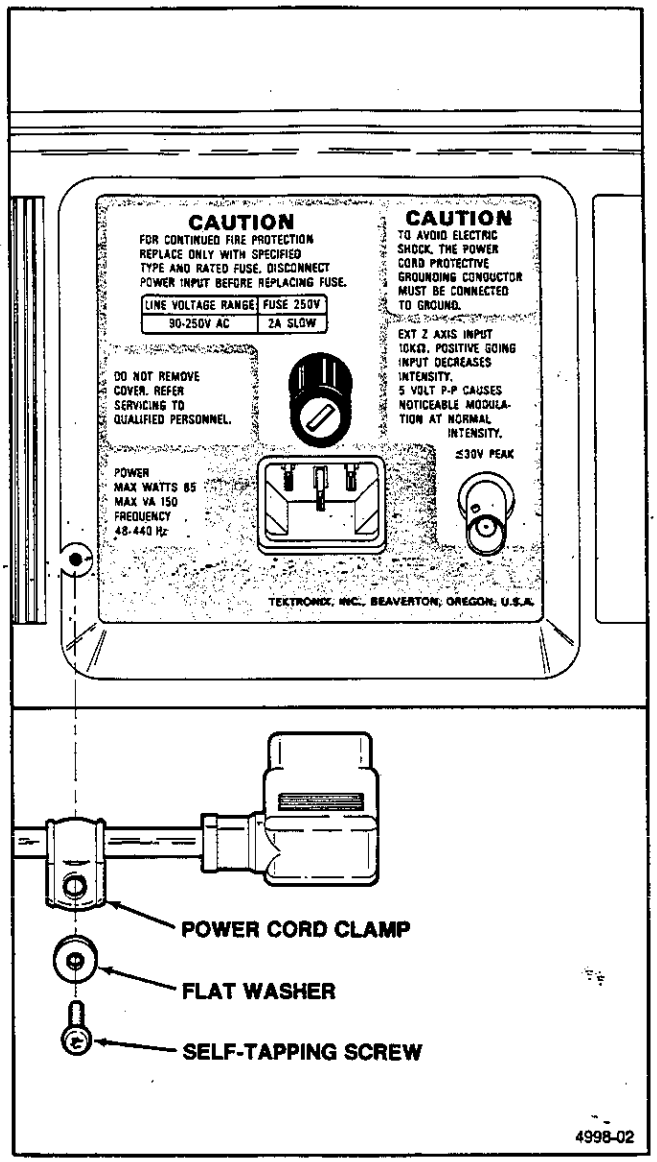
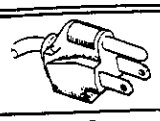
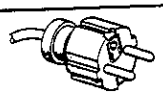
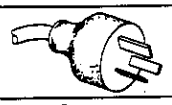
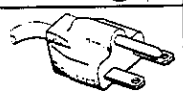
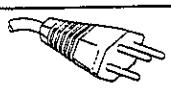


Figure 2-1. Securing the detachable power-cord to the instrument.

Plug Configuration	Usage	Line Voltage	Reference Standards
	North American 120V/ 15A	120V	ANSI C73.11 NEMA 5-15-P IEC 83
	Universal Euro 240V/ 10-16A	240V	CEE (7).II,IV,VII IEC 83
	UK. 240V/ 13A	240V	BS 1363 IEC 83
	Australian 240V/ 10A	240V	AS C112
	North American 240V/ 15A	240V	ANSI C73.20 NEMA 6-15-P IEC 83
	Switzerland 220V/ 6A	220V	SEV

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

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Figure 2-2. Optional power-cord data.

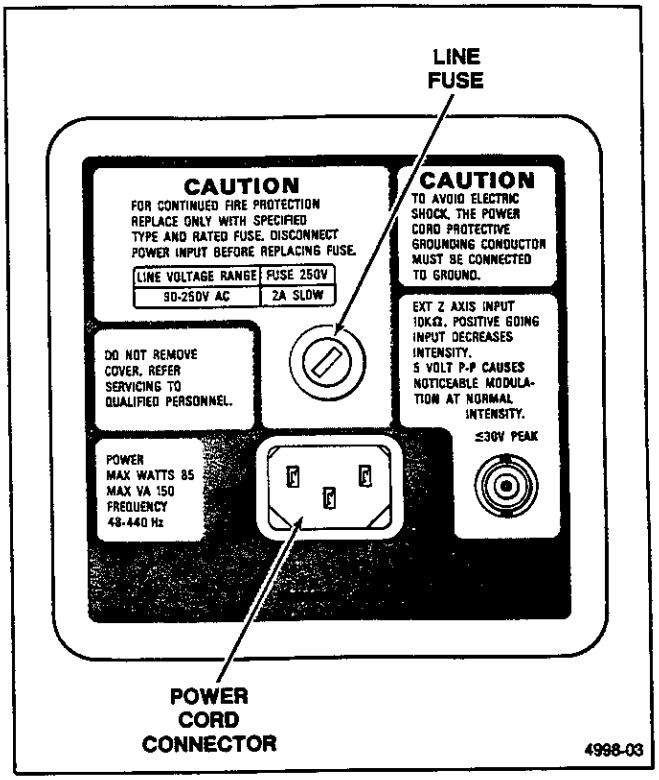

Figure 2-3. Fuse holder and detachable power-cord connector.

LINE FUSE

The instrument fuse holder is located on the rear panel (see Figure 2-3) and contains the line-protection fuse. The following procedure may be used either to verify that the proper fuse is installed or to install a replacement fuse.

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

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

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

4. Verify that the proper fuse is installed (see the rear-panel fuse nomenclature).

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

INSTRUMENT COOLING

To prevent instrument damage from overheated components, adequate internal airflow must be maintained at all times. Before turning on the power, first verify that both the fan-exhaust holes on the rear panel and the air-intake holes on the side panel are free from any obstructions to airflow. After turning on the instrument, verify that the fan is exhausting air.

START-UP

The instrument automatically performs power-up tests of the digital portion of the circuitry each time the instrument is turned on. The purpose of these tests is to provide the user with the highest possible confidence level that the instrument is fully functional. If no faults are encountered during the power-up testing, the instrument will enter the

normal operating mode. If the instrument fails one of the power-up tests, the instrument attempts to indicate the cause of the failure.

If a failure of any power-up test occurs, the instrument may still be useable for some applications, depending on the nature of the failure. If the instrument functions for your immediate measurement requirement, it may be used, but refer it to a qualified service technician for repair of the problem at the earliest convenience. Consult your service department, your local Tektronix Service Center, or your nearest Tektronix representative if additional assistance is required.

REPACKAGING

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

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

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

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

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

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

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

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

CONTROLS, CONNECTORS, AND INDICATORS

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

POWER AND DISPLAY

Refer to Figure 3-1 for location of items 1 through 9.

(1) **Internal Graticule**—Eliminates parallax viewing error between the trace and the graticule lines. Rise-time amplitude and measurement points are indicated at the left edge of the graticule.

(2) **POWER Switch**—Turns instrument power on or off. Press in for ON; press again for OFF.

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

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

(5) **STORAGE/READOUT INTENSITY Control**—Adjusts the brightness of the STORE mode displayed waveforms and the readout intensity in both STORE and NON STORE mode. The fully counterclockwise position of the control toggles the STORE/NON STORE readout on and off.

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

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

(8) **A INTENSITY Control**—Adjusts the brightness of all NON STORE displayed waveforms. The control has no effect on the STORE mode displays or the crt readouts.

(9) **B INTENSITY Control**—Adjusts the brightness of the NON STORE B Delayed Sweep and the Intensified zone on the A Sweep. The control has no effect on STORE mode displays or crt readouts.

VERTICAL

Refer to Figure 3-2 for location of items 10 through 19.

(10) **VOLTS/DIV Switches**—Select the vertical channel deflection factors from 2 mV to 5 V per division in a 1-2-5 sequence. The VOLTS/DIV switch setting for both channels is displayed in the crt readout. The VOLTS/DIV control settings for displayed waveforms containing cursor symbols are shown in the crt readout.

In STORE mode, SAVE waveforms and waveforms waiting to be updated between trigger events may be vertically expanded or compressed by up to a factor of 10 times (or as many VOLTS/DIV switch positions remaining—whichever is less) by switching the corresponding VOLTS/DIV control (waveforms acquired at 2 mV/div cannot be expanded and waveforms acquired at 5 V/div cannot be compressed). The VOLTS/DIV readout reflects the vertical scale factor of the displayed waveform. If the VOLTS/DIV switch is switched beyond the available expansion or compression range, the readout is tilted to indicate that the VOLTS/DIV switch setting and the VOLTS/DIV readout no longer agree.

1X PROBE—Front-panel marking that indicates the deflection factor set by the VOLTS/DIV switch when a X1 probe or a coaxial cable is attached to the channel input connector.

10X PROBE—Front-panel marking that indicates the deflection factor set by the VOLTS/DIV switch when a properly coded 10X probe is attached to the channel input connector.

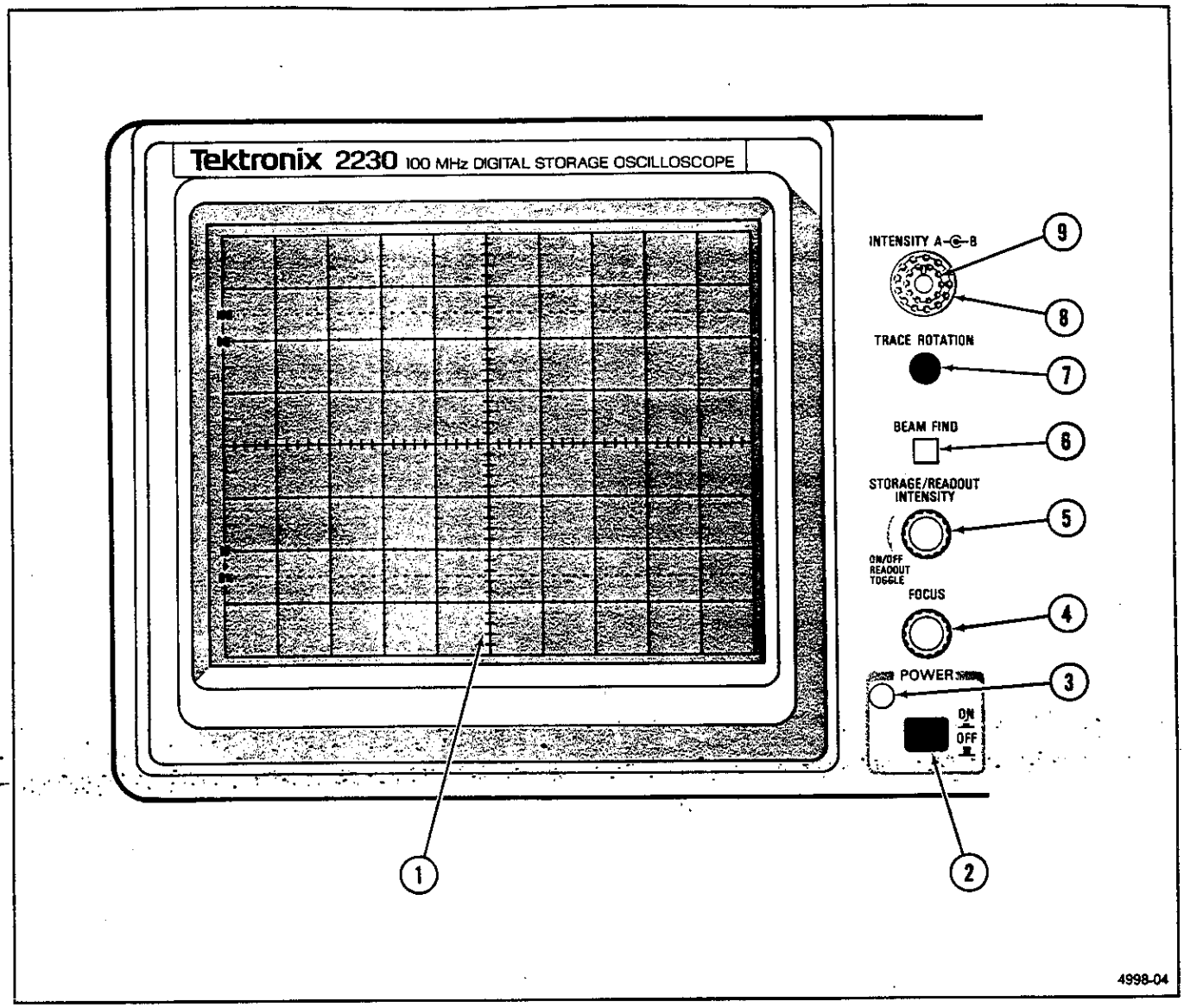

Figure 3-1. Power and display controls and power-on indicator.

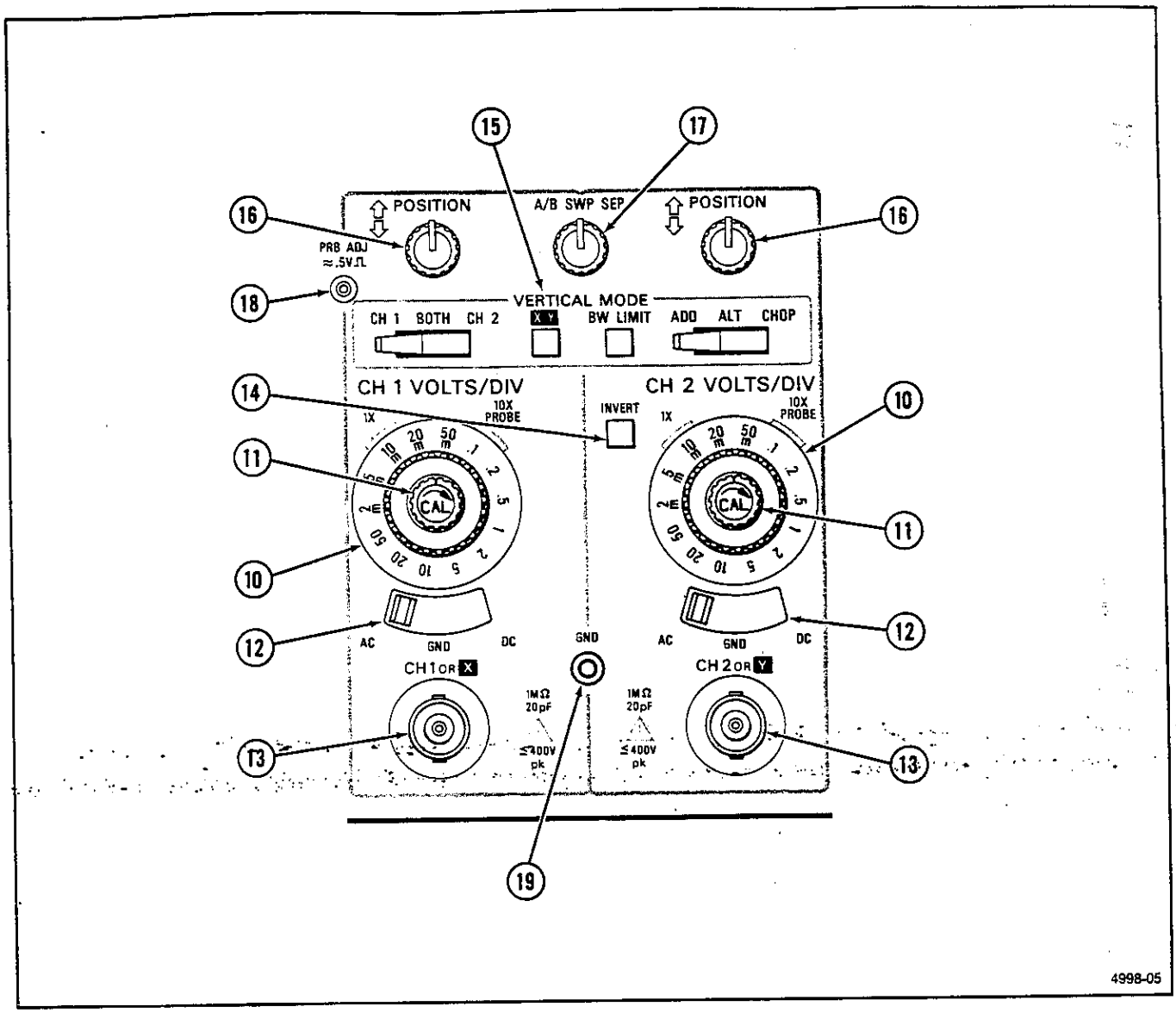

Figure 3-2. Vertical controls and connectors.

If properly coded probes (1X, 10X, or 100X, see Table 3-1) are connected to a channel input connector, the crt VOLTS/DIV readout will reflect the correct deflection factor of the display.

Table 3-1
Probe Coding

Probe	Coding Resistance
1X	Infinite
10X	11 kΩ ±10%
100X	5.6 kΩ −10% to 6.2 kΩ +10%
IDENTIFY	0 Ω or none of the above

(11) **Variable VOLTS/DIV Controls**—Provide continuously variable uncalibrated deflection factors between the calibrated positions of the VOLTS/DIV controls. The VOLTS/DIV sensitivity is reduced by up to at least 2.5 times the sensitivity at the fully counterclockwise position of the variable knob. A detent at the fully clockwise position indicates the calibrated VOLTS/DIV position of the variable knob. The uncalibrated condition is indicated by a greater-than symbol (>) in front of the affected VOLTS/DIV readout.

(12) **AC-GND-DC (Input Coupling) Switches**—Select the method of coupling the input signal to the CH 1 and CH 2 vertical amplifiers and the storage acquisition system.

AC—Capacitively couples the input signal to the vertical deflection and signal acquisition systems. The DC component of the input signal is blocked. The lower −3 dB bandpass is 10 Hz or less. Selection of AC input coupling is indicated in the readout by a tilde symbol (~) over the V on the associated channel's VOLTS/DIV readout.

GND—Grounds the input of the vertical amplifier; provides a zero (ground) reference voltage display (does not ground the input signal). In STORE mode, the ground reference is acquired and displayed in the first sample location of the acquisition waveform display. When GND input coupling is selected, a ground symbol is displayed in the associated VOLTS/DIV readout.

DC—All frequency components of the input signal are coupled to the vertical deflection and signal acquisition systems. When DC input coupling is selected, no additional indicators are displayed with the associated VOLTS/DIV readout.

(13) **CH 1 OR X and CH 2 OR Y Input Connectors**—Provide for application of signals to the inputs of the vertical deflection system and the storage acquisition system.

Coding-ring contacts on each of the input connectors are used to automatically switch the scale factor displayed by the crt readout when a properly coded probe is attached to the input connector. Displayed STORE mode waveforms are reformatted to maintain the correct deflection as indicated by the VOLTS/DIV readout on the affected channel(s). In X-Y mode, the signal connected to the CH 1 OR X input controls the horizontal deflection, and the signal connected to the CH 2 OR Y input controls the vertical deflection.

(14) **CH 2 INVERT Switch**—Inverts the Channel 2 display and STORE mode Channel 2 acquisition signal when pressed in. An invert symbol (↓) is displayed with the CH 2 VOLTS/DIV readout when CH 2 is inverted. With CH 2 inverted, the oscilloscope may be operated as a differential amplifier when the Vertical MODE of BOTH-ADD is selected.

(15) **VERTICAL MODE Switches**—Select the mode of operation for the vertical amplifier. There are two three-position switches and one two-position switch that determine display and acquisition modes and one two-position push-button switch that controls the nonstore bandwidth.

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

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

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

ADD—Displays (NON STORE) or acquires and then displays (STORE) the sum of the Channel 1 and Channel 2 input signals when BOTH is also selected. The difference of the Channel 1 and Channel 2 input signals is displayed (NON STORE) or acquired and then displayed (STORE) when the Channel 2 signal is inverted.

ALT—Alternately displays the nonstore Channel 1 and Channel 2 input signals. The nonstore alternation occurs during retrace at the end of each sweep. ALT Vertical MODE is most useful for

acquiring and viewing both channel input signals at sweep rates of 0.5 ms per division and faster. Channel 1 and Channel 2 STORE mode signals are acquired on alternate acquisition cycles at one-half the sampling rate of a single-channel acquisition.

CHOP—Switches the nonstore display between the Channel 1 and Channel 2 vertical input signals during the sweep. The chopped switching rate for NON STORE mode (CHOP frequency) is approximately 500 kHz. Chopped STORE mode signals are acquired on alternate time-base clock cycles with each channel being acquired at one-half the sampling rate of a single-channel acquisition. In STORE mode at sweep speeds of 5 μs per division or faster, CHOP becomes ALT mode.

BW LIMIT Switch—When pressed in while in NON STORE mode, the bandwidth of the vertical amplifier system and the A Trigger system is limited to approximately 20 MHz. This reduces interference from unwanted high-frequency signals when viewing low-frequency signals. In STORE mode, pressing in the BW LIMIT switch reduces only the trigger bandwidth. Press the switch a second time to release the switch and regain full bandwidth.

X-Y Switch—Automatically selects X-Y mode when pressed in. The CH 1 input signal provides horizontal deflection for X-Y displays, and the CH 2 input signal provides vertical deflection. In STORE mode, CH 1 and CH 2 signals are acquired in a chopped manner with no more than 100 ns between corresponding sample points on opposite channels, with the CH 1 signal being sampled before the CH 2 signal. The sampling mode and sampling rate are controlled by the A or the B SEC/DIV switch (depending on the Horizontal Display mode). The sampling rate is displayed in the crt readout in either the A or the B SEC/DIV display area (as appropriate), with the readout not in use being blanked. The X-Y waveform is acquired in SAMPLING mode and displayed with dots.

(16) **Vertical POSITION Controls**—Control the vertical display position of the CH 1 and CH 2 signals.

In STORE mode, the controls determine the vertical position of displayed waveforms during acquisition and in SAVE mode. Any portions of a signal being acquired that are outside the dynamic range of the A/D converter are blanked when positioned on screen. The Vertical POSITION controls can also reposition a vertically expanded SAVE waveform so that portions of the waveform outside the graticule area can be observed.

In NON STORE X-Y mode, the CH 2 POSITION control vertically positions the display, the horizontal POSITION control positions the display horizontally, and the CH 1 POSITION control is not active. In STORE mode, the CH 1 POSITION control is active, and both it and the Horizontal POSITION control affect the horizontal position of the displayed waveform.

(17) **A/B SWP SEP Control (NON STORE only)**—While in NON STORE mode, vertically positions the B Sweep trace with respect to the A Sweep trace when the HORIZONTAL MODE is BOTH.

(18) **PRB ADJ Connector**—Provides an approximately 0.5 V, negative-going, square-wave voltage (at approximately 1 kHz) for compensating voltage probes and checking the operation of the oscilloscope's vertical system. It is not intended to verify the accuracy of the vertical gain or the horizontal time-base circuitry.

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

HORIZONTAL

Refer to Figure 3-3 for location of items 20 through 26.

(20) **SEC/DIV Switches**—Determine the SEC/DIV setting for both the NON STORE sweeps and the STORE mode waveform acquisitions. To obtain calibrated A and B NON STORE sweeps, the Variable SEC/DIV control must be in the CAL detent.

In STORE mode, the SEC/DIV switches determine the default acquisition and display modes, set the sampling rate, and establish the seconds-per-division scale factor of the displayed waveforms. The SEC/DIV parameters displayed on the crt readout are for the waveforms identified by CURSORS.

Table 3-2 lists the default Storage, Acquisition, Process, and Display modes with respect to the SEC/DIV switch setting and the selected Trigger mode. Waveforms of SCAN, and ROLL displays are updated one data point at a time. All data points of a RECORD display are updated at the same time (total record replacement).

A SEC/DIV Switch—Selects the calibrated A Sweep rates from 0.5 s to 0.05 μs/div in a 1-2-5 sequence of 22 steps for the A Sweep generator and sets the delay time scale factor for delayed-sweep operation.

In STORE mode, the A SEC/DIV switch controls the default Storage, Acquisition, Process, and Display modes when making acquisitions using the A Time Base. It also selects the external clock signal, from the EXT CLK input, for the storage acquisition circuitry.

B SEC/DIV Switch—Selects the calibrated B Sweep rates from 50 ms/div to 0.05 μs/div in a 1-2-5 sequence of 19 steps.

In STORE mode, the B SEC/DIV switch controls the default Storage, Acquisition, Process, and Display modes when making acquisitions using the B Horizontal mode.

UNTRIGGERED mode performs acquisitions without reference to the trigger circuit, and there is no trigger marker on the screen. Triggers are ignored in STORE mode at SEC/DIV settings of 5 s per division to 0.1 s per division under the following conditions:

ROLL is selected. Selecting ROLL forces the screen to continuously update as on a chart recorder. Triggers would stop the display. ROLL is operational at sweep speeds slow

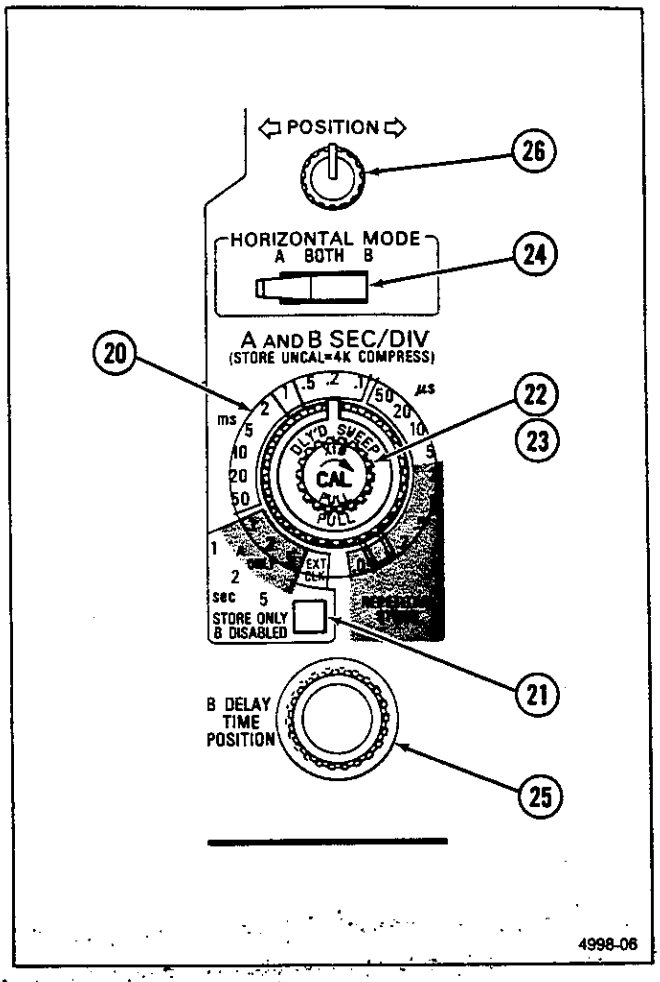

Figure 3-3. Horizontal controls.

Table 3-2

Default Digital Storage Modes

	UN-TRIG[a] 5 s to 0.1 s	TRIG[b] 5 s to 0.1 s	SLOW RECORD 50 ms to 20 μs	FAST RECORD 10 μs to 5 μs	REPETITIVE 2 μs to 0.05 μs
SAMPLE[c]	OFF	OFF	OFF	ON	OFF
AVERAGE[c]	—	OFF	OFF	OFF	ON
ACCPEAK[c]	—	OFF	OFF	OFF	OFF
PEAKDET[c]	ON	ON	ON	—	—
SMOOTH[d]	ON	ON	ON	OFF	OFF
VECTORS	ON	ON	ON	ON	DOTS only

[a]See the "UNTRIGGERED" discussion.

[b]See the "TRIGGERED" discussion.

[c]These Storage modes are mutually exclusive.

[d]Works with ACCPEAK and PEAKDET only.

enough that the acquisition can manually be stopped when events of interest are observed.

P-P AUTO is selected. P-P AUTO provides a baseline in the absence of triggers from the input signal. The circuit considers the absence of triggers to be about half of a second without a trigger. Below 50 ms per division, the triggers are prevented for longer than that by the sweep time itself, therefore triggers are ignored.

TRIGGERED mode performs triggered acquisitions in STORE mode at SEC/DIV settings of 5 s per division to 0.1 s per division when triggers can be meaningful. Triggers are meaningful in SCAN mode if the A TRIGGER mode is NORM or SGL SWP. Triggers are not meaningful in ROLL mode or in the A TRIGGER Mode of P-P AUTO.

REPETITIVE Store mode (2 μs/div to 0.05 μs/div) requires a repetitive trigger signal. Sampling occurs at the maximum A/D conversion rate. If a control affecting an acquisition parameter or function is changed, the acquisition is reset, and the waveform being acquired is cleared on the next sample acquired. On each valid trigger, 10 or more equally spaced samples are acquired and displayed on the waveform record, depending on the SEC/DIV setting (see Table 3-3). The random time delay from the trigger to the following sample clock transition is measured by the Clock Delay Timer circuit and used to place the acquired waveform samples in the correct display memory location. Any display location is equally likely to be filled. Table 3-3 gives the statistically expected number of trigger events required to completely fill the display, assuming a uniform distribution of trigger events relative to the sample interval.

FAST RECORD Storage mode (5 μs/div to 10 μs/div) updates a full record of the acquired waveform.

SLOW RECORD Storage mode (20 μs/div to 50 ms/div) updates a full record of the acquired waveform.

SCAN Storage mode (for NORM TRIGGER mode and 0.1 s/div to 5 s/div or EXT CLOCK) updates pretrigger data when a trigger is received. The waveform display then scans to the right from the trigger point to finish the post-trigger acquisition and then freezes.

SCAN Storage mode (for P-P AUTO TRIGGER mode with auto triggers disabled and 0.1 s/div to 5 s/div or EXT CLOCK) continuously updates the display serially as each data point is acquired. It writes over previous data from left to right.

ROLL Storage mode (P-P AUTO TRIGGER mode and 0.1 s/div to 5 s/div or EXT CLOCK) continuously acquires and displays signals. Triggers are disabled. The waveform display scrolls from right to left across the crt with the latest samples appearing at the right edge of the crt.

SCAN-ROLL-SCAN Storage mode (SGL SWP TRIGGER mode and 0.1 s/div to 5 s/div or EXT CLOCK) serially updates the display. The waveform display SCANS left to right until the pretrigger record is filled, and then ROLLS right to left until a trigger is received. It then SCANS left to right again to fill the post-trigger acquisition record and then freezes (see SGL SWP description for further details).

PEAKDET Acquisition mode digitizes and stores, in acquisition memory as a data pair, the minimum and maximum levels of the input signal within the time represented by 1/50 of a division UN-MAG (1/25 division in CHOP or ALT).

SAMPLE samples the signal at a rate that produces 100 samples per graticule division. In the RECORD Sampling modes, the displayed sample points are displayed by vectors or dots. For REPETITIVE Store mode, the sample points are displayed as dots.

Table 3-3

Repetitive Store Sampling Data Acquisition

SEC/DIV Switch Setting	Samples Per Acquisition		Expected Acquisition Per Waveform[a]	
	1K Mode	4K Mode	1 Channel	2 Channel
0.05 μs	10	40	519	450
0.1 μs	20	80	225	191
0.2 μs	40	160	96	83
0.5 μs	100	400	30	23
1 μs	200	800	12	11
2 μs	200	800	12	11

[a]Expected acquisitions per waveform for a 50% probability of fill.

AVERAGE Acquisition mode can be used for multiple record averaging. A normalized algorithm is used for continuous display of the signal at full amplitude during the averaging process. The amplitude resolution increases with the number of weighted acquisitions included in the display. The default mode for REPETITIVE Store mode is AVERAGE. The averaging weight (the number of weighted waveform acquisitions included in each average display) is MENU selectable. The default average weight is 1/4. The number of sweeps (SWP LIMIT) allowed to occur before averaging stops is also MENU selectable.

SMOOTH Processing mode reorders acquired data for correct slope and interpolates the data for drawing a smooth waveform. Smoothing looks at the change in data point values between adjacent sample intervals. If the change in value does not exceed certain limits, the values are interpreted as a continuous slope for drawing vectors or dots. If the value change exceeds the interpreted "no-change" limit, the data point value is not modified, and the vectors drawn in the display will show a discontinuity in the waveform. This method of display of the waveform data provides a smoothed display of the waveform, yet retains the glitch-catching capabilities of PEAKDET or ACCPEAK modes.

(21) **STORE Mode A SEC/DIV Multiplier**—Functions only in the STORE mode at SEC/DIV switch settings of 0.1, 0.2, and 0.5 s/div. When pressed in, the A Sweep time base of these three settings is increased by a factor of 10 to 1 s/div, 2 s/div, and 5 s/div. Releasing the button returns the STORE mode time base to X1. The X10 MAG control is still functional on waveforms acquired at the slow STORE mode SEC/DIV settings.

(22) **Variable SEC/DIV and 4K COMPRESS Control**—Controls the NON STORE sweep time per division and compresses STORE mode waveform records.

Variable SEC/DIV—Continuously varies the uncalibrated NON STORE sweep time per division to at least four times the calibrated time per division set by the SEC/DIV switch (increases the slowest NON STORE A Sweep time per division to at least 2 s). The Variable SEC/DIV control does not affect the storage time base for acquiring or displaying signals.

4K COMPRESS—If the Variable SEC/DIV control is rotated out of the CAL detent position during waveform acquisitions or SAVE mode, a 4K record is compressed by a factor of four (4K COMPRESS) to display the acquired data in one display window. For 4K COMPRESS the SEC/DIV is further multiplied by 4.

(23) **X10 Magnifier Switch**—Magnifies the NON STORE displays or expands the STORE acquisition and SAVE waveform displays by 10 times. STORE mode displays are expanded when the Variable SEC/DIV knob is pulled to the out position (X10 PULL). The SEC/DIV scale factor readouts are adjusted to correspond to the correct SEC/DIV of the displayed waveform (either NON STORE or STORE). Magnification of the NON STORE displays occurs around the center vertical graticule division; STORE mode displays are expanded around the active CURSOR. The display window for STORE mode X10 expanded waveforms may be positioned using the CURSORS Control to view any one-window portion of the acquisition record.

(24) **HORIZONTAL MODE Switch**—Determines the operating mode of the horizontal deflection system in both NON STORE and STORE. For STORE mode, the switch selects the acquisition time base and storage mode (either A SEC/DIV or B SEC/DIV).

A—Only the A Sweep is displayed. NON STORE time base and STORE acquisitions are controlled by the A SEC/DIV switch. The A SEC/DIV switch setting is displayed on the crt readout.

BOTH—Alternates the NON STORE display between the A Intensified and B Delayed Sweeps. The STORE mode display is the A Intensified trace only. The intensified zone on the A trace indicates the approximate delay position and length of the B Delayed Sweep. The A SEC/DIV, B SEC/DIV, and B DELAY TIME POSITION settings are displayed on the crt readout. In BOTH, STORE mode acquisitions are controlled by the A SEC/DIV switch.

B—Displays either the NON STORE or the STORE B Sweep trace. The A SEC/DIV, B SEC/DIV, and B DELAY TIME POSITION settings are displayed on the crt readout, just as in BOTH. The STORE mode waveform acquisitions are controlled by the B SEC/DIV switch.

(25) **B DELAY TIME POSITION Control**—Adjusts the delay between the start time of the A Sweep and the time that the B Sweep either starts (RUNS AFTER DLY) or can be triggered (Triggerable After Dly). (The A Sweep does not have to be displayed.) The delay time is variable from 0.5 to 10 times the A SEC/DIV, plus 300 ns.

In Triggerable After Delay, the delay time readout indicates the time that must elapse after the A trigger before the delayed sweep or delayed acquisition can be triggered; not the actual position of the trigger point. However, the readout of the delay time on the crt follows the setting of the B DELAY TIME POSITION control in either B Trigger mode.

The setting of the 1K/4K switch affects the delay time position setting for STORE mode displays by a factor of approximately four times. When switching between 1K and 4K record lengths, the delay time position setting must be readjusted to obtain the same delay time.

(26) **Horizontal POSITION Control**—Positions all the NON STORE waveforms horizontally over a one-sweep-length range (either X1 or X10 Magnified). Using the Horizontal POSITION control, STORE mode waveforms may be positioned over a range of only one display window. When a STORE mode acquisition display is longer than one screen (as in 4K records and/or X10 MAG), the CURSORS POSITION control is used to position the display window to any position of the acquisition record. The Horizontal POSITION control does not position the crt readout displays.

TRIGGER

Refer to Figure 3-4 for location of items 27 through 38.

NOTE

The Trigger controls affect the acquisition of the next waveform. They are inactive in SAVE Acquisition mode.

(27) **A TRIGGER Mode Switches**—Determine the NON STORE A Sweep triggering mode. STORE mode triggering depends on the position of the A SEC/DIV, the SCAN/ROLL switch, and the A Trigger mode. The trigger position is marked by a T on acquired waveforms.

NORM—Permits triggering at all sweep rates (an autotrigger is not generated in the absence of an adequate trigger signal). NORM Trigger mode is especially useful for low-frequency and low-repetition-rate signals.

In STORE mode, the last acquired waveform is held on display between triggering events. The pretrigger portion of the acquisition memory is continually acquiring new pretrigger data until a trigger event occurs. How the waveform display is updated after the trigger occurs, depends on the SEC/DIV setting. From 5 s per division to 0.1 s per division, the pretrigger portion of the displayed waveform is updated by the pretrigger data in the acquisition memory, then the post-trigger data points are placed in the display as they are acquired. For faster sweep speeds, the post-trigger data points are acquired in the acquisition memory prior to completely updating the waveform display, using the newly acquired data.

P-P AUTO—TV LINE—In NON STORE mode, triggering occurs on trigger signals having adequate amplitude and a repetition rate of about 20 Hz or faster. In the absence of a proper trigger signal, an autotrigger is generated, and the sweep free runs.

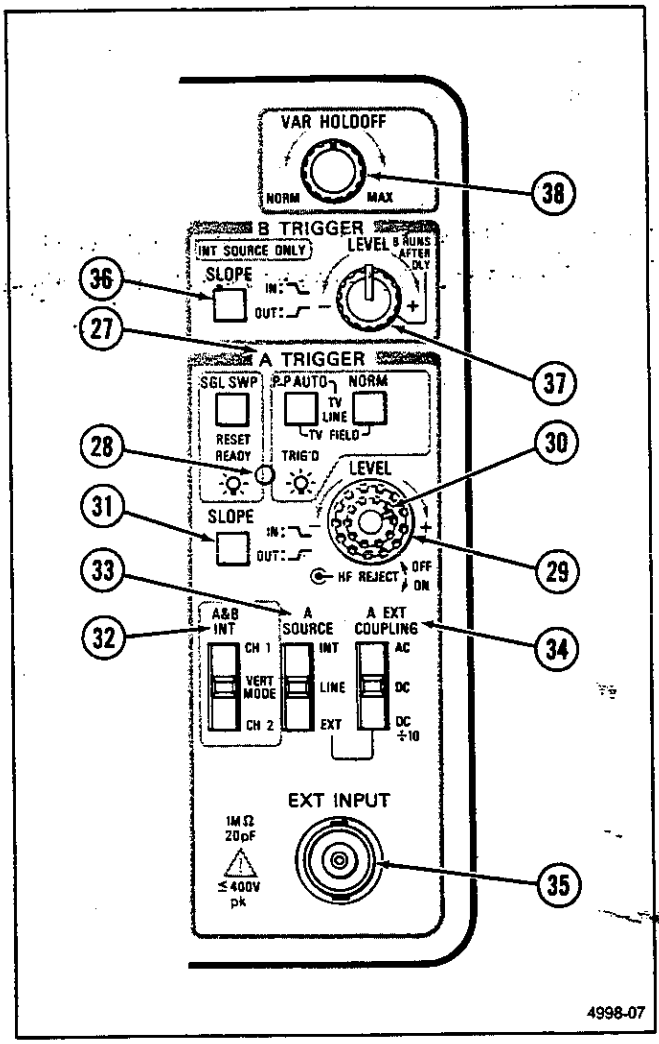

Figure 3-4. Trigger controls, connector, and indicator.

In STORE mode, for SEC/DIV settings of 5 s per division to 0.1 s per division, the P-P AUTO trigger mode is disabled, and the acquisition free-runs. At faster SEC/DIV settings, triggered acquisitions occur under the same conditions as NON STORE mode P-P AUTO triggering, and the acquisition free-runs if proper triggering conditions are not met. The manner in which the display is filled and updated is the same as for NORM triggering.

For either NON STORE or STORE mode, the range of the A TRIGGER LEVEL control is automatically restricted to the peak-to-peak limits of the trigger signal for ease in obtaining triggered displays and acquisitions. P-P AUTO is the usual Trigger mode selection to obtain stable displays of TV Line information.

TV FIELD—Permits stable triggering on a television field (vertical sync) signal when the P-P AUTO and the NORM Trigger buttons are pressed in together. In the absence of an adequate trigger signal, the sweep (or acquisition) free-runs. The instrument otherwise behaves as in P-P AUTO.

SGL SWP—Arms the A Trigger circuit for a single sweep in NON STORE or a single acquisition in STORE. Triggering requirements are the same as in NORM Trigger mode. After the completion of a triggered NON STORE sweep or a STORE SGL SWP acquisition, pressing in the SGL SWP button rearms the trigger circuitry to accept the next triggering event or start the next storage acquisition.

In STORE mode when the SGL SWP is armed, the acquisition cycle begins, but the READY LED does not come on until the pretrigger portion of the acquisition memory is filled. At the time the READY LED comes on, the acquisition system is ready to accept a trigger. When a trigger event occurs, the post-trigger waveform data is stored to complete the single-sweep acquisition. After triggering, the READY LED goes out, and the single sweep cannot be rearmed until the acquisition is completed.

The SEC/DIV switch setting and the STORE mode determine how the display is updated. For settings of 5 s per division to 0.1 s per division, a storage process known as SCAN-ROLL-SCAN is used. The last acquired waveform is erased when SGL SWP is armed, then the pretrigger acquisition scans from the left edge to the trigger position. At that point, the pretrigger portion of the display is rolled left from the trigger position until a triggering event occurs. Upon receiving an adequate trigger, the post-trigger portion of the display scans from the trigger point to the right until the remaining data points are filled, and then the display freezes.

For SEC/DIV settings of 0.05 s per division and faster, the display is updated as a full record. The previously displayed waveform remains on the crt until the post-trigger portion of the acquisition memory is filled after a triggering event. Then the waveform display is updated with the newly acquired data in its entirety.

(28) **READY—TRIG'D Indicator**—A dual-function LED indicator. In P-P AUTO and NORM Trigger modes, the LED is turned on when triggering occurs. In SGL SWP Trigger mode, the LED turns on when the A Trigger circuit is armed, awaiting a triggering event, and turns off again as soon as the single sweep (or acquisition) is triggered.

In STORE mode, pressing the SGL SWP button to arm the trigger circuitry does not immediately turn on the READY LED. The pretrigger portion of the acquisition memory starts filling after the SGL SWP button is pressed in; the READY LED is turned on when the filling is completed. The storage acquisition system is then ready to accept a triggering event. When a triggering event occurs, the READY LED is turned off.

(29) **A TRIGGER LEVEL Control**—Selects the amplitude point on the A Trigger signal that produces triggering. The trigger point for STORE mode is identified by a T on the acquired waveform.

(30) **HF REJECT Switch**—Rejects (attenuates) the high-frequency components (above 40 kHz) of the trigger signal when the control is in the ON position.

(31) **A TRIGGER SLOPE Switch**—Selects either the positive or negative slope of the trigger signal to start the NON STORE A Sweep or to reference the next STORE mode acquisition cycle.

(32) **A&B INT Switch**—Determines the source of the internal trigger signal for both the A and the B Trigger Generator circuits.

CH 1—Trigger signal is obtained from the CH 1 input.

VERT MODE—Trigger signal is obtained alternately from the CH 1 and CH 2 input signals if the

VERTICAL MODE is ALT. In the CHOP VERTICAL MODE, the trigger signal is the sum of the CH 1 and CH 2 input signals.

CH 2—Trigger signal is obtained from the CH 2 input. The CH 2 INVERT switch also inverts the polarity of the internal CH 2 trigger signal so the displayed slope agrees with the Trigger SLOPE switch.

(33) **A SOURCE Switch**—Determines if the SOURCE of the A Trigger signal is internal, external, or from line.

INT—Routes the internal trigger signal selected by the A&B INT switch to the A Trigger circuit.

LINE—Routes a sample of the ac power source to the A Trigger circuit.

EXT—Routes the signal applied to the EXT INPUT connector to the A Trigger circuit.

(34) **A EXT COUPLING Switch**—Determines the method of coupling the signal applied to the EXT INPUT connector to the input of the A Trigger circuit.

AC—Input signal is capacitively coupled, and the dc component is blocked.

DC—All frequency components of the external signal are coupled to the A Trigger circuit.

DC÷10—Attenuates the external signal by a factor of 10 before application to the A Trigger circuit. As with DC COUPLING, all frequency components of the input signal are passed.

(35) **EXT INPUT Connector**—Provides for connection of external signals to the A Trigger circuit.

(36) **B TRIGGER (INT SOURCE ONLY) SLOPE Switch**—Selects either the positive or the negative slope of the B Trigger signal that starts the NON STORE sweep or completes the STORE acquisition.

(37) **B TRIGGER LEVEL Control**—Selects the amplitude point on the B Trigger signal where triggering occurs in Triggerable After Delay mode. The B Trigger point is displayed as a T on the STORE mode waveform display when in B Horizontal mode. The fully clockwise position of the B TRIGGER LEVEL Control selects the Runs After Delay mode of operation for the B Trigger circuitry. Out of the cw position, B Sweep is triggerable after the delay time.

(38) **VAR HOLDOFF Control**—Adjusts the NON STORE Variable Holdoff time over a 10 to 1 range. NON STORE Variable Holdoff starts at the end of the A Sweep. STORE mode Holdoff starts at the end of the acquisition cycle, and ends after the waveform data has been transferred from the acquisition to the display memory and the pretrigger portion of the acquisition memory has been filled. After STORE mode Holdoff ends, the next acquisition can be triggered after the next (or current, if one is in progress) NON STORE Variable Holdoff ends. STORE mode Holdoff may be many times the length of the A Sweep time so that several NON STORE Holdoffs may occur during STORE Holdoff time. This ensures that STORE mode triggering is controllable by the VAR HOLDOFF control and will be stable if the NON STORE display is stable.

STORAGE CONTROLS

Refer to Figure 3-5 for location of items 39 through 42.

(39) **STORE/NON STORE Switch**—Selects either the NON STORE or the STORE waveforms for display. The STORE acquisition system is turned off while NON STORE is selected, keeping the last-acquired

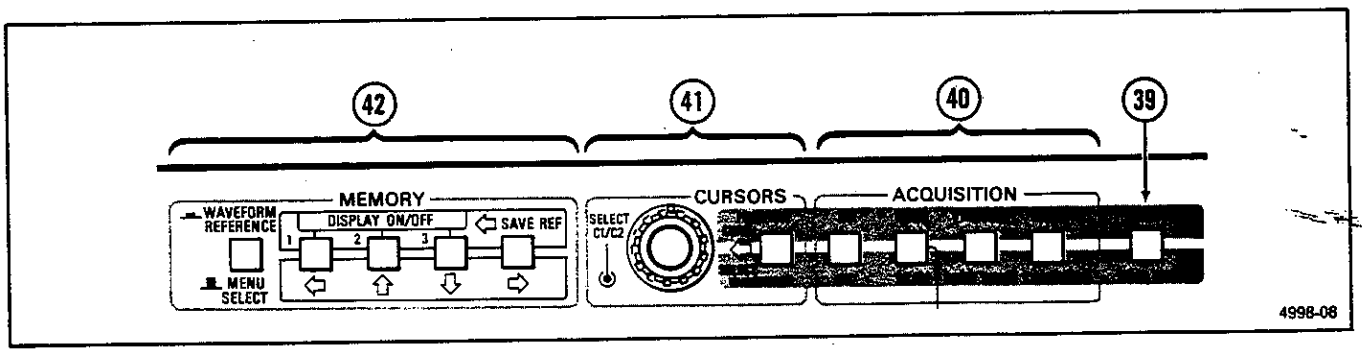

Figure 3-5. Storage controls.

STORE waveform in memory. Selects NON STORE when out and STORE when pressed in.

(40) **ACQUISITION Controls**—Determine the method of acquiring and displaying the acquired STORE waveform.

1K/4K Switch (Record Length)—Selects an acquisition record length of either one screen (1K) or four screens (4K). Pressing the button in selects 1K record length, and pressing it again to release it returns to 4K record length acquisitions. In either case, the displayed waveform has 100 data points per horizontal graticule division (50 if two channels are acquired).

When a waveform is acquired using the B time base, switching between record lengths also changes the delay time position setting by the same factor of four. The B DELAY TIME POSITION control must be repositioned to obtain the same delay.

When the 4K record length is selected, a one-screen (1K) window of the acquisition is displayed, and a bar graph is used to indicate the position of the displayed window within the record. Turn the CURSORS Position control to move the display window to any position within the record.

The 4K acquisition record can be compressed to a length of 1K by rotating the Variable SEC/DIV control out of the CAL detent position. The SEC/DIV readout is adjusted to reflect the correct time per division of the displayed waveform. The acquisition record may be magnified using the X10 Magnifier.

PRETRIG/POST TRIG Switch—Positions the trigger point for acquisitions either near the end (PRETRIG) or the beginning (POST TRIG) of the waveform. A T is displayed on the waveform to indicate the trigger point. Pressing the button in sets the trigger point to PRETRIG; out is the POST TRIG position.

ROLL/SCAN Switch—Selects either ROLL or SCAN acquisition and display mode. When pressed in (ROLL mode), at SEC/DIV switch settings from 0.1 s per division to 5 s per division the triggers are disabled for NORM and P-P AUTO Trigger modes, and the signals are continuously acquired and displayed. The waveform display scrolls from right to left across the crt with the latest samples appearing at the right edge of the crt. At SEC/DIV switch settings from 0.1 s per division to 5 s per division in SGL SWP Trigger mode, SCAN/ROLL/SCAN storage mode is selected.

At SEC/DIV switch settings of 0.05 s per division and faster, the ROLL/SCAN switch is not functional, and waveform samples require a triggering event to complete the acquisition before the display is updated.

When the ROLL/SCAN switch is in the out position (SCAN mode), the A TRIGGER Mode controls are functional. For NORM Trigger mode, the pretrigger waveform is updated by the trigger and the post trigger scans from the trigger position to the right. For SGL SWP, SCAN mode is overridden by SCAN/ROLL/SCAN. Triggers are disabled in P-P AUTO and TV FIELD Trigger modes.

SAVE/CONTINUE Switch—Stops the current acquisition and display update in progress when pressed in. Pressing the SAVE/CONTINUE switch a second time releases it and restarts (CONTINUE) the acquisition process. If the SEC/DIV switch setting is 0.1 s per division or slower, the SAVE state is entered immediately upon pressing the button. At SEC/DIV settings of 50 ms per division and faster, if an acquisition has been triggered, the acquisition is allowed to complete before the SAVE state is entered.

The pretrigger portion of an untriggered acquisition stops filling in SAVE mode. When leaving SAVE, a new acquisition is started, and a trigger is not accepted until the pretrigger portion again refills.

(41) **CURSORS Controls**—These controls apply to all displayed STORE mode waveforms. Delta Volts, Delta Time, One Over Delta Time, and Delay Time measurements of the STORE displays are made using the CURSORS controls. Positioning of the display window within a 4K acquisition record length is done using the CURSORS Position control. See the "Crt Readout" description for the cursor readout display.

POSITION CURS/SELECT WAVEFORM Switch—Determines the function of the CURSORS Position control. When pressed in (POSITION CURSORS mode), the CURSORS Position control functions as a cursor horizontal positioning control. When the push button is in the out position (SELECT WAVEFORM mode), the CURSORS Position control is used to position the cursor(s) to the desired waveform(s).

CURSORS Position Control—Provides for either horizontal positioning of the active cursor (or active cursors when there are two waveforms displayed in a display set) or for switching the cursors between waveform display sets. When cursors are positioned to a new waveform set, they return to the position that they had when they were last on that waveform set. Cursor positioning continues to function during SAVE mode, and measurements can be made on any displayed waveform. When SAVE is released, the cursors return to the acquisition waveform set.

Cursors are placed on all waveforms in a display set. A display set is one or both waveforms from the following: Acquisition, CH 1 and CH 2; Reference 1, CH 1 and CH 2; Reference 2, CH 1 and CH 2; and Reference 3, CH 1 and CH 2. Cursors can be placed on SAVE REF waveforms only if in SAVE mode. Cursors move to the acquisition waveform if they were on a SAVE REF waveform that is turned off. The acquisition parameters of the waveform set in which the cursors are located are displayed in the crt readout. Cursors movable by the CURSORS Position control are enclosed in a box.

When the acquisition record length is 4K, a one-screen (1K) window of the record is displayed. A bar graph indicates the position of the display window within the acquisition record. The position of the display window is adjusted to provide a display of the cursor position. If the displayed cursor is positioned to either edge of the display window, further positioning starts the waveform display scrolling in the opposite direction as the display-window position moves. Display-window positioning can be continued to the ends of the record, allowing observations and measurements to be made over the entire 4K acquisition record.

When switching between BOTH (A INTEN in STORE mode) and B ONLY STORE displays, the active cursor is displayed. Cursors in the intensified zone on A INTEN traces switch to their correct relative positions in a B ONLY trace. An active cursor outside the A intensified zone switches to the nearest displayed end of the B ONLY trace. Upon switching back to A INTEN the cursor returns to the correct position in the intensified zone.

SELECT C1/C2 (Cursor-Select) Switch—Selects the cursor(s) that can be positioned by the CURSORS Position control. Cursors are activated alternately with each press of the C1/C2 button. Each selected cursor is enclosed in a box.

(42) **MEMORY and Menu Controls**—These switches control MENU operation while the MENU is displayed, and they control the storage and display of the SAVE Reference waveforms when the MENU is not displayed.

WAVEFORM REFERENCE/MENU SELECT Switch—Selects either the MENU or SAVE REF MEMORY displays. In Waveform Reference mode, the MEMORY switches control the Save Reference Memory. In MENU mode, the MEMORY switches control the Menu, allowing selection of alternate parameters and modes that override the default front-panel settings.

SAVE REF MEMORY CONTROL—When the WAVEFORM REFERENCE/MENU SELECT switch is in the WAVEFORM REFERENCE position (button in), the MEMORY switches control the Save Reference Memory.

SAVE REF/→ Switch—Pressing this button just prior to pressing one of the DISPLAY ON/OFF buttons writes the displayed acquisition waveform into the selected Save Reference memory. The written waveform remains displayed on the crt. A control change or a delay of five seconds between pressing the SAVE REF button and selecting a memory location cancels the SAVE request.

Menu Select/DISPLAY ON/OFF Switches—These buttons select one of three memories that is either written to for saving a 1K acquisition waveform (if SAVE REF has been pressed) or toggles the reference memory display on or off (if the SAVE button has not been pressed). The stored waveforms of all three memories can be displayed at the same time. If a SAVE REF memory is chosen for display and no data is stored in that memory, a message to that effect is displayed. Two channels acquired in CHOP or ALT may be stored in a SAVE REF memory.

MENU CONTROL—When the WAVEFORM REFERENCE/MENU SELECT switch is in the MENU SELECT position (button out), the MEMORY switches control Menu Operation. Waveforms are only displayed with menus when a menu choice requires a waveform be displayed in order to perform the selected change. The Menu allows selection of alternate parameters and modes that override the default front-panel settings.

SAVE REF/→ Switch—When pressed, the next (to the right) Menu level is entered.

Menu Select/DISPLAY ON/OFF Switches—These three buttons select choices presented in the MENU. The ← button recalls the previous (to the left, higher) Menu level. The ↑ button selects the previous entry in the **current** Menu level. The ↓ button selects the next entry in the current Menu level.

MENU SELECTED FUNCTIONS

This part describes the Menu selected functions that provide selection of parameters, settings, and features not controlled by the front-panel switches.

ACQ MODE SETUP TABLE

ACQ MODE SETUP TABLE controls the acquisition mode setup using a table.

DEFAULT—Selects the default acquisition modes for all sweep speeds (see Table 3-2 for the default modes).

SELECT MODE—Displays the acquisition modes in a table. The desired modes for each sweep speed may be selected using the SEC/DIV switch to select the column, the CURSORS Position control selects the row, and the SELECT C1/C2 switch toggles the choice for the table position that is enclosed in a box.

SWP LIMIT—Selects the number of acquisitions before the acquisition system halts in either ACCPEAK or AVERAGE. The acquisition system may be reset by pressing the SELECT C1/C2 switch.

WEIGHT—Selects the weight of the last sample in AVERAGE mode.

A TRIG POS

A TRIG POS selects the number of points acquired prior to or following the trigger.

DISPLAY

DISPLAY controls the selection of display parameters.

DELTA T MODE—Selects either DELTA TIME or ONE OVER DELTA TIME for display in the readout.

VECTORS ON/OFF—Selects either DOTS or VECTORS as the waveform display mode. Vectors are not allowed in REPETITIVE mode.

SMOOTH ON/OFF—Selects the process with which the vector displays are produced when in PEAKDET or ACCPEAK.

With SMOOTH OFF, no reordering of the data points is done, and vectors are drawn between all of the minimum and maximum data points.

With SMOOTH ON, data points are reordered for correct slope and interpolated for drawing a smooth waveform. Smoothing looks at the change in value of reordered data points between adjacent sample intervals. If the change in value does not exceed certain limits, the values are interpreted as a continuous slope for drawing either vectors or dots. If the value change exceeds the interpreted "no-change" limit, the data point value is not modified, and the vectors drawn in the display show a discontinuity in the waveform. This method of display of the waveform data provides a smoothed display of the waveform, yet retains the glitch-catching capabilities of PEAKDET or ACCPEAK modes.

FORMATTING

FORMATTING selects a SAVE REF memory for formatting. The vertical gain, horizontal gain, and vertical position of the selected reference waveform may be changed. The acquisition mode used to store the waveform may also be displayed.

TARGET REFERENCE—Selects one of the SAVE REF memories for formatting.

VGAIN—Allows adjustment of the vertical gain of SAVE REF memories.

VPOSITION—Allows adjustment of the vertical position of SAVE REF memories.

HMAG—Turns X10 horizontal magnification of SAVE REF memories on or off.

MODE—Displays the parameters used to acquire a SAVE REF memory.

PLOT

PLOT controls the transmission of waveforms over the X-Y Plotter output.

START—Initiates the transmission of a waveform over the X-Y Plotter output.

GRATICULE ON/OFF—Enables or disables plotting of the graticule.

ADVANCED FUNCTIONS

REFERENCE—Allows a SAVE REF memory to be Erased or Copied.

ERASE—Selects and erases a SAVE REF memory.

COPY—Selects and copies one SAVE REF memory to another SAVE REF memory.

COMM—Allows the selection of parameters for optional communications options, when they are present.

ACQ MODE SETUP TREE—Controls the acquisition mode setup using a tree. This provides control of the same functions as the ACQ MOD SETUP TABLE.

DEFAULT—Selects the default acquisition modes for all sweep speeds (see Table 3-2 for the default modes).

REPETITIVE—Selects the acquisition modes for sweep speeds from 0.05 μs to 2 μs per division.

FAST RECORD—Selects the acquisition modes for sweep speeds from 5 μs to 10 μs per division.

SLOW RECORD—Selects the acquisition modes for sweep speeds from 20 μs to 50 ms per division.

SLOW TRIGGERED—Selects the triggered acquisition modes for sweep speeds from 0.1 to 5 s per division or EXT CLOCK.

SLOW UNTRIGGERED—Selects the untriggered acquisition modes for sweep speeds from 0.1 to 5 s per division or EXT CLOCK.

DIAGNOSTICS—Controls the selection of diagnostic TESTS, EXERCISERS, and PICTURES.

Acquisition Modes

PEAK DETECT (PEAKDET) and SAMPLE (NORMAL)—Select how samples are processed on successive acquisitions. See Table 3-2 for the default modes set by the SEC/DIV switch.

In Peak Detect mode, the minimum and maximum levels of the input signal within the time represented by 1/50 of a division unmagnified (1/25 of a division in CHOP or ALT) are digitized and stored in acquisition memory as a data pair. The displayed data points are connected by vectors.

In Sample mode, the signal is sampled at a rate that produces 100 samples per graticule division. In RECORD sampling, the displayed sample points are connected by either vectors or dots. For REPETITIVE Storage mode, the sample points are displayed as dots.

ACCPEAK—Will cause displays to accumulate. The largest maximum and smallest minimum sample acquisitions are retained for each trigger-referenced sample record over multiple acquisition cycles. When ACCPEAK is used with hardware peak detection (50 μs per division to 0.1 s per division), updating of maximum and minimum samples also occurs within each time-base clock period. Changing any switch that affects the acquisition parameters resets ACCPEAK displays. ACCPEAK mode is valid for triggered acquisitions only and is not operational in any mode that does not allow triggers (see Table 3-2).

AVERAGE—Is used for multiple record averaging. Whenever AVERAGE is selected, SAMPLING is also selected automatically. When on, a normalized algorithm is used for continuous display of the signal at full amplitude during the averaging process. Averaging is the default for REPETITIVE Store mode only. The amplitude resolution increases with the number of weighted acquisitions included in the display. The number of weighted acquisitions included in the AVERAGE display is Menu selectable. The default weight of AVERAGE mode is 1/4. Other choices are Menu selectable. The number of sweeps (SWP LIMIT) allowed to occur before averaging stops is also Menu selectable.

REAR PANEL

Refer to Figure 3-6 for location of items 43 through 45.

(43) **EXT Z-AXIS Input Connector**—Provides an input connector allowing external signals to be applied to the Z-Axis circuit to intensity modulate the NON STORE waveform display. Applied signals do not affect the display waveshape. External signals with fast rise and fall times provide the best defined intensity modulation. Noticeable intensity modulation is produced at normal viewing intensity levels by a 5 V p-p signal. The Z-Axis signals must be time-related to the trigger signal to obtain a stable intensity-modulation pattern on the displayed waveform.

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

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

SIDE PANEL

The standard side panel includes one AUXILIARY CONNECTOR. Refer to Figure 3-7 for the location of item 46.

(46) **AUXILIARY CONNECTOR**—Provides connections for an X-Y Plotter and an External Clock input (see Table 3-4).

NOTE

To avoid causing interference to other instruments, use a shielded cable for connections to the AUXILIARY CONNECTOR.

X-Y Plotter Connections—Provide connections for X-Axis output, Y-Axis output, and Pen Lift control to drive an external X-Y Plotter. All displayed waveforms and the crt readout are transmitted over the Plotter Interface. The settling time allowed for each movement is approximately proportional to the distance of the movement. Connections for Signal Ground and Shield Ground are also provided for grounding between the instrument and the external X-Y Plotter. Waveforms and the Readout are plotted on the crt while a plot is in progress.

Table 3-4

Auxiliary Connector

Pin Number	Function
1	EXT CLK Input
2	Pen Lift, Normally Closed
3	X Output
4	SHIELD GND
5	Y Output
6	+4.2 V
7	Pen Lift, Normally Open
8	Pen Lift, Relay Common
9	SIG GND

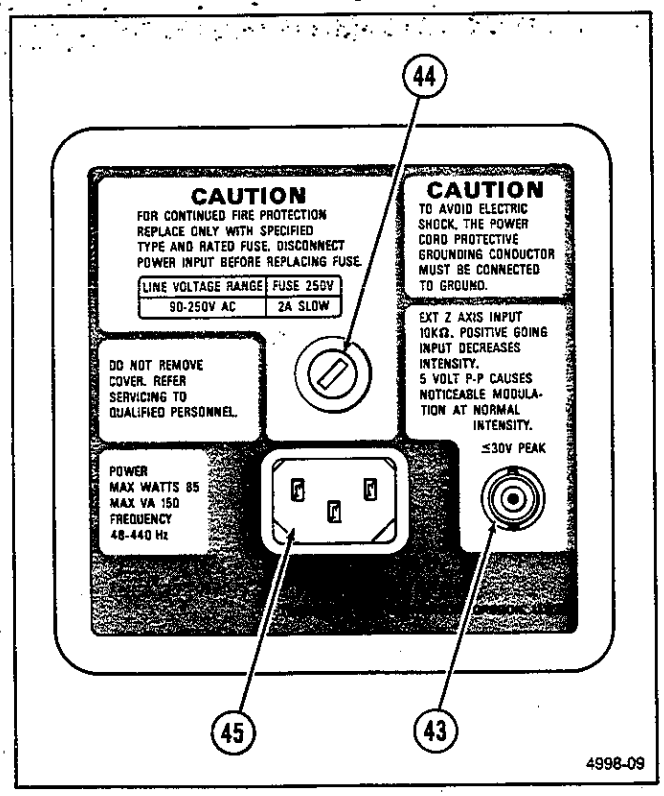

Figure 3-6. Rear panel.

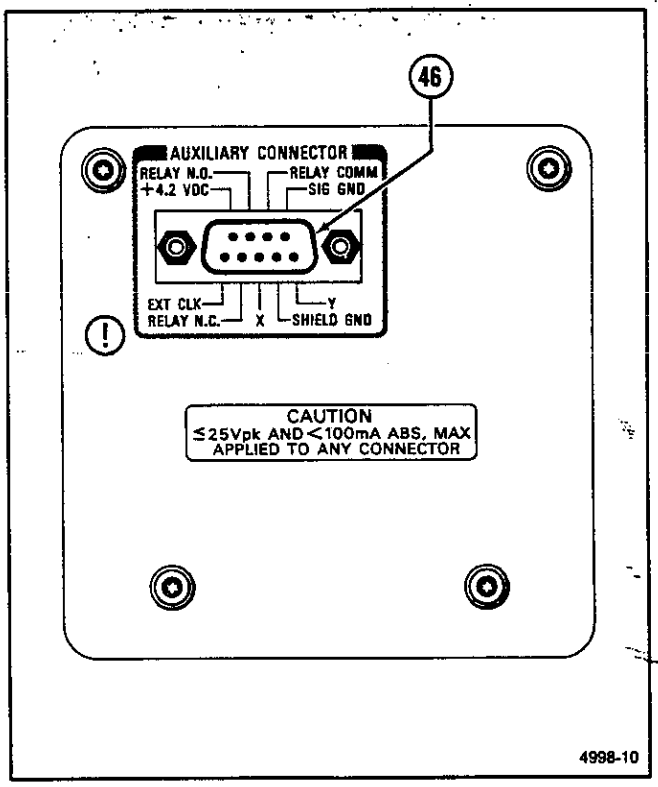

Figure 3-7. Side panel.

To be fully compatible, the X-Y Plotter used must have X and Y inputs with sensitivity control and penlift control.

Signals available at the AUXILIARY CONNECTOR allow the Pen Lift circuit to be wired for a plotter with either active HI or active LO drive requirements and several logic families. Examples for both an active HI and an active LO TTL drive are shown in Figure 3-8.

EXT CLK Input—Provides an input for EXT CLOCK signals (up to 1000 samples per second) to the storage acquisition circuitry in conjunction with the EXT CLK position of the A SEC/DIV switch. Samples are referenced by falling edges. Input is TTL compatible. Samples become visible by pairs, as SCAN or ROLL. Several clocks are required before the point associated with the first clock is visible.

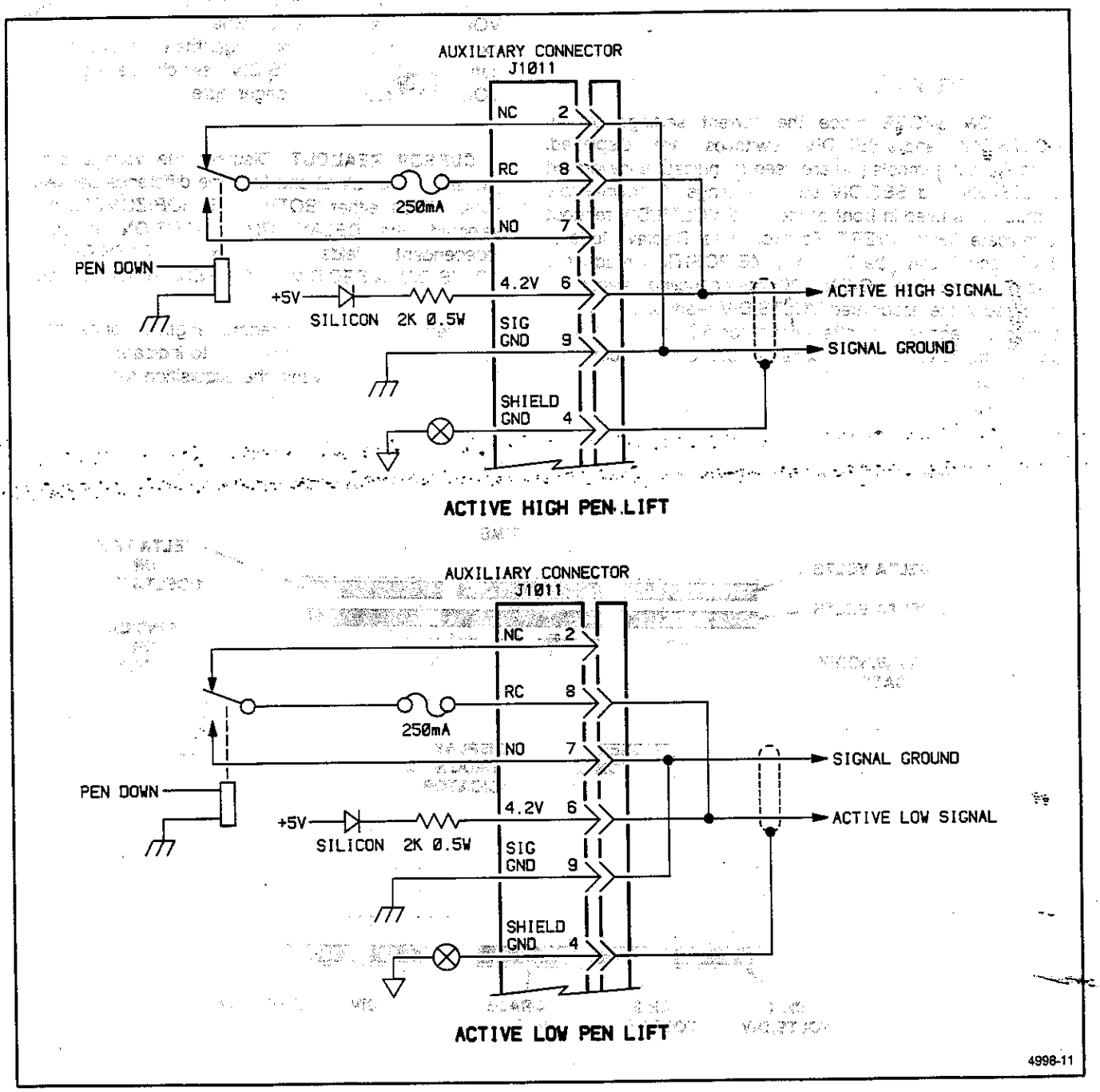

Figure 3-8. X-Y Plotter interfacing.

CRT READOUT

The Readout System provides an alphanumeric display of information on the crt along with the waveform displays. The readout (non MENU) is displayed in three rows of characters. Two rows are within the top graticule division, and the other row is within the bottom graticule division. The locations and types of information displayed under normal operating modes are illustrated in Figure 3-9.

NON STORE Mode

In NON STORE mode the current settings of the VOLTS/DIV and SEC/DIV switches are displayed. Greater-than symbols (>) are used to indicate uncalibrated VOLTS/DIV and SEC/DIV switch settings. A down-arrow symbol (↓) is used in front of the CH 2 VOLTS/DIV readout to indicate CH 2 INVERT. For Horizontal Display Mode of BOTH and B only, the DELAY TIME POSITION readout is also displayed. The AC-GND-DC input coupling selection is indicated in the associated VOLTS/DIV readout with a tilde symbol (~) above the volts symbol for AC, a ground symbol (⏚) for GND, and no extra symbol for DC input coupling.

STORE Mode

In STORE mode, many of the crt readout displays are associated with the parameters of stored waveforms.

PARAMETER READOUT. Displays the VOLTS/DIV, SEC/DIV and B DELAY TIME settings of the displayed waveforms on which the intensified cursors are placed. The AC-GND-DC input coupling selection is indicated in the associated VOLTS/DIV readout with a tilde symbol (~) above the volts symbol for AC, a ground symbol (⏚) for GND, and no extra symbol for DC input coupling. If the VOLTS/DIV switch is switched beyond the available expansion or compression range, the readout is tilted, indicating that the VOLTS/DIV switch setting and the VOLTS/DIV readout no longer agree.

CURSOR READOUT. Displays the voltage difference (either ΔV 1 or ΔV 2) and the time difference between cursors. When either BOTH or B HORIZONTAL mode is selected, the DELAY TIME POSITION is displayed. Independent fields for CH 1 VOLTS/DIV, CH 2 VOLTS/DIV, A SEC/DIV, and B SEC/DIV are provided.

When the acquisition record length is longer than one screen (1K), a bar graph is used to indicate the position of the display window within the acquisition record.

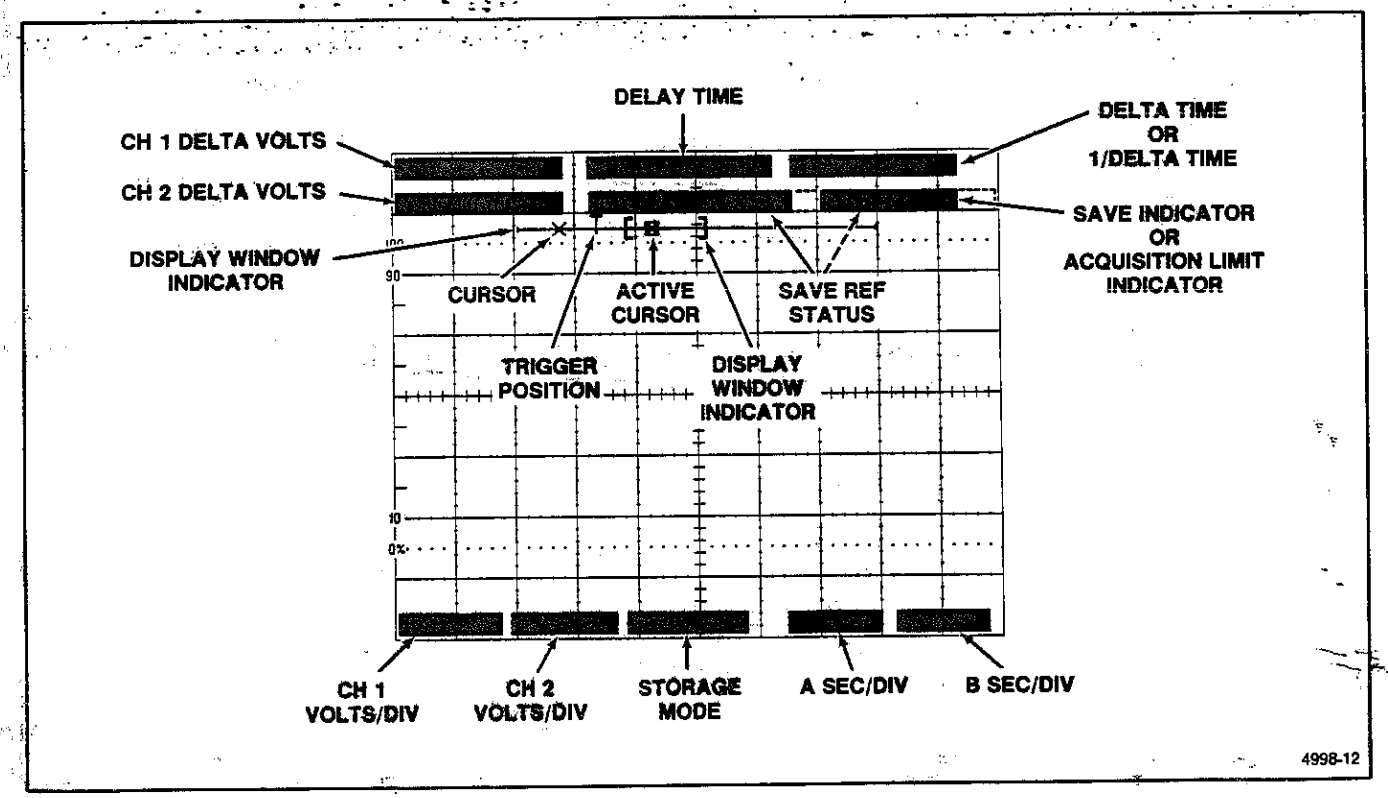

Figure 3-9. Crt readout display.