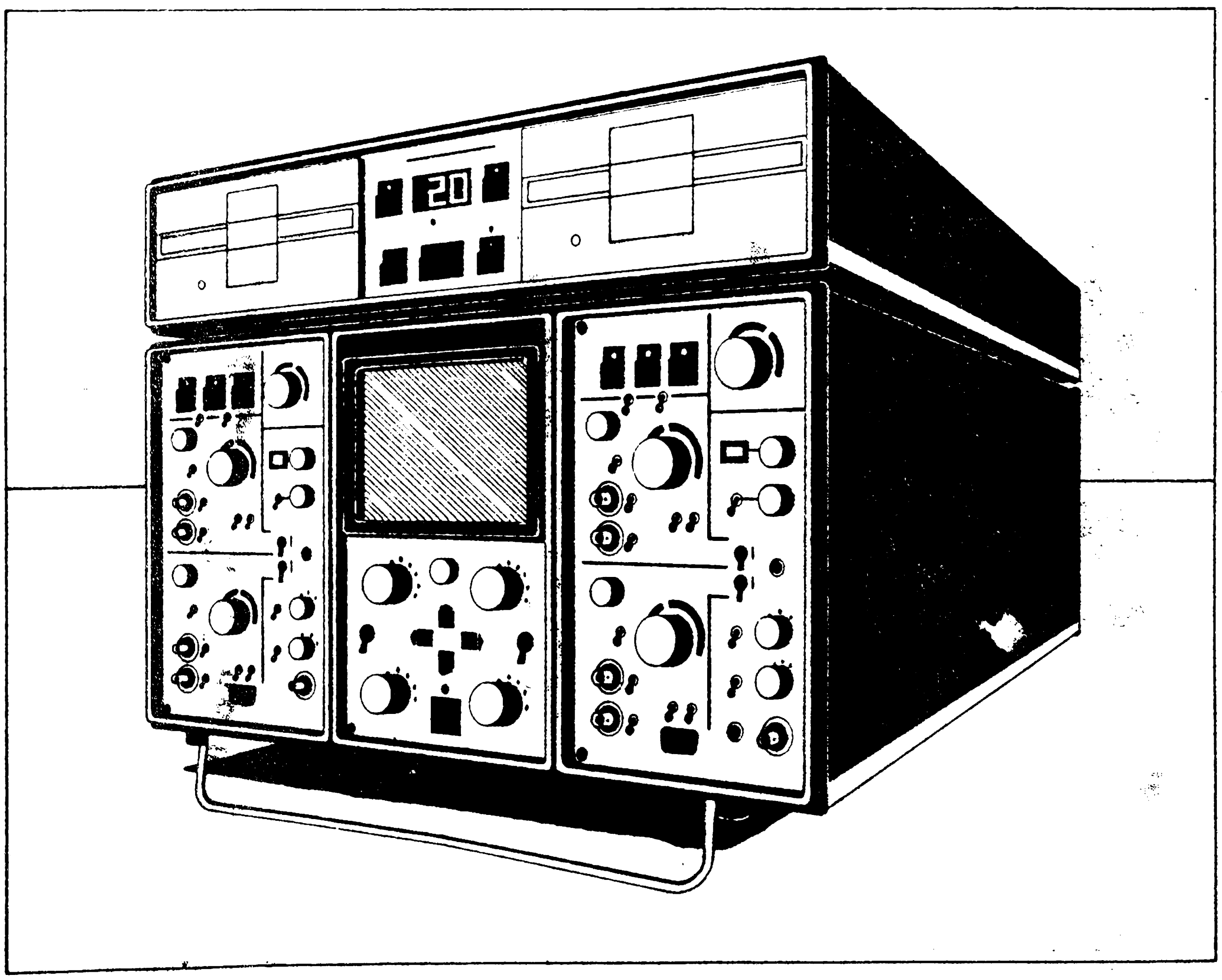
NICOLET
INSTRUMENT
CORPORATION
OSCILLOSCOPE DIVISION

OPERATION MANUAL

SERIES 4094 DIGITAL OSCILLOSCOPES



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CAUTIONS

CAUTION: This instrument and related accessories are not designed for biomedical experiments on humans and should not be directly connected to human subjects.

CAUTION: This instrument must not be operated in explosive atmospheres.

The following information is required by the FCC and relates only to the interference potential of this equipment. This message is a direct quotation. Although stated as a "Warning", there is essentially no risk of injury, loss of life, or equipment damage.

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. As temporarily permitted by regulation, it has not been tested for compliance with the limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

WARNING: Inspect the voltage selection switch, Figure 5-2, located at the rear of the 4094 for the correct setting BEFORE applying power. Use Table 5-1 to verify the correct setting.

Page 5-2

WARNING: Before applying power to this instrument, refer to the *Receiving & Pwr Req's* tab, page 5-2.

Pages 7-3, 7-9 & 12-3

CAUTION: Remove all power from the oscilloscope before replacing the fuse.

Page 7-9

CAUTION: Always ensure that the input signals never exceed the maximum, allowable input voltage, with respect to ground, listed under tab *Specifications*.

Page 8-12

WARNING: To guard against physical damage to the disk heads and/or diskette, ALWAYS open the drive's door when:

a. Power is off, or
b. Applying/removing power, or
c. Drive is not being used, or
d. Transporting the instrument.

Pages 9-9 & 11-1

WARNING: Always ensure that the position of the XF-44's POWER selector corresponds to that of the 4094's POWER selector before applying power to either unit.

Page 11-4

WARNING: Lethal voltages exist within the XF-44. It should be serviced only by qualified personnel. Remove all power from this instrument before servicing. Reapply power only after all safety measures have been observed.

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GLOSSARY

- ANALOG ZERO: Identified by the position of the Plug-in's trigger crosshair.

- BNC: Connector used to input/output signals.

- DATA GROUP: The displayed input signal.

- DATA POINTS: The small dots, displayed on the screen, representing the discrete, digitized time and voltage coordinates of the analog input signal.

- DIGITAL ZERO: Located at screen vertical center.

- DIGITIZER: Converts analog input signals into discrete, digitized time and voltage coordinates.

- DISK RECORDER: Optional F-43 and XF-44 conversions used to permanently record input signals on a floppy diskette.

- HOLD MODE: The status of the Plug-in when only the Hold Last LED is illuminated. The Live and Hold Next LEDs are turned off.

- LED: A light emitting diode used as a status light.

- LIVE: The status of the Plug-in when input signals are being acquired and stored in the memory.

- MAINFRAME: Includes the display memory, display screen, and controls used to manipulate the displayed input signal.

- MEMORY: Device used to temporarily record the digitized input signal(s).

- NOISE: Undesirable voltage disturbances on the input signal.

- NUMERICS: The alphanumerics readouts on the display screen.

- PLUG-IN: The Model 4562 and 4851 plug-in units containing the digitizing and buffer memory circuitries and the controls used to acquire the input signal(s).

- RESOLUTION: The ability to discern the minimum voltage difference between any two digitized data points and still retain the optimum characteristics of the analog signal.

- SEGMENT: Either one-half or one-quarter of the floppy diskette's record as determined by the position selected on the MEMORY switch.

- SUBSECTION: Either one-half or one-quarter of the display memory's addresses as determined by the position selected on the MEMORY switch.

- SWEEP: The acquisition and display of the input signal. Initiated after a valid trigger has been received.

- TRIGGER: The input signal applied to the Plug-in which, when possessing the required characteristics, will initiate a sweep.

- WINDOW: The voltage span (difference) between two voltage levels.

4094 SPECIFICATIONS

MAINFRAME	
Memory Size:	16K words, 16 bits.
Addressable Subgroups:	Halves (8K), Quarters (4K).
Data Memory:	15,872 words, 16 bits.
Storage Capacity:	Up to 32 Waveforms.
Display:	5-inch, high definition.
Expansion:	Up to X256, both axes, cursor-interactive.
Numerics:	
(a) YT Display Mode:	Time and voltage plus channel identifier.
(b) XY Display Mode:	X-voltage and Y-voltage plus channel identifier.
Numeric Displays (XY/YT):	
(a) Normal:	Absolute numerics.
(b) Reset Numerics:	Relative numerics.
(c) Grid:	Numeric scale per grid mark.
Arithmetic Functions:	Subtract, Invert, Data Move.
Optional Functions:	Variety of mathematical routines available on diskettes.
Autocenter:	
(a) Unexpanded Display:	Automatic lock of cursor to waveform.
(b) Expanded Display:	Automatic waveform centering.
Zero (Spring-loaded):	Automatic check of analog zero.
Pen:	Analog output to XY or YT pen recorder. Output to digital plotter.

Specifications are subject to change without notice.

PARAMETER	PLUG-IN MODEL	
	4562	4851
Buffer Memory Size:	16K x 16-bits	16K x 16-bits
Overall Accuracy:	0.2% F.S.	0.2% F.S.
Linearity:	0.1% F.S.	0.1% F.S.
Noise, (RMS, open inputs):	0.025% F.S.	0.006% F.S. + 7uV
Absolute Timing:	±0.01% time/pt.	±0.01% time/pt.
Single Sweep Drift (Note 1):	0.04% F.S./°C	0.04% F.S./°C
Zero Position Range:	10 to 90% F.S.	10 to 90% F.S.
Vertical Resolution	12-bits (0.025%)	15-bits (0.003%)
Maximum Sweep Length:	15,872 pts	15,872 pts
Aperture Uncertainty:	50 pSec	700 pSec
External Clock Rate (Max):	3.5 uSec/pt	20 uSec/pt
Accuracy		
a. Time Base:	0.01%	0.01%
b. Ground Reference:	0.1% F.S.	0.05% F.S.
Analog Bandwidth		
a. 1V, 2V, 10V, 20V:	650 KHz	50 KHz
b. 100mV to 400mV:	400 KHz	50 KHz
c. 4V, 40V:	400 KHz	50 KHz
Inputs		
a. Type:	2 Differential	2 Differential
b. Coupling:	AC/DC/GND	AC/DC/GND
c. Ranges (Full Scale):	±100mV to +40V	±100mV to +40V
d. Impedance:	1 Megohm, 47pF	1 Megohm, 47pF
e. Filter, (Switchable, RC):	100 KHz	1 KHz
Safe Overload		
a. 10V to 40V:	400V	150V
b. 1V to 4V:	300V	40V
c. 100mV to 400mV:	300V	40V

NOTE 1: Each new sweep removes thermal drift variations automatically.

Specifications are subject to change without notice

PARAMETER	PLUG-IN MODEL	
	4562	4851
Common Mode		
a. Voltage Range:	200% F.S.	200% F.S.
b. Rejection Ratio:	72 dB	90 dB
Digitizing Rate:		
a. Maximum	500 nSec/pt.	10 uSec/pt.
b. Minimum	200 Sec/pt.	200 Sec/pt.
Trigger		
a. Modes:	Auto/Norm	Auto/Norm
b. Coupling:	AC/DC	AC/DC
c. Slope:	+,-,Dual	+,-,Dual
d. Source:	ChA, ChB, Ext, Slave	ChA, ChB, Ext, Slave
Trigger Range		
a. External:	±10 Volts	±10 Volts
b. Internal:	80% F.S.	80% F.S.
Trigger Sensitivity		
a. External:	0.5 Volts	0.5 Volts
b. Internal:	5% F.S.	5% F.S.
Trigger Delay		
a. Post-Trigger (max):	2^{26} x time/pt.	2^{26} x time/pt.
b. Pre-Trigger:	99.9% of sweep time	99.9% of sweep time
c. To First Sample:	210nS	350nS
Trigger Uncertainty		
a. Zero/Post-trigger:	20nS	10nS
b. Pre-trigger:	One Sample Period	One Sample Period
Sweep Intervals, (Min)		
a. Hi Speed Mode	@<20uS/pt (62mS/4K)	@<50uS/pt (80mS/4K)
b. Lo Speed Mode	@>20uS/pt (30mS)	@>50uS/pt (20mS)
c. Hi Speed Mode (w/Averaging)	@<200uS/pt (250mS/4K)	@<500uS/pt (325mS/4K)
d. Lo Speed Mode (w/Averaging)	@>200uS/pt (30mS)	@>500uS/pt (82mS)

OTHER STANDARD PLUG-IN FEATURES
(a) The ability to retain a reference signal on each channel. (b) Sweep averaging at all speeds. (c) Point averaging (inter-sample averaging) at speeds slower than 500uS/pt. (d) Trigger view mode for trigger set-up.

Specifications are subject to change without notice.

PARAMETER	4175 PLUG-IN
Buffer Memory Size:	16K x 8-bits
Vertical Resolution:	8-Bits (0.4%)
Maximum Sweep Length:	15,872 pts
External Clock Rate (max):	50 nS/pt.
Linearity:	±0.4% F.S.
Time Base Accuracy:	0.01% **(Note 1)**
Safe Overload:	150V **(Note 2)**
Accuracy	
a. DC to 2 MHz:	±3% F.S.
b. 2 MHz to 20 MHz:	±5% F.S. (at 10 points per cycle)
Analog Bandwidth **(Note 3)**	
a. DC Coupled:	DC to 75 MHz
b. AC Coupled	
1M Ohm input:	0.5 Hz to 75 MHz
50 Ohm input:	3 KHz to 75 MHz
Common Mode	
a. Voltage Range:	200% Full Scale
b. Rejection Ratio	
1 Megohm:	30 dB to 1 MHz
50 Ohm:	30 dB to 1 MHz, 25 dB to 10 MHz
Digitizing Rate	
a. Maximum (single-shot):	50 MHz (20 nS/pt)
b. Minimum (single-shot):	10 Sec/pt
c. Maximum Apparent (sampling Mode):	500 MHz. (2 nS/pt)

NOTE 1: The timebase accuracy is ±2nS in the sampling mode.

NOTE 2: The 50 ohm inputs are automatically limited to ±5 volts.

NOTE 3: The bandwidth in trigger view is limited to 50 MHz.

Specifications are subject to change without notice

PARAMETER	4175 PLUG-IN
Inputs (two)	
a. Differential:	DC to 5 MHz
b. Single Ended:	DC to 75 MHz
c. Coupling:	AC/DC/GND
d. Ranges (Full Scale):	±100mV to ±40V
e. Impedance (switchable):	50 Ohm or 1 Megohm (47pF)
f. Filter (switchable):	10 MHz
g. Zero Position Range:	10 to 90% Full Scale
Noise (RMS, open inputs)	
a. Filter Off:	0.5% Full Scale
Trigger	
a. Modes:	Auto/Norm
b. Coupling:	AC/DC/HREJ/LREJ
c. Slope:	+, -, Dual
d. Source:	ChA, ChB, Ext, Slave
Trigger Range	
a. Post-Trigger (max delay):	2^{20} x Time Per Point (nonsampling)
b. Pre-Trigger (max):	99.9% of Sweep Time
c. External:	±5V
d. Internal:	80% Full Scale
Trigger Sensitivity	
a. External:	1V to 8V
b. Internal:	10% to 80% Full Scale

OTHER STANDARD PLUG-IN FEATURES

(a) The ability to retain a reference signal on each channel.

(b) Sweep averaging at all speeds.

(c) Trigger view mode for trigger set-up.

(d) Front panel functions controllable via computer interfaces.

Specifications are subject to change without notice

DISK RECORDER	
Disk Recorder Type:	5-1/4" Floppy, double sided, double density, soft-sectored, 96 TPI.
Storage Capacity/Diskette:	Twenty 16K, forty 8K or eighty 4K records.
Record Identification:	3-digit L.E.D.
Write Protection:	Automatic, manual unprotect.
Autocycle:	Automatic consecutive capture-and-store of up to 80 records.

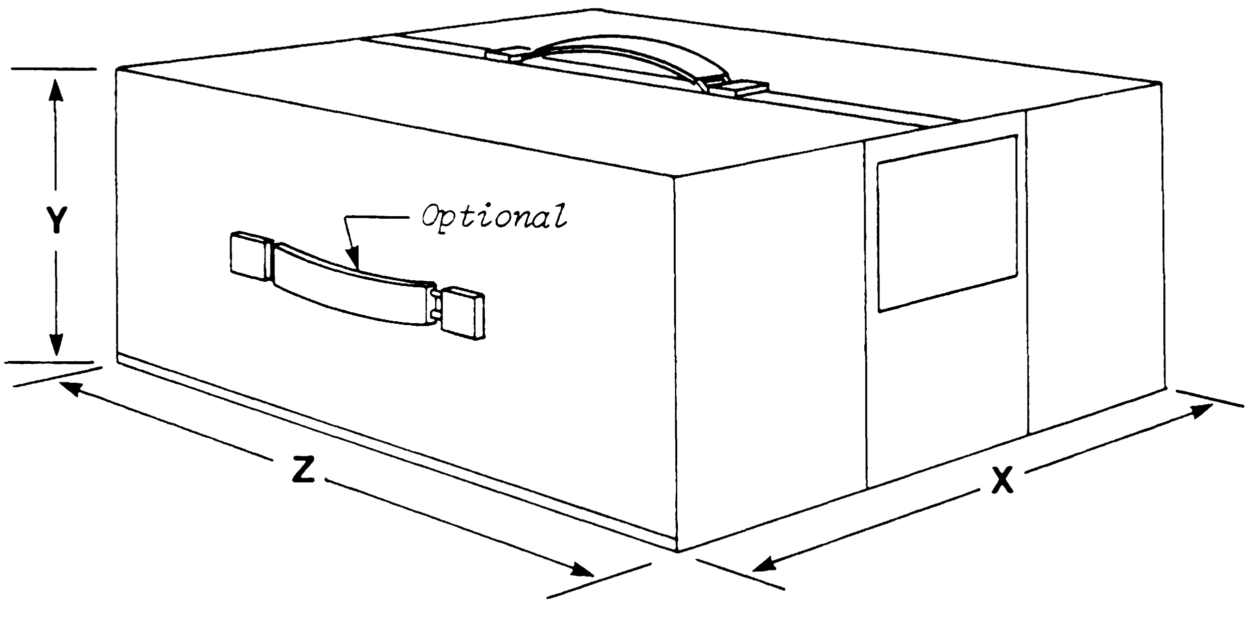
DIGITAL I/O	
Interfaces Available:	IEEE-488 (GPIB), RS-232C, Digital Plotter controller, (RS-232C).
IEEE-488 (GPIB):	Bi-directional, up to 20K bytes/second, ASCII or binary.
RS-232C:	Bi-directional, up to 19,200 baud, ASCII or printable binary.
Minimum Transfer Times (16K):	GPIB Binary, 1.5 seconds. RS-232C Binary, 18 seconds.

POWER REQUIREMENTS
120 or 240 VAC, +8% to - 20%; Single Phase, 50-60 Hz (+5%); 460 Volt-amperes maximum.

Specifications are subject to change without notice.

APPROXIMATE DIMENSIONS

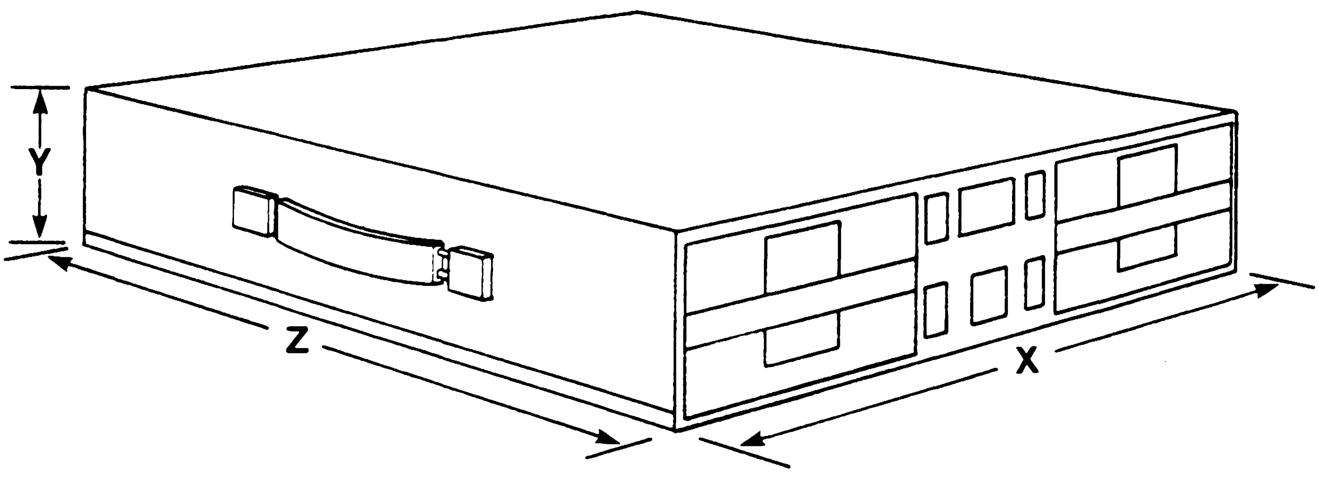
MODEL 4094 OSCILLOSCOPE



	DESCRIPTION	APPROXIMATE DIMENSIONS
X	Basic Frame Width	16-15/16" (43.1 cm)
	Side Mounted Carrying Handle, add	1/2" (1.3 cm)
	Side Mounted Bumpers, add	1/4" (0.6 cm)
Y	Basic Frame Height	8-3/4" (22.2 cm)
	Top Mounted Carrying Handle, add	1/2" (1.3 cm)
	Bottom Mounted Feet, add	5/8" (1.6 cm)
Z	Basic Frame Length	18-1/4" (46.4 cm)
	Front Panel Control Knobs, add	5/16" (0.8 cm)

Specifications are subject to change without notice

XF-44 DISK RECORDER



	DESCRIPTION	APPROXIMATE DIMENSIONS
X	Basic Frame Width	16-15/16" (43.1 cm)
	Side Mounted Handle, add	5/16" (0.8 cm)
	Side Mounted Bumpers, add	1/16" (0.2 cm)
Y	Basic Frame Height	4-1/8" (10.5 cm)
	Bottom Mounted Feet, add	5/8" (1.6 cm)
Z	Basic Frame Length	18-1/4" (46.4 cm)
	Front Panel Controls, add	1/8" (0.3 cm)
	Rear Panel Controls, add	3/8" (0.9 cm)

Specifications are subject to change without notice

APPROXIMATE WEIGHTS

DESCRIPTION	APPROXIMATE WEIGHTS
4094 mainframe only	30 lbs.
4175 Plug-in	10 lbs.
4562 Plug-in	7 lbs.
4851 Plug-in	7 lbs.
F-43/1 right bay disk recorder with one disk drive	3 lbs.
F-43/2 right bay disk recorder with two disk drives	4 lbs.
XF-44/1 external disk recorder with one disk drive	17 lbs.
XF-44/2 external disk recorder with two disk drives	20 lbs.

Specifications are subject to change without notice

RECEIVING

Unpack the Model 4094 Digital Oscilloscope and save the carton and packing material in case the instrument must be shipped to another site or returned to the factory for service.

INSPECTION

Inspect the exterior of the instrument for any visible signs of damage that may have occurred during transit.

<u>If damaged</u>, call NICOLET Oscilloscope Division, Shipping Department, at (608) 271-3333 for instructions.

POWER REQUIREMENTS

The Model 4094 Digital Oscilloscope's power requirement is nominally *** volt-amperes. It is designed to operate from either of these two single phase power source voltages: 120 or 240 vac, both +8% or -20%.

The power source must include:

#1. A neutral wire at or near ground potential; and

#2. A separate safety ground at ground potential; and

#3. A line (hot) wire.

Figure 5-1 illustrates the locations of the neutral, line, and earth ground terminals located on the male power connector at the rear of the 4094.

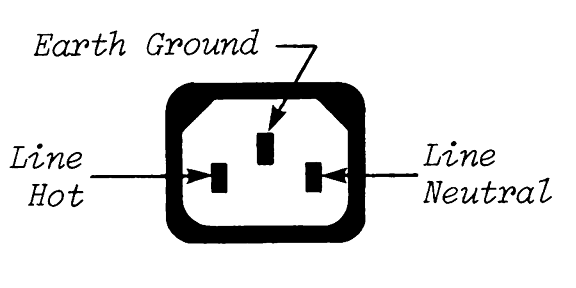


Figure 5-1

WARNING: Inspect the voltage selection switch, Figure 5-2, located at the rear of this instrument, for the correct setting BEFORE applying power. Use Table 5-1 to verify the correct setting.

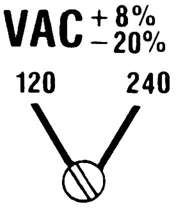


Figure 5-2

SWITCH POSITION	RANGE
120	*96 - 129V*
240	*192 - 259V*

Table 5-1

** Exact spec's to be verified.*

INTRODUCTION

The Start-up section of this manual provides the operator with a general overview of the 4094 oscilloscope. Users unfamiliar with digital oscilloscope operation will have the most to gain by reading this section.

Only the most common oscilloscope (Mainframe and Plug-in) operations are covered here. Detailed explanations of specific controls are found in the appropriate specialized sections of this manual.

Part I of the Start-up section does not assume the availability of a signal source.

Part II assumes that a function generator or other signal source is available to provide input waveforms. The reader is urged to locate a signal source in order to gain experience under realistic conditions.

NOTE: Part I must be read before proceeding to Part II.

PART I

Part I assumes that the inputs to the 4094 oscilloscope remain unconnected to outside devices.

● PART I INITIAL SET-UP

#1. Remove diskettes in disk recorders (if applicable) and leave the disk recorder doors open.

#2. Turn the oscilloscope power OFF, POWER button located under the screen.

#3. Turn <u>all</u> knobs on the front of the oscilloscope to the extreme counterclockwise positions.

#4. Place <u>all</u> lever switches to the down position.

Figure 6-1 illustrates the initial set-up positions for the Mainframe and Plug-in controls.

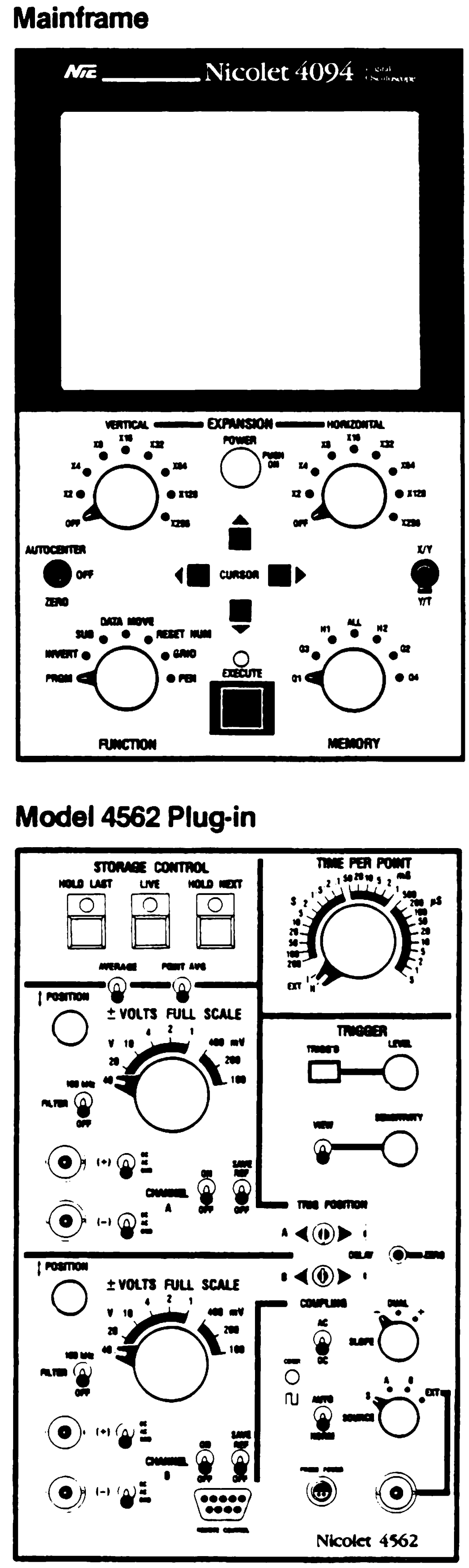


Figure 6-1

● OVERVIEW OF CONTROLS

NOTE: Figures 6-2 through 6-10 identify controls which correspond to areas under discussion or require setting selections within the text.

In addition, if the 4094 oscilloscope has two Plug-ins, use only the one on the left side of the oscilloscope for this section (Part I). Leave the other Plug-in with both Channel A and B "ON/OFF" switches in the OFF position.

#1. Apply power to the oscilloscope by pressing in the POWER button located under the screen.

#2. Make the following settings, (Figure 6-2):

a.	TIME PER POINT:	10μS
b.	CHANNEL A:	On
c.	TRIGGER:	Auto
d.	TRIGGER SOURCE:	A
e.	LIVE:	Press.

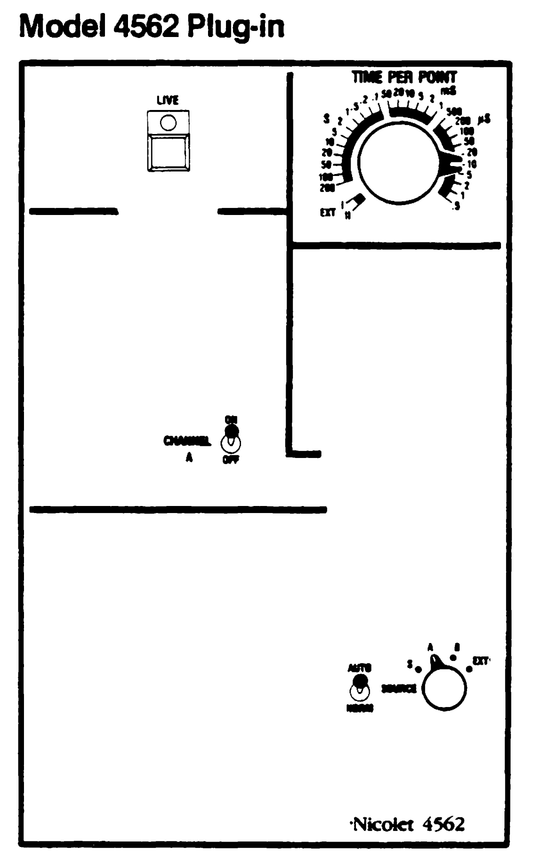


Figure 6-2

After the LIVE button has been pressed, the screen will display the horizontal and vertical cursors, and a single line (trace) and crosshair associated with channel A, (Figure 6-3).

NOTE: Since Channel A inputs have been left grounded, the trace will appear as a straight line. The (1A) designation in the lower center of the display screen denotes "Plug-in #1/ Channel A" is being used.

Note that the TRIGGER light is flashing, indicating that sweeps are being made across the display. Each sweep is initiated by a trigger resulting from the AUTO trigger setting.

At this point, it is important to fully understand the display. The vertical and horizontal cursor lines are used to inspect the display for time and voltage.

#3. Manipulate the UP/DOWN and LEFT/ RIGHT cursor controls, Figure 6-3, while observing the time and voltage numerics.

Zero time is located at the left edge of the display. Zero voltage is located at the level of the displayed input from Channel A (ground = zero volts).

The crosshair (also referred to as the "trigger cursor") associated with the Channel A input is always located at zero time, zero voltage. Movement of the horizontal cursor beyond the upper/lower limits of the screen causes them to automatically "wrap-around" and reappear on the opposite side of the display. Movement of the vertical cursor beyond the left/right limits of the screen causes the cursor to stop at the limit. Releasing the CURSOR button and then repressing it

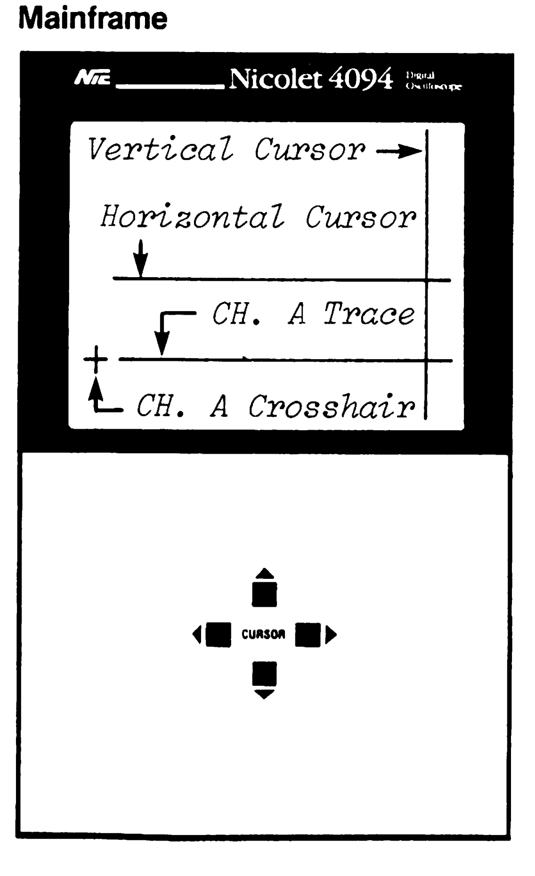


Figure 6-3

allows the cursor to "wrap-around" to the opposite side of the screen. This feature can be used to quickly move the cursors from one side to the other.

The most common use of the horizontal and vertical cursors is to indicate the time and voltage of various points on the input waveform. The easiest way to accomplish this is to switch into AUTOCENTER.

#4. Place the AUTOCENTER switch to the Autocenter position, Figure 6-4.

The horizontal cursor immediately jumps to the intersection point of the vertical cursor and the input waveform.

While in Autocenter, the UP/DOWN cursor controls are inoperative, while the RIGHT/LEFT cursor controls operate as before. The horizontal cursor will always remain located at the intersection of the input waveform and the vertical cursor.

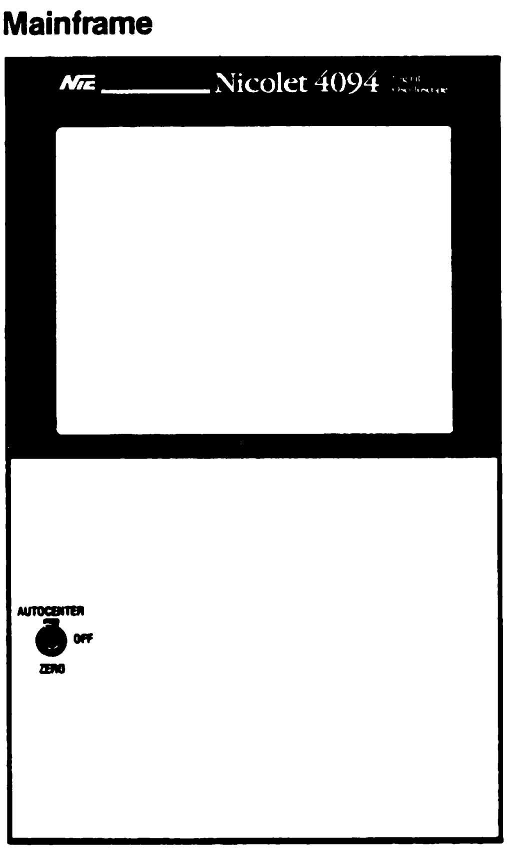


Figure 6-4

In order to help make the cursors uses even more apparent:

#5. Adjust the Channel A POSITION control (Figure 6-5) until the crosshair, trace, and horizontal cursor are located approximately at the center of the screen.

Note that the voltage numerics are not changed in this process (after the motion is stopped). The POSITION knob affects only the display positioning and does not affect the time or voltage values.

#6. Turn on Channel B, (Figure 6-5).

A new line appears on the screen which represents the Channel B input signal (grounded inputs).

#7. Momentarily tap the LEFT or RIGHT cursor controls.

The crosshair and horizontal cursor shift from the Channel A input trace to the Channel B input trace, and then back again as the cursor control is tapped.

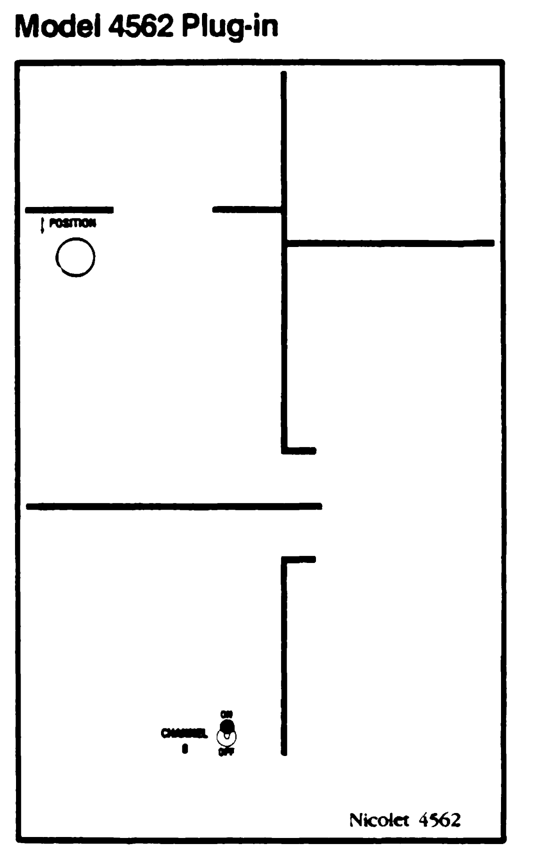


Figure 6-5

In order to gain a clearer picture of what is occurring as the cursor control is being tapped:

#8. Place the HORIZONTAL EXPANSION switch to the X256 position, (Figure 6-6).

The two rows of dots indicate the data points on the Channel A and B traces. The display has been symmetrically expanded about the vertical cursor. The crosshairs (trigger cursors) will not be visible unless the expanded portion of the display lies very close to the left edge of the screen.

#9. Momentarily tap the LEFT or RIGHT cursor buttons again.

The vertical cursor moves to the next, closest data point. The input traces appear to move since the display remains centered about the vertical cursor. The horizontal cursor moves to the intersection of the input waveform and the vertical cursor because the AUTOCENTER switch (Step #4) is still in the Autocenter position.

The "1A"/"1B" notations indicate the origins of the data point under inspection. The time and voltage numerics indicate the values associated with each data point coordinate.

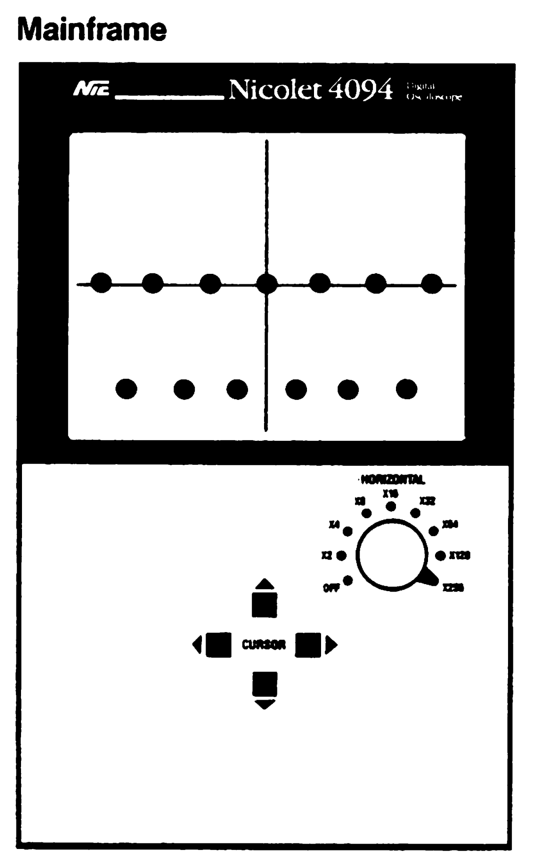


Figure 6-6

While the HORIZONTAL EXPANSION switch is still in the X256 position, a couple of interesting display features can be seen.

Channel A and Channel B data points are acquired simultaneously by two separate analog to digital converters. Half of the displayed points belong to Channel A and the other half belong to Channel B. They are displayed in an alternating fashion as though they were taken at different times. However, by stepping the cursor across the screen, point by point, it can be seen that the time numerics are the same for pairs of data points (one from Channel A, one from Channel B) which are acquired at the same time.

Note that the voltage numerics are approximately the same for Channels A and B (since all inputs are grounded) even though they appear vertically separated on the screen. Displayed voltage differences, if any, are due to small amounts of system "noise" inherent in any measuring device.

The time and voltage numerics are always the most important indicators of the waveform characteristics. The common visual judgements made when using analog oscilloscopes are not necessarily valid with digital oscilloscopes.

The last two, but very important, oscilloscope controls to be discussed in Part I are the TIME PER POINT and STORAGE CONTROL switches, (Figure 6-7). Each of these controls are necessary for basic 4094 oscilloscope operation.

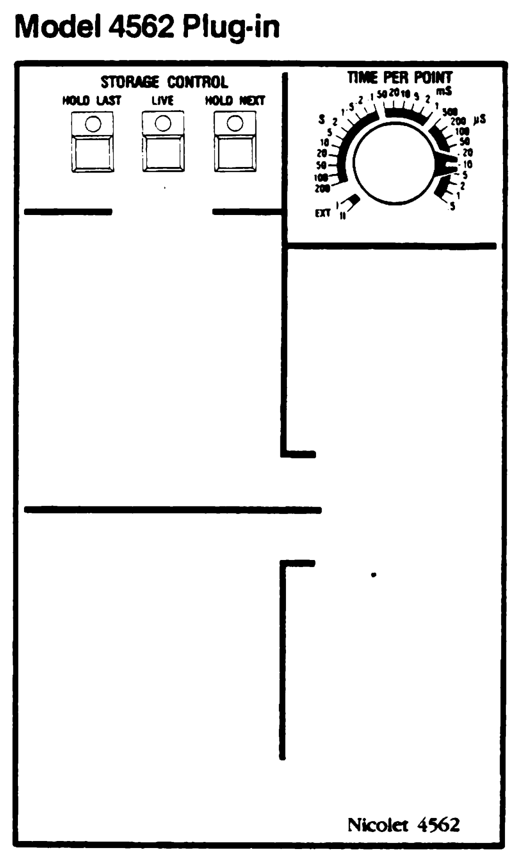


Figure 6-7

The TIME PER POINT switch functions like the time-per-division control on an analog oscilloscope. The TIME PER POINT setting controls sweep speed.

The input to the 4094 oscilloscope is sampled by an analog-to-digital converter and represented on the display as discrete data points.

The time from one point to the next is determined by the TIME PER POINT setting. In order to accurately represent quickly changing input signals, it is necessary to closely space the data points by selecting a small time-per-point. Slow changing inputs do not require high speed sampling and, therefore, larger TIME PER POINT settings are best.

The actual sweep time across the display screen is dependent on the time-per-point and the number of points allotted to the input signal.

The 4094 oscilloscope has the capacity to store and display 15,872 data points. The number of points actually used depends on the MEMORY switch, (see the MAINFRAME section of this operation manual). The total number of points selected is also divided among the input channels in use.

To observe the effect that the TIME PER POINT setting has on the sweep speed:

#10. Place the HORIZONTAL EXPANSION switch to the OFF position, (Figure 6-8).

#11. Place the TIME PER POINT switch to the 5mS position, (Figure 6-9).

#12. Press the LIVE button and observe the sweep speed as the trace moves across the screen.

#13. Place the TIME PER POINT switch to either side of the 5mS position and press the LIVE button. Note the difference in the sweep speed.

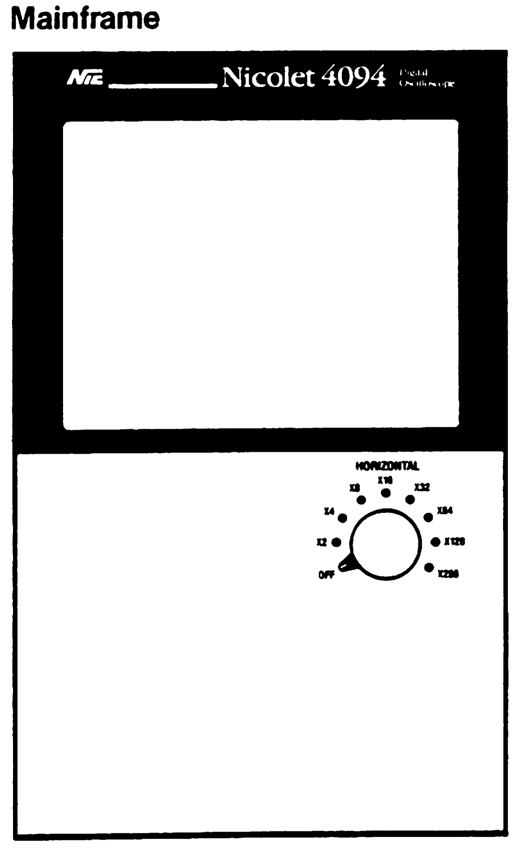


Figure 6-8

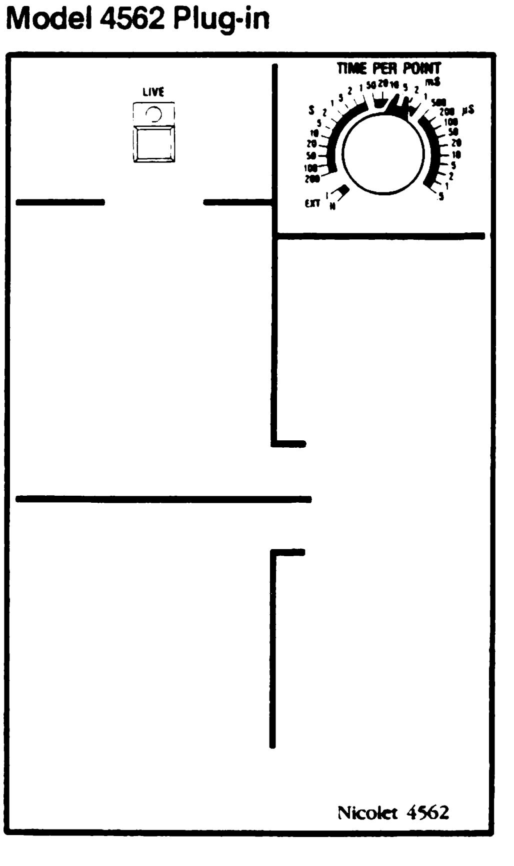


Figure 6-9

The STORAGE CONTROL buttons (HOLD LAST, LIVE, and HOLD NEXT) are not complicated and are essential for even the simplest 4094 oscilloscope operation. Definitions of each button are:

- HOLD LAST - Holds the acquired data points in the internal (display) memory of the 4094. HOLD LAST should be pressed if the current display should be saved.

- LIVE - Does not permanently hold any data points in memory. Allows continuous sweeps across the screen (as long as triggers are received), displaying the input signals.

  NOTE: Front panel settings are only acknowledged by the 4094 <u>between</u> each sweep. If a change is made to any front panel control and must be immediately acknowledged by the 4094, the LIVE button must be pressed. Pressing the LIVE button stops sweeps in progress, erases the display, and forces the 4094 to review <u>all</u> front panel settings before continuing. The LIVE button is a <u>very powerful</u> front panel control.

- HOLD NEXT - Holds the data points acquired on the next sweep in the 4094 internal (display) memory. The most common situation is to press LIVE and then HOLD NEXT <u>before</u> a new sweep is started. This sequence will save data acquired during the next sweep in the display memory. Once the data is saved, only the HOLD LAST LED will be illuminated.

#14. Place the TIME PER POINT switch to the 5mS position, (Figure 6-10).

#15. Press the LIVE button.

#16. While in the middle of the sweep, press the HOLD LAST button.

Note that both the LIVE and HOLD LAST LEDs are illuminated. When the sweep is finished, however, only the HOLD LAST button will remain illuminated, the sweeps stop (trigger light stops flashing), and all of the data acquired during the last sweep is saved.

#17. Press the LIVE button.

#18. While in the middle of the sweep, press the HOLD NEXT button.

Note that both the LIVE and HOLD NEXT LEDs are illuminated. In addition, note that the current sweep is not held, but the next sweep is held in the memory. (Watch the TRIGG'D light to see the new sweep being initiated.) The LIVE and HOLD NEXT LEDS turn off and the HOLD LAST LED turns on upon completion of the next sweep.

#19. Press the LIVE button.

Sweeps resume across the screen.

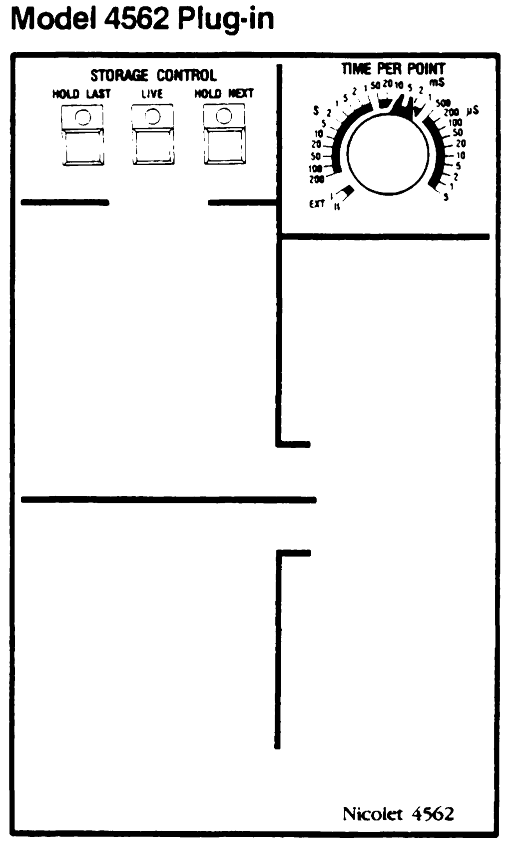


Figure 6-10

● ANALOG SCOPE USERS

The most common beginning problem that analog oscilloscope users face when using a 4094 digital oscilloscope is that a display can exist which does not match the input signal. This happens when the data in memory is not replaced by the expected signal.

There are five possible reasons for this, and are listed below in the order of probability:

#1. The 4094 oscilloscope is <u>not</u> in LIVE and therefore will not allow new signals to enter the scope.

#2. Triggering is not occurring. When in doubt, switch into AUTO triggering to ensure that triggering will occur.

#3. Possibly, a sweep has started but is very slow due to a long time-per-point. A time-per-point setting of 200 seconds could make one sweep take longer than five weeks to complete! Turn the TIME PER POINT switch to a faster setting and press the LIVE button.

#4. If only a portion of the display appears "frozen," turn off the SAVE REF switch. A complete explanation of this control is found under the PLUG-INS tab in this manual.

#5. The display may be showing the trigger signal rather than the expected input signal if the trigger VIEW switch is on. A complete description of this switch can be found in Part II of this section and under the PLUG-INS tab in this manual.

PART II

Part II requires the use of a function generator, or other source of input signals to demonstrate several 4094 oscilloscope controls important for real-life measurements.

NOTE: It is assumed, and recommended, that Part I has been read.

● PART II INITIAL SET-UP

#1. All knobs on the front panels should be in the extreme counterclockwise positions, except -

   a. TIME PER POINT: 5mS

   b. TRIGGER SOURCE: A

#2. All lever switches should be in the down position, except -

   a. AUTOCENTER: On

   b. Channel A: On

   c. AUTO/NORM: Auto

Figure 6-11 illustrates the initial set-up positions for the Mainframe and Plug-in controls.

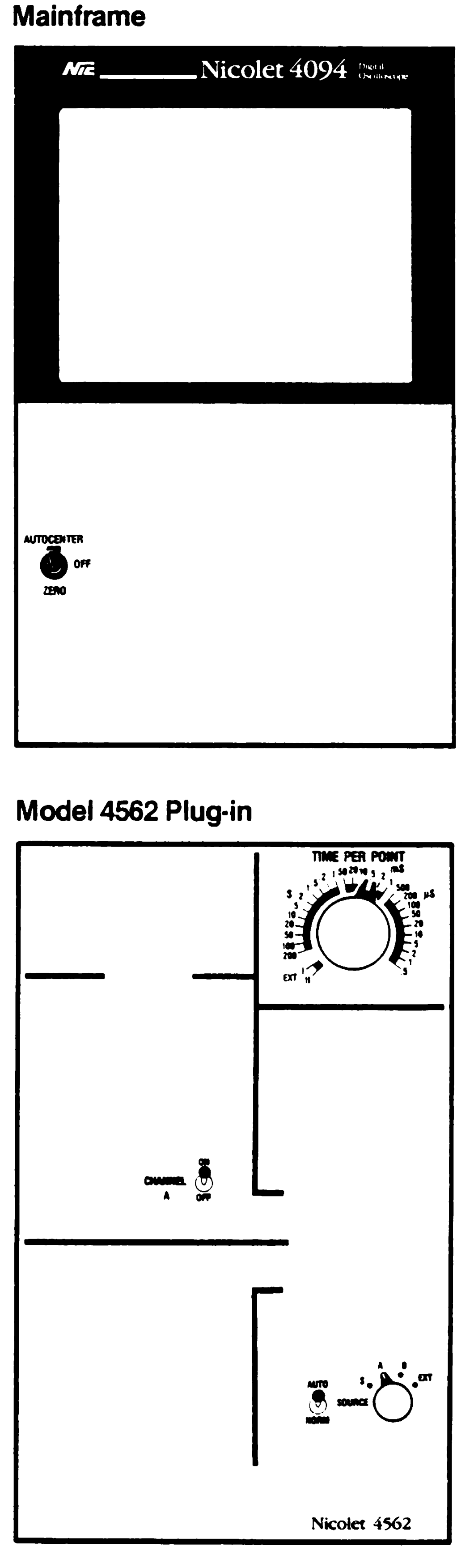


Figure 6-11

● OVERVIEW OF CONTROLS

NOTE: Figures 6-11 through 6-17 illustrate the controls which will require repositioning during the following discussions.

#1. Connect the function generator's output to the Channel A (+) input BNC and its sync output to the external (EXT) trigger input BNC, (Figure 6-12).
NOTE: If possible, select a 100 Hz triangle waveform output from the function generator.

#2. Place the Channel A (+) input BNC's switch to the DC position. The "DC" position allows both changing (AC) voltages and non-changing (DC) voltages to enter the oscilloscope. The "AC" position allows only changing voltages to enter the oscilloscope. The "GND" position sets the inputs at zero volts (ground voltage).

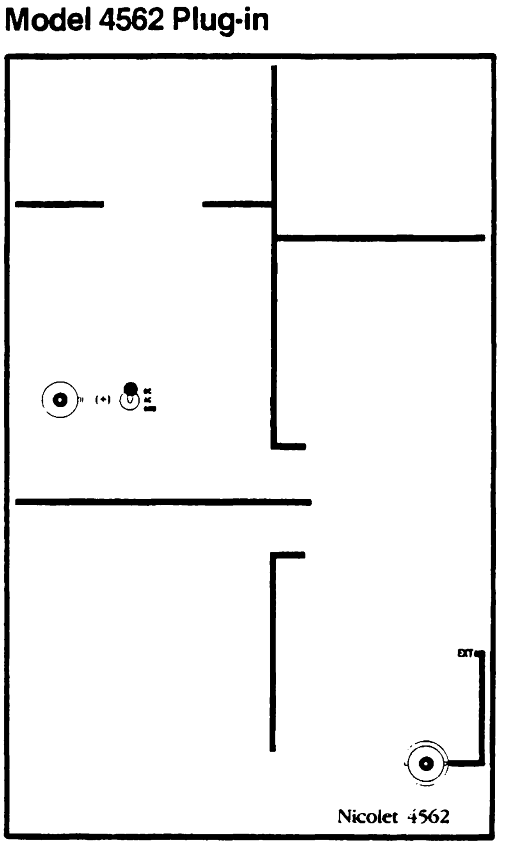


Figure 6-12

At this point, the oscilloscope's screen will display the waveform coming from the function generator.

If necessary, adjust the Channel A POSITION control (Figure 6-13) so that the input signal appears approximately in the middle of the screen.

#3. Adjust the ±VOLTS FULL SCALE switch (Figure 6-13) until the waveform's amplitude is as large as possible without exceeding the screen's vertical limits. The ±VOLTS FULL SCALE switch sets the maximum allowable input voltage which can be viewed without being too large for the display.

#4. Adjust the TIME PER POINT switch until the waveform is easily seen. A function generator setting of approximately 100 Hz will be sufficient for this section.

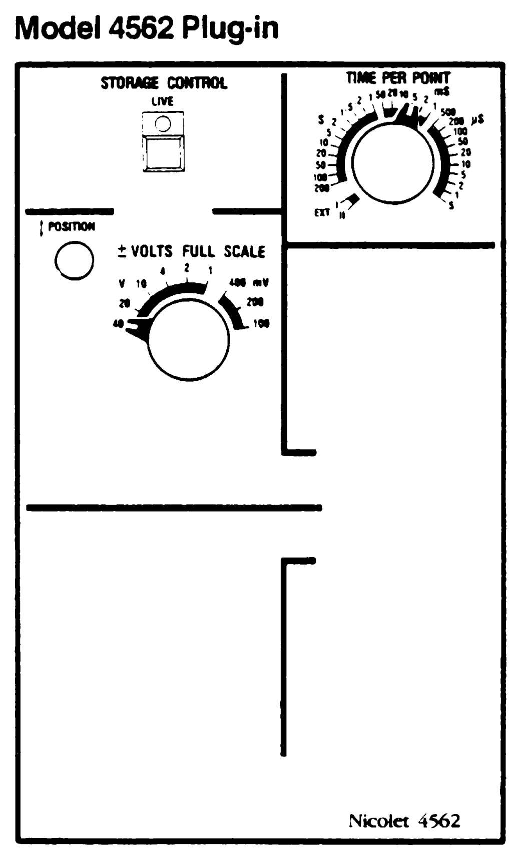


Figure 6-13

NOTE: Press the LIVE button after each new TIME PER POINT setting is made, forcing the 4094 to acknowledge each new setting. It is not necessary, however, to press the LIVE button if fast TIME PER POINT settings are selected, causing rapid sweeps. This is because the 4094 automatically verifies all of the front panel control positions at the beginning of each new sweep.

An acceptable TIME PER POINT setting allows the user to see necessary details in the input waveform. There are pitfalls to be avoided when choosing the correct TIME PER POINT. The following exercise will show the ease with which TIME PER POINT settings can be made correctly.

#5. Place the TIME PER POINT switch to the extreme clockwise (.5μS) position while observing the display. Shorter times between sample points will make the waveform to appear stretched out.

#6. Move the TIME PER POINT switch one step at a time in the counterclockwise direction. The longer the times between sample points, the more compressed the waveform appears. When the display of the waveform becomes so compressed that the actual wave shape cannot be discerned, stop moving the TIME PER POINT switch. Are the data points now too far apart to be useful?

#7. Turn the HORIZONTAL EXPANSION switch until the waveform can be easily seen. There are obviously more than enough points to define the waveform. Without HORIZONTAL EXPANSION, the confused appearance of the waveform is due to visual aliasing. In other words, the human eye has difficulty seeing the correct dot to dot alignment.

#8. Move the TIME PER POINT switch, one step at a time, in the counterclockwise direction. Wait long enough between switch settings to see the display actually change to reflect the new data point spacing. Each time the waveform becomes difficult to see, increase the HORIZONTAL EXPANSION. At some point, the waveform is totally lost and can not be retrieved by expanding. The TIME PER POINT setting is now too slow and the display does not show worthwhile information. This situation is called sample time aliasing.

#9. Place the HORIZONTAL EXPANSION switch to the OFF position in order to view the pattern of data points due to visual aliasing.

#10. Turn the TIME PER POINT switch even further in the counter-clockwise direction. This may result in recognizable patterns to appear out of the confused "jumble" of data points. However, these patterns do not accurately represent the input signals since the sampling rate is much too slow.

How is the best TIME PER POINT setting selected? Always begin the search at the fastest TIME PER POINT setting and slowly work toward the slower settings. In this manner it is easy to avoid accidentally stopping on a TIME PER POINT which is too slow for the input. Another method is to set the TIME PER POINT to be equal to, or less than, 1/10 of the input waveform period -

$$\text{period} = \frac{1}{\text{freq.(Hz)}}$$

A quick mental approximation is usually good enough to avoid undersirable aliasing effects.

The final important area to be covered in Part II is triggering. Proper triggering is necessary in virtually every measuring situation.

In many cases, important data will be lost if trigger controls are set improperly.

Triggering is a widely used term which denotes an internal decision within the oscilloscope to start a new sweep. All sweeps must be initiated by a trigger. The decision to sweep is usually synchronized with the input signal. Trigger location with respect to the display, trigger sensitivity, and trigger level are all used to select triggers which aid waveform measurements. Initiating triggers at the proper time is often the most critical part of an experimental oscilloscope setup.

The AUTO triggering used in the preceding descriptions assures that a trigger will be received so that each new sweep can start. However, unless triggering is synchronized with the input signal, the displayed waveform will "free run" across the screen. The trigger controls covered here allow the user to synchronize the triggering to the input signal.

#11. Place the trigger VIEW switch to the VIEW position, (Figure 6-14).

#12. Make sure that the trigger SOURCE switch is still set at "A."

#13. Press the LIVE button.

Model 4562 Plug-in

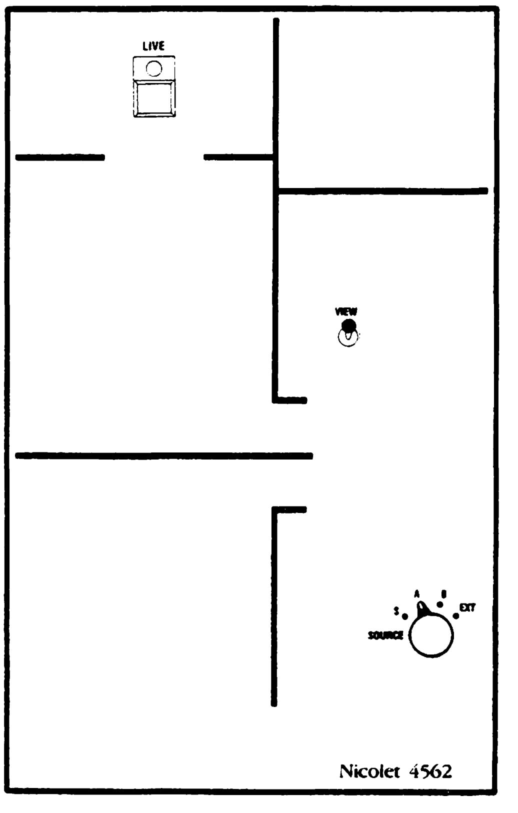


Figure 6-14

The trigger VIEW display makes trigger adjustments very easy and accurate. The traditional guesswork used to set analog oscilloscope trigger controls is not necessary. The right side of the trigger VIEW display shows the input signal used to synchronize triggering. The input signal shown is dependent on the position of the trigger SOURCE switch, (Figure 6-14).

#14. Rotate the trigger SOURCE switch to the EXT position and then back to "A."

Observe the display to see the channel A and external trigger inputs available for trigger synchronization (assuming that the EXT (external) trigger input has been connected to the function generator).

#15. Adjust the trigger LEVEL control (Figure 6-15) until the two horizontal lines intersect with the waveform.

Note that triggering is now synchronized and the "free-running" waveform has stabilized.

#16. Adjust the trigger SENSITIVITY control (Figure 6-15) while watching for the waveform to "free-run."

As long as both horizontal lines intersect the waveform, triggers will be synchronized with the input.

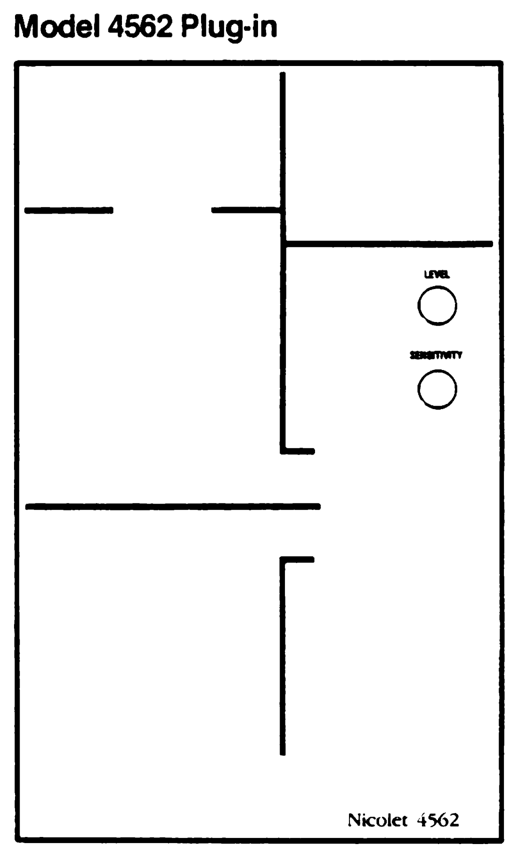


Figure 6-15

A synchronized trigger will occur within the oscilloscope when the input voltage crosses the two horizontal lines shown in trigger VIEW, (Figure 6-16).

An increased trigger LEVEL will mean that the input signal will need larger voltages to produce a trigger. A wider gap between the lines decreases the sensitivity, making the trigger circuitry less susceptible to random low amplitude noise. With AUTOCENTER switched on, the voltage numerics will show the actual voltage level of each horizontal line when the horizontal cursor is made to align with them (move the vertical cursor if necessary).

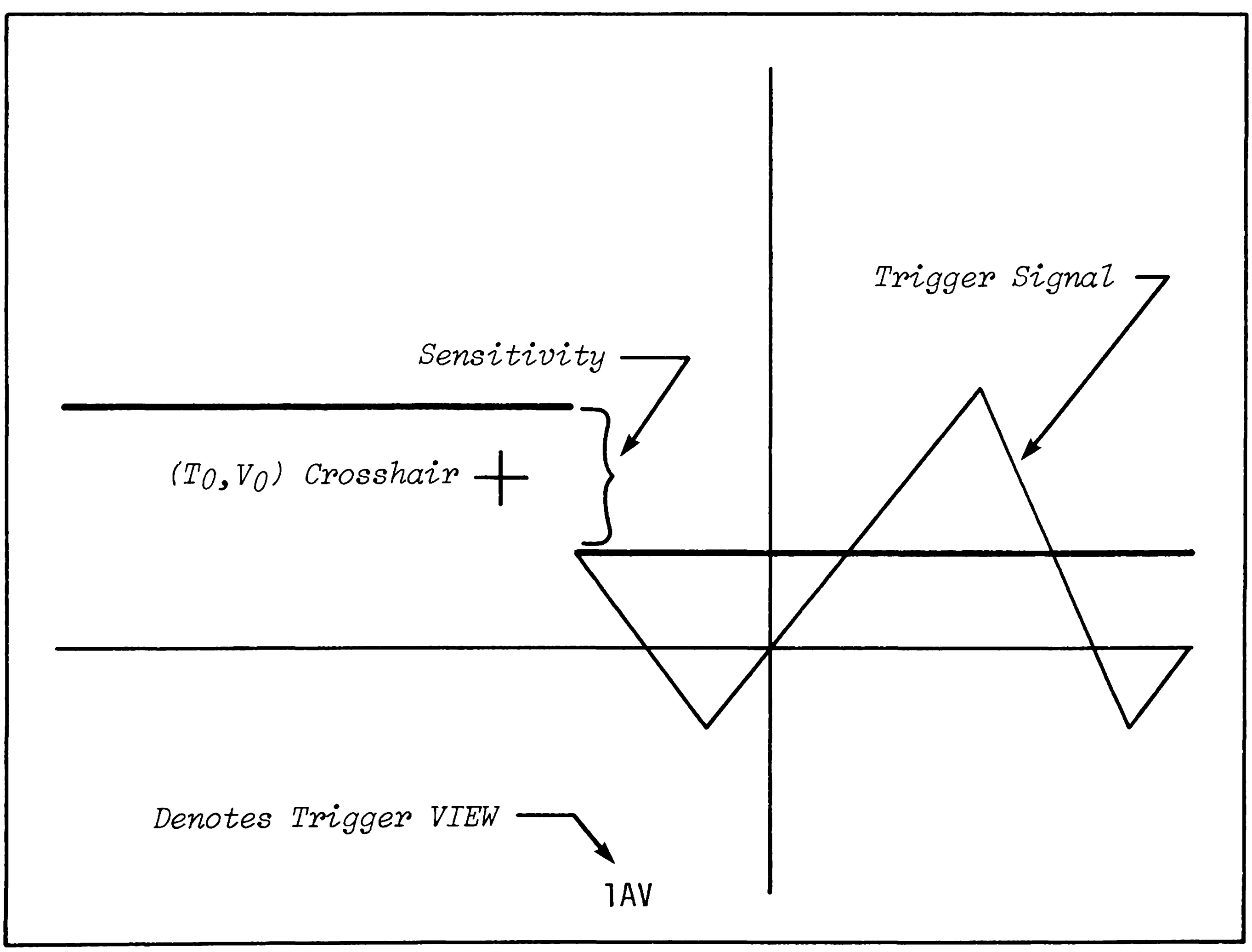


Figure 6-16

#17. Place the trigger SLOPE switch to the "DUAL" and then "+" positions while observing the display, (Figure 6-17).

The trigger SLOPE switch determines whether the triggers take place on rising (+) slopes, or falling (-) slopes of the waveform.

The DUAL setting allows a trigger to occur on whichever slope appears first, (+) or (-), and only requires the waveform to cross one of the horizontal lines. DUAL is useful for triggering on single pulses when the correct slope is not known. When the input waveform is repetitive, DUAL cannot be used since the displayed waveform will "free-run."

#18. Switch from AUTO triggering to NORM triggering and then back again to AUTO, (Figure 6-17).

Note that synchronization is not lost and the trigger light remains flashing.

AUTO triggering forces a trigger to occur even if the trigger controls are misadjusted and synchronization is not possible. NORM triggering does not force triggers to occur and, therefore, the correct trigger LEVEL and SENSITIVITY must be selected.

AUTO triggering is commonly used during oscilloscope setup. Once the correct front panel settings are selected it is usually desirable to switch away from AUTO. Transient pulses can only be captured while in NORM since only one sweep is required.

#19. Turn trigger VIEW off, (switch down position), Figure 6-17.

The input signal is now easily viewed.

Model 4562 Plug-in

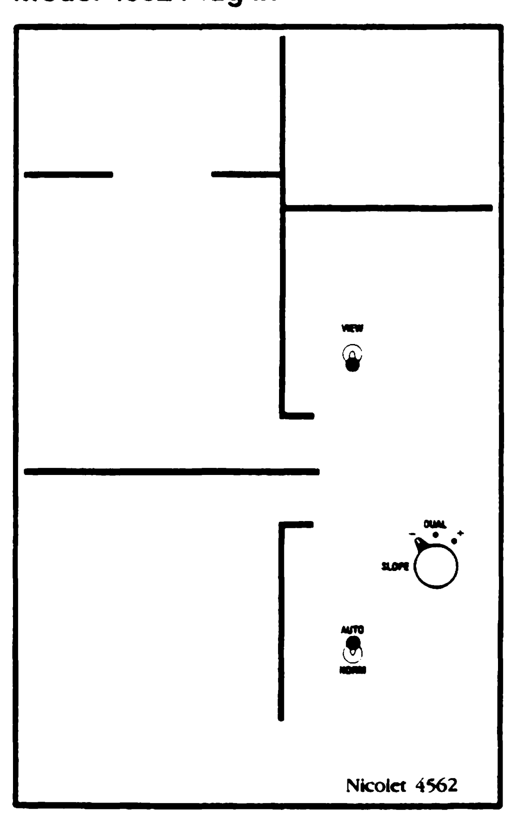
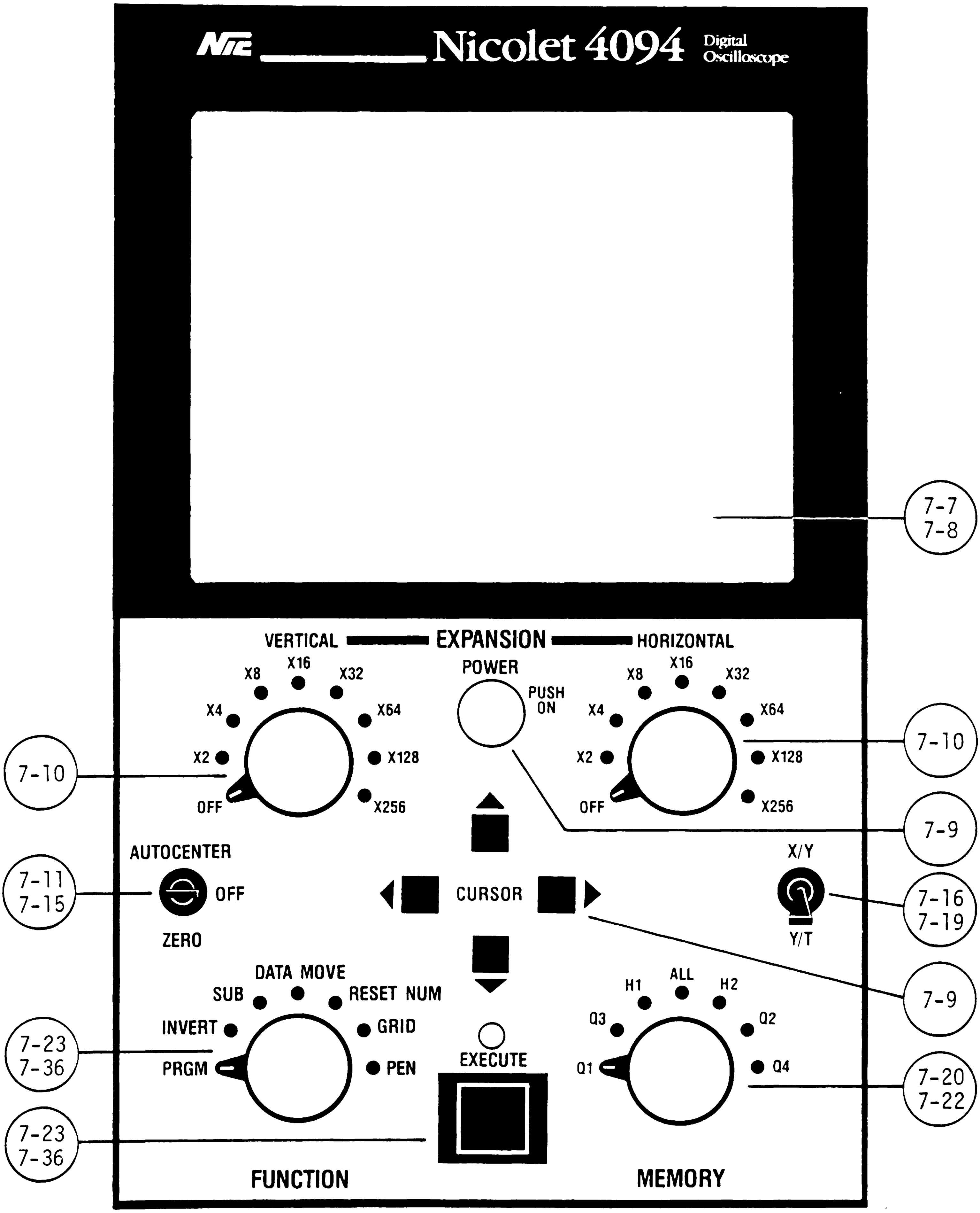


Figure 6-17

SUMMARY

Parts I and II have covered the essential 4094 front panel controls which are necessary for virtually any standard measurement. Many controls and functions remain which have not been discussed and which give power and versatility to the 4094. In depth explanations of all controls can be found in the appropriate sections of this manual.

Mainframe


NIC
Nicolet 4094
Digital Oscilloscope
VERTICAL
EXPANSION
HORIZONTAL
X8
X16
X32
X4
X64
X2
X128
OFF
X256
POWER
PUSH ON
AUTOCENTER
OFF
ZERO
CURSOR
X/Y
Y/T
DATA MOVE
SUB
RESET NUM
INVERT
GRID
PRGM
PEN
EXECUTE
H1
ALL
H2
Q3
Q2
Q1
Q4
FUNCTION
MEMORY
7-7
7-8
7-10
7-9
7-11
7-15
7-16
7-19
7-23
7-36
7-20
7-22

INTRODUCTION

The Mainframe includes a display memory, display screen and various controls to manipulate the display screen components.

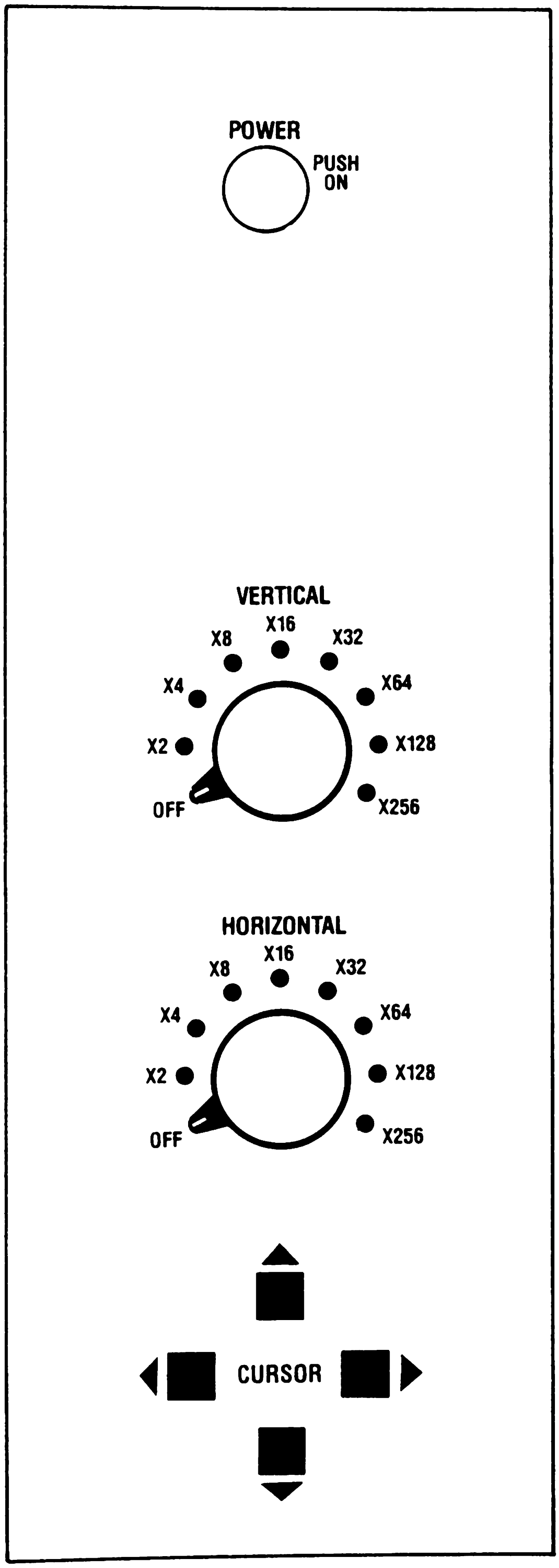
Features include -

- Horizontal expansion of up to X256.
- Vertical expansion of up to X256.
- Autocentering.
- Choice of XY or YT displays.
- 15,872 (2^{14} - 512) word display memory which can be left intact or divided into halves or quarters.
- Multiple function abilities; including arithmetic manipulations, electronic graticule, and pen recording outputs.

NOTE: In order to simplify the following discussions within this section of the manual, the number of addresses (words) in the memory will be rounded off as follows -

- 15,872 words = (16K)
- 7,936 words = (8K)
- 3,968 words = (4K)

➤ IMPORTANT: The term "Hold mode" will be used in the following discussions to signify that the Plug-in is in the Hold Last mode. (The LIVE and HOLD NEXT LEDs are off and only the HOLD LAST LED is illuminated.)



POWER SWITCH OPERATOR

Applies line power to the 4094 when pushed in. Removes power when pulled out.

> WARNING: Before applying power to this instrument, refer to the *Receiving & Pwr Req's* tab, page 5-2.

VERTICAL EXPANSION SWITCH

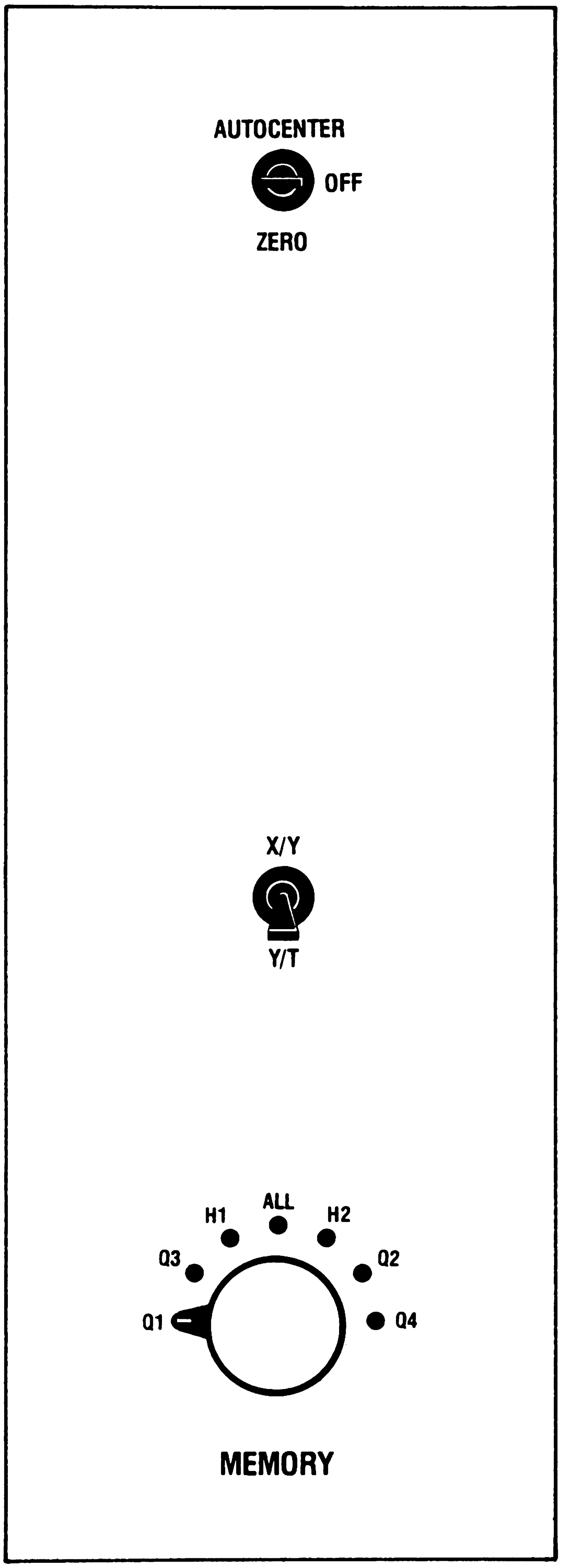
Vertically expands the displayed data group by up to 256 times.

HORIZONTAL EXPANSION SWITCH

Horizontally expands the displayed data group by up to 256 times

CURSOR BUTTONS

Reposition the displayed data group and/or Mainframe cursors on the display screen.



AUTOCENTER SWITCH

- AUTOCENTER - Data group passes through screen center when vertical and horizontal expansions are on. When the Expansion switches are off, the horizontal cursor intersects the vertical cursor at the coordinate decoded by the numerics display.
- OFF - Turns Autocenter off.
- ZERO - Repositions Mainframe's horizontal cursor to zero volts coordinate.

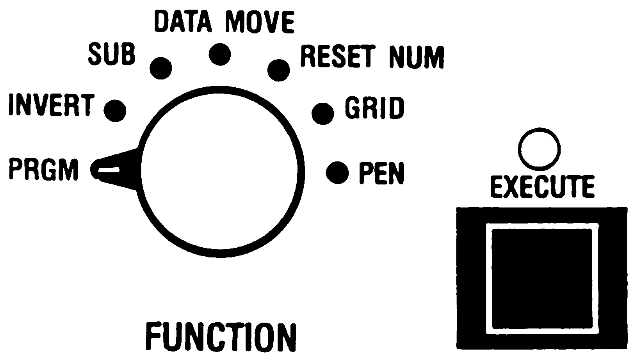
XY-YT SWITCH

- XY - One data group is displayed as a function of another.
- YT - Displays data groups as voltage functions of time.

MEMORY SWITCH

Determines the length of record for the data group to be acquired. Also determines where a waveform will be stored or which data group(s) will be displayed.

- ALL - 15,872 (16K) words.
- H1 & H2 - 7,936 (8K) words, each.
- Q1 - Q4 - 3,968 (4K) words, each.



FUNCTION SWITCH

The EXECUTE button must be pressed, unless otherwise noted, before the selected function will be performed.

- PRGM - Activates the one-button functions, as selected through recall, from the Program Diskettes.
- INVERT - Multiplies displayed data by (-1).
- SUB - Subtracts one data group from another. Can also be used to "add" two data groups by inverting one of the groups and then subtracting.
- DATA MOVE - Vertically repositions a selected data point to the level of the horizontal cursor. All other data points in the selected data group shift by the same amount.
- RESET NUM - Resets the voltage-time origins (0,0) to any point on the screen selected by the intersection of the vertical and horizontal cursor.
- GRID - Allows an electronic graticule to appear on the screen. Does not have to be Executed.
- PEN - Initiates a pen recording output.

MAINFRAME

DISPLAY COMPONENTS

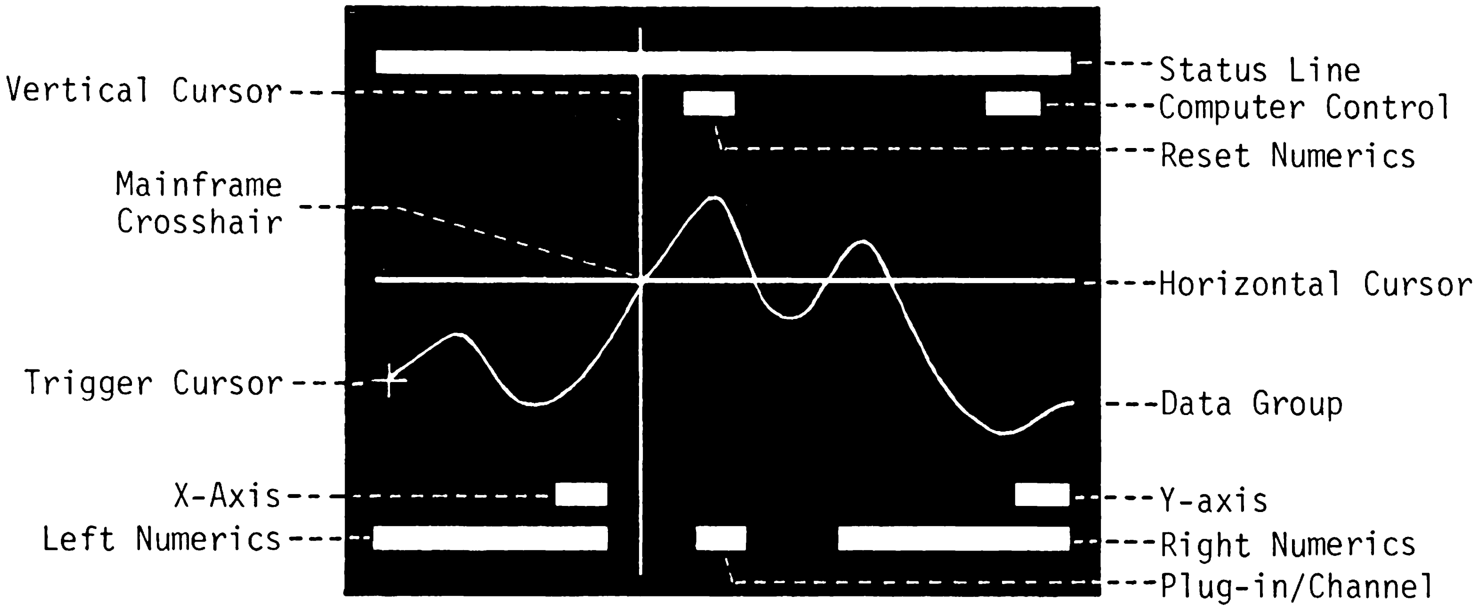


Figure 7-1

● STATUS LINE

Function of the Disk Programs. See *Disk Programs* tab.

● RESET NUMERICS INDICATOR

Indicates new (0,0) origins have been selected. See page 7-29.

● DATA GROUP

The displayed input signal (waveform).

● TRIGGER CURSOR

Identifies the time and voltage (0,0) origins. See *Plug-ins* tab, page 8-38.

● X-AXIS & Y-AXIS IDENTIFIERS

Identify which Plug-in/Channel acquired the displayed voltage values. (Appear in the XY mode only.)

● COMPUTER CONTROL INDICATOR

Indicates the front panel controls are inhibited. See *Input/Output* tab, page 13-1 and *Disk Programs* tab, page 14-7.

● LEFT NUMERICS

- YT Mode - Time coordinates.
- XY Mode - X-axis' voltage.

● RIGHT NUMERICS

- YT Mode - Voltage coordinates.
- XY Mode - Y-axis' voltage.
- Trigger View Mode - Upper/lower threshold voltages. See *Plug-ins* tab, page 8-33.

● PLUG-IN/CHANNEL IDENTIFIER

Identifies which Plug-in/Channel acquired the signal. In addition -

- 1AR = Plug-in 1/Channel A; Save Reference mode selected.
- 1AV = Plug-in 1/Channel A; View mode selected.
- 1EV = Plug-in 1, External trigger and View modes selected.

● VERTICAL & HORIZONTAL CURSORS

The vertical (time) and horizontal (voltage) cursors form the Mainframe's crosshair.

MAINFRAME

NUMERICS SYMBOLOGY

Table 7-1 tabulates the power of ten symbols used to describe the voltage and time numerics readouts.

SYMBOLS	POWER FACTORS
p = pico	10^{-12}
n = nano	10^{-9}
u = micro	10^{-6}
m = milli	10^{-3}
"blank"	10^{0}
k = kilo	10^{3}
M = mega	10^{6}
G = giga	10^{9}
T = tera	10^{12}
P = pata	10^{15}
E = exa	10^{18}
? = **	10^{21}
! = **	10^{24}

Table 7-1

** NOTE: Power factors above 10^{18} are not industry standards. The symbols (?) and (!) have been selected to call attention to the operator that extreme numbers are being used.

POWER OPERATOR

> WARNING: Before applying power to this instrument, refer to *Receiving & Pwr Req's* tab, page 5-2.

Pressing the POWER operator applies power to the switching power supply. Pulling the operator out removes the power.

The magnetic power switch, mounted inside and toward the rear of the Mainframe, is designed to remove power from the switching power supply when a current overload occurs.

Power can be reapplied, after the proper current level has been restored, by cycling the POWER operator.

The switching power supply is also guarded by a 5 amp fuse mounted on the supply board.

> CAUTION: Remove all power from the oscilloscope before replacing the fuse.

CURSOR BUTTONS

The CURSOR buttons manipulate the Mainframe's vertical and horizontal cursors. They also manipulate the display data group, depending upon whether or not Autocenter and/or Display Expansion are being used. Refer to *Autocenter Switch,* page 7-11.

EXPANSION SWITCHES

The displayed data group can be symmetrically expanded up to 256 times about the cursors.

- **Horizontal Expansion Switch**

The vertical cursor and data point it is intersecting reposition to screen center. All other data points reposition by the same amount, symmetrically expanding about the vertical cursor.

- **Vertical Expansion Switch**

The horizontal cursor repositions to screen center. Vertical expansion is symmetrical about the horizontal cursor. To vertically reposition data, use the up/down cursor controls.

NOTE: Switching on Autocenter will automatically reposition data to intersect the vertical and horizontal cursors, but will inhibit the use of the up/down cursor controls (see Page 7-11).

EXAMPLE #7-1

Figure 7-2: An unexpanded display.

Figure 7-3: After a (X4) horizontal expansion.

Figure 7-4: After a (X4) vertical expansion.

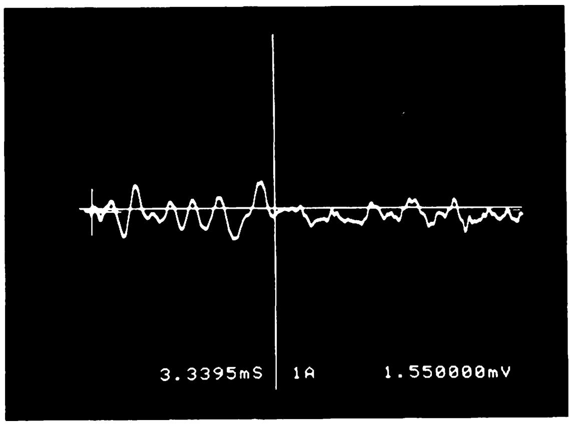


Figure 7-2

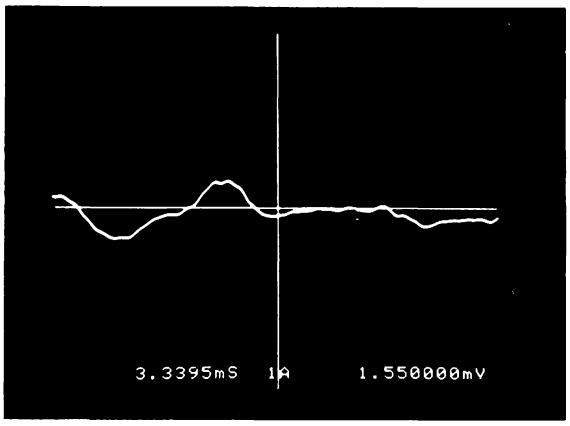


Figure 7-3

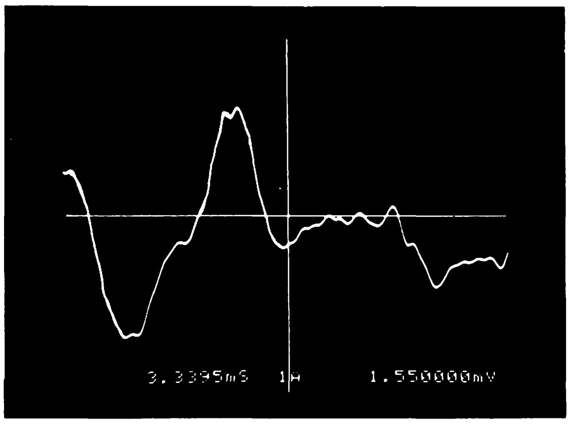


Figure 7-4

MAINFRAME

AUTOCENTER SWITCH

The AUTOCENTER switch enables the operator to manipulate the display elements in various combinations according to the position selected.

- ZERO

The Mainframe's horizontal cursor repositions to the zero volts location.

The position is spring loaded, automatically returning to the "OFF" position when released.

- OFF

Turns off the Autocenter mode, enabling the operator to manipulate the display elements individually with the CURSOR buttons.

Which of the elements will be affected depends upon the positions selected on the EXPANSION switches. See Table 7-2 (Autocenter OFF).

EXPANSION SWITCHES		CURSOR BUTTONS	
HORIZONTAL	VERTICAL	LEFT - RIGHT	UP - DOWN
OFF	OFF	*Vertical Cursor*	*Horizontal Cursor*
OFF	ON	*Vertical Cursor*	*Data Group*
ON	OFF	*Data Group*	*Horizontal Cursor*
ON	ON	*Data Group*	*Data group*

Table 7-2 (Autocenter OFF)

• AUTOCENTER

The Mainframe's crosshair superimposes over the data point intersected by the vertical cursor.

In Horizontal expansion mode, the data group passes through screen center when the left or right CURSOR buttons are pressed.

Autocenter is also used when displaying multiple data groups, enabling the operator to determine which data point corresponds with the numerics' readout. The Plug-in/Channel numerics indicate which Plug-in and channel acquired the displayed data point being inspected. (i.e., 1A = Plug-in #1/Channel A.)

The operator can manipulate the display screen elements in various combinations by pressing the CURSOR buttons. Which of the elements will be affected depends upon the positions selected on the EXPANSION switches. See Table 7-3 (Autocenter ON).

EXPANSION SWITCHES		LEFT - RIGHT CURSOR BUTTONS
HORIZONTAL	VERTICAL	
OFF	OFF	*Horizontal and Vertical Cursors*
OFF	ON	*Vertical Cursor*
ON	OFF	*Horizontal Cursor and Data Group*
ON	ON	*Data Group*

Table 7-3 (Autocenter ON)

● Autocenter & Expansion Combined

The combination of Autocenter and both vertical and horizontal expansion is the most commonly used form of display expansion.

This mode of operation allows a specific area of interest to be repositioned to screen center for close inspection. The data group passes through screen center when the left or right CURSOR buttons are pressed.

#1. Position the vertical cursor over the area of interest.

#2. AUTOCENTER: On
   a. Mainframe's crosshair superimposes over data point intersected by the vertical cursor.

#3. Place display into both vertical and horizontal expansion.
   a. Crosshair and area of interest reposition to screen center.

#4. Press left or right CURSOR button.
   a. Data group passes through screen center.

MAINFRAME

EXAMPLE #7-2

Figure 7-5: Unexpanded display. The vertical cursor is positioned over the area of interest.

Figure 7-6: AUTOCENTER switch is turned on. The Mainframe's crosshair superimposes over the data point intersected by the vertical cursor.

Figure 7-7: Vertical and horizontal expansion applied. The crosshair and area of interest reposition to screen center.

Pressing either the left or right CURSOR buttons causes the data group to pass through screen center.

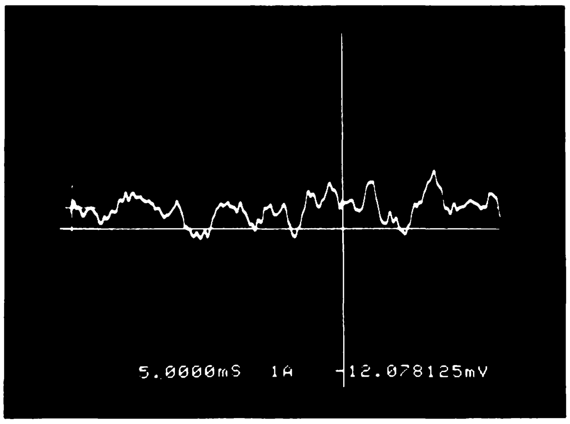


Figure 7-5

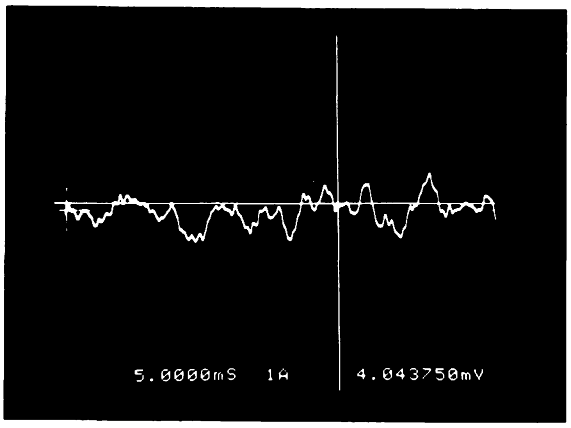


Figure 7-6

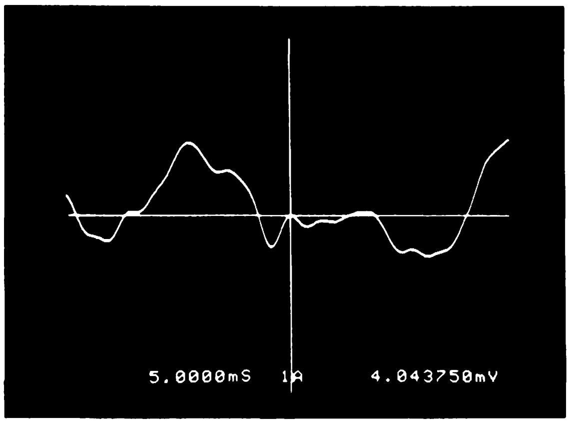


Figure 7-7

● Multiple Data Group Displays

The numerics correspond to the intersection of the vertical and horizontal cursor.

Turning the Autocenter mode on superimposes the Mainframe's crosshair over the data point being inspected. The crosshair alternates between the data groups when either the left or right CURSOR button is pressed.

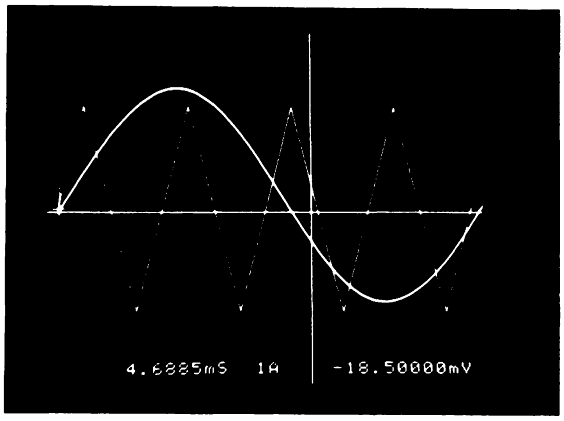


Figure 7-8

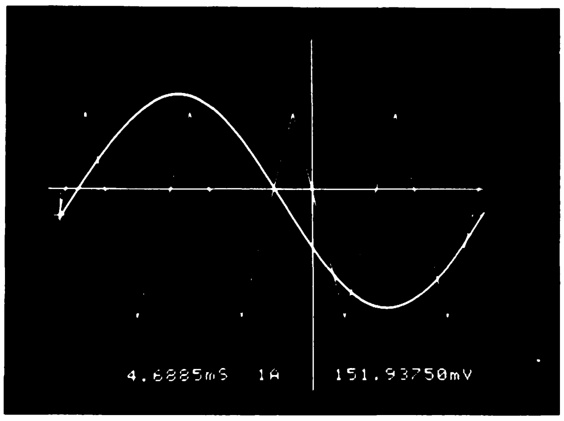


Figure 7-9

EXAMPLE #7-3

Figure 7-8: Display with two superimposed data groups and Autocenter turned off. The voltage numerics correspond to the position of the horizontal cursor and are not related to either data group.

Figure 7-9: The same display, but with the AUTOCENTER switch turned on. The Mainframe's crosshair superimposes over the data point being inspected The Plug-in/Channel numerics indicate which Plug-in/Channel acquired the data point being inspected.

XY-YT SWITCH

- YT

Displays data groups as voltage functions of time.

The left numerics (time) and right numerics (voltage) reflect the values at the intersection of the vertical and horizontal cursors. With the AUTOCENTER switch on, this intersection will coincide with a specific displayed data point.

- XY

Displays one data group's voltage values plotted as a function of another.

The left numerics (X-axis' voltage) and right numerics (Y-axis' voltage) reflect the values measured at the intersection of the vertical and horizontal cursors. (With AUTOCENTER on, this intersection will coincide with a specific data point.) The X-axis' Identifier is displayed over the Left Numerics and the Y-axis' Identifier over the Right Numerics.

Store the X-axis' data group in either the Q1, Q2, or H2 subsections of the display memory. The Y-axis' data group must be stored in the corresponding subsections of either Q3, Q4, or H2.

For example, if the X-axis' data group is stored in subsection Q1, then the Y-axis' data group must be stored in subsection Q3. Placing the MEMORY switch to the H1 position, after both data groups have been stored, produces the XY display.

Table 7-4 summarizes which subsections the respective data groups must be stored in, and the MEMORY switch position required for the XY display.

MEMORY SWITCH POSITION REQUIRED FOR XY DISPLAYS	AXIS Vs SUBSECTION	
	X-axis	Y-axis
H1	*Q1*	*Q3*
H2	*Q2*	*Q4*
ALL	*H1*	*H2*

Table 7-4

NOTE: The AUTOCENTER switch must be turned on to select a specific data point for inspection. The Mainframe's crosshair will superimpose over the selected data point. If both EXPANSION switches are turned off, the crosshair will trace the XY display when either the left or right CURSOR buttons are pressed. Placing the display into horizontal expansion will slow the rate of movement if it is too fast to control.

The XY display can be selected to pass through screen center by placing the display into both horizontal and vertical expansion.

An XY display can also be obtained in the Live move of operation when acquiring signals with two channels. Input the X-axis' signal to channel A and the Y-axis' signal to channel B.

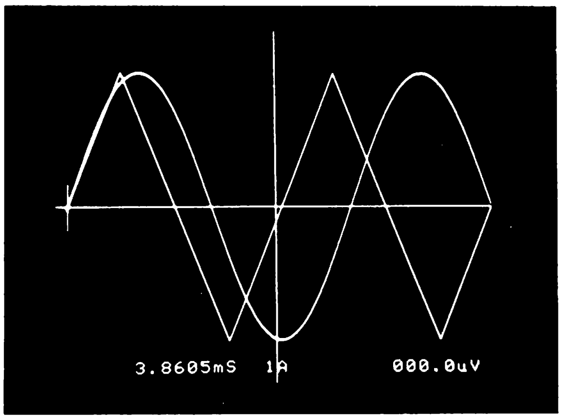


Figure 7-10

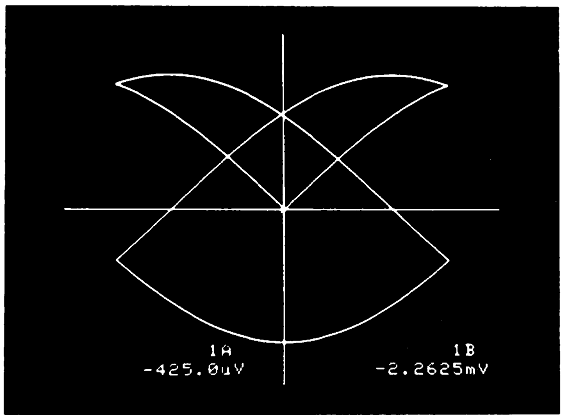


Figure 7-11

EXAMPLE #7-4

Figure 7-10: Two data groups displayed in the YT mode.

Figure 7-11: The same two data groups displayed in the XY mode.

MAINFRAME

- XY Display Procedure

#1. Store the X-axis' data group in either subsection Q1, Q2, or H1.

#2. Store the Y-axis' data group in the associated subsection of either Q3, Q4, or H2.

#3. Display both data groups by selecting the appropriate position on the MEMORY switch.

#4. XY-YT switch: XY

#5. AUTOCENTER switch: On

#6. EXPANSION switches: Both "ON" if XY display is to pass through screen center. If crosshair is to trace the XY display, horizontal expansion will slow the rate of movement.

#7. Select the data point to be inspected by pressing either the left or right CURSOR buttons.
   a. Left Numerics = X-axis volts
   b. Right Numerics = Y-axis volts

NOTE: In "dual channel" operation and with the MEMORY switch in either the ALL, H1, or H2 position, signals acquired by channels A and B are automatically routed to the correct subsections for an XY display.

Table 7-5 summerizes which subsections the respective signals will be routed to according to the position selected on the MEMORY switch.

DUAL CHANNEL OPERATION		
MEMORY SWITCH	CHANNEL A	CHANNEL B
ALL	*H1*	*H2*
H1	*Q1*	*Q3*
H2	*Q2*	*Q4*

Table 7-5

MAINFRAME

● Rotating an XY Display

If the X-axis' data group was erroneously stored in the Y-axis' subsection, and vice versa, an incorrect XY display will occur.

The error can be quickly corrected, without have to perform the measurements over again, by following the appropriate procedure listed below.

ROTATING Q1 AND Q3	ROTATING H1 AND H2	ROTATING Q2 AND Q4
#1. XY/YT: YT	#1. XY/YT: YT	#1. XY/YT: YT
#2. MEMORY: Q1	#2. MEMORY: H1	#2. MEMORY: Q2
#3. Execute SUB	#3. Execute SUB	#3. Execute SUB
#4. MEMORY: Q3	#4. MEMORY: H2	#4. MEMORY: Q4
#5. Execute SUB	#5. Execute SUB	#5. Execute SUB
#6. MEMORY: Q1	#6. MEMORY: H1	#6. MEMORY: Q2
#7. Execute SUB	#7. Execute SUB	#7. Execute SUB
#8. MEMORY: H1	#8. MEMORY: ALL	#8. MEMORY: H2
#9. Execute INVERT	#9. Execute INVERT	#9. Execute INVERT
#10. XY/YT: XY	#10. XY/YT: XY	#10. XY/YT: XY

MEMORY SWITCH

The display memory contains (16K) words of memory which can be left intact or be divided into either halves or quarters.

Typically, the display memory will be left intact, recording a single input signal with all (16K) words of memory. This will provide the highest detailed reproduction of the input signal.

However, dividing the memory into subsections allows several input signals to be compared or arithmetically manipulated.

EXAMPLE #7-5

The following figures will be used to represent intact and divided memories for the remaining examples.

Figure 7-12: Intact memory of (16K) words. All data points displayed.

Figure 7-13: Memory divided into two (8K) word subsections. Every other data point is displayed.

Figure 7-14: Memory divided into four (4K) word subsections. Every fourth data point is displayed.

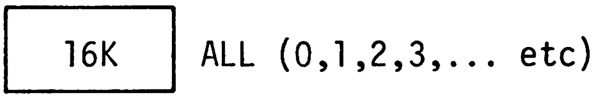


Figure 7-12

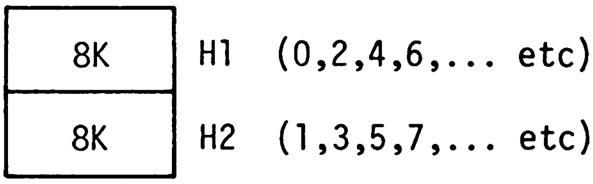


Figure 7-13

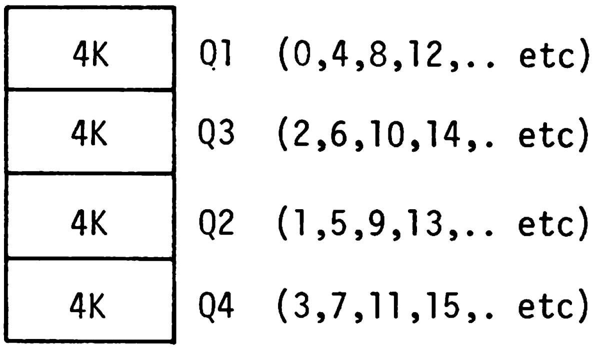


Figure 7-14

● Storing Data Groups

The position selected on the MEMORY switch, at the time of acquisition, determines whether the input signal will be recorded by the entire memory or by a subsection of the memory. It also determines where, within the memory, the input signal will be stored.

EXAMPLE #7-6

Figure 7-15: Illustrates that all (16K) words of memory will record the input signal when the MEMORY switch is in the "ALL" position.

Figure 7-16: The input signal will be recorded with (8K) words of memory and be stored in subsection H1 or H2, determined by the position of the MEMORY switch.

Figure 7-17: The input signal will be recorded with (4K) words of memory and be stored in subsection Q1, Q3, Q2, or Q4, determined by the position of the MEMORY switch.

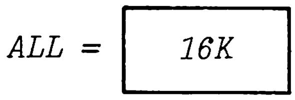


Figure 7-15

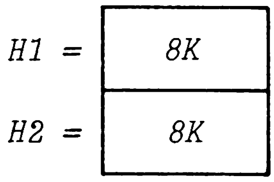


Figure 7-16

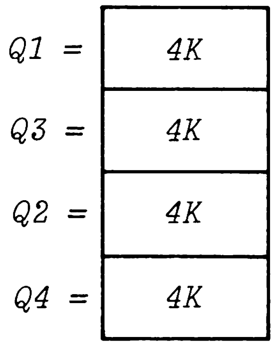


Figure 7-17

● Viewing Stored Data Groups

The number of data groups recorded in the display memory and the position selected on the MEMORY switch determine whether single or multiple data groups will be displayed.

The Plug-in must be in the Hold mode.

EXAMPLE #7-7

Figure 7-18: Either one (16K), two (8K), or four (4K) data groups will be displayed with the "ALL" position selected.

Figure 7-19: Either a single (8K) or up to two (4K) data groups will be displayed with either the "H1" or "H2" position selected.

Figure 7-20: A single (4K) data group will be displayed when the MEMORY switch is placed to either the "Q1, Q3, Q2, or Q4" position.

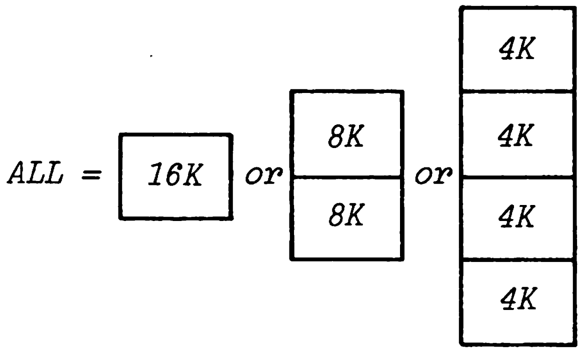


Figure 7-18

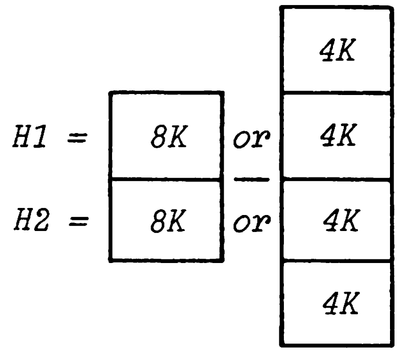


Figure 7-19

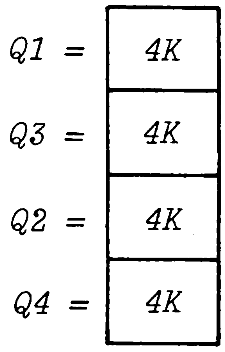


Figure 7-20

FUNCTION & EXECUTE CONTROLS

The FUNCTION switch and EXECUTE button are interactive. The selected function (except for "GRID") will not be performed unless the EXECUTE button is pressed.

NOTE: The Plug-in should be in the Hold mode before executing a function. Otherwise, a trigger will replace the data being manipulated with the data collected during the next sweep.

- PRGM

The PRGM position activates the one-button functions, as selected through recall, from the Program Diskettes when executed. Refer to the *Disk Programs* tab for additional information.

● INVERT

Multiplies the voltage coordinates by (-1) in the YT mode only.

► IMPORTANT: The displayed data group is Inverted around *digital zero* (screen vertical center) and not *analog zero* (Plug-in's Trigger cursor). In order to obtain optimum "mirror-measurements," position the *analog zero* reference as close as possible to *digital zero* (using the POSITION control) when acquiring the signal.

To invert a data group display -

#1. Store the data group.
#2. Place Plug-in into Hold mode.
#3. XY/YT switch: YT
#4. HORIZONTAL EXPANSION: Off
#5. MEMORY switch: Display the data group to be inverted.
#6. FUNCTION switch: Invert
#7. EXECUTE button: Press.

EXAMPLE #7-8

Figure 7-21: MEMORY switch: ALL.
Data Group A (analog and digital zeros NOT superimposed) was stored in H1.
Data Group B (analog and digital zeros superimposed) was stored in H2.
Figure 7-22: MEMORY switch: H1.
Data Group A after being inverted.
Figure 7-23: MEMORY switch: H2.
Data Group B after being inverted.

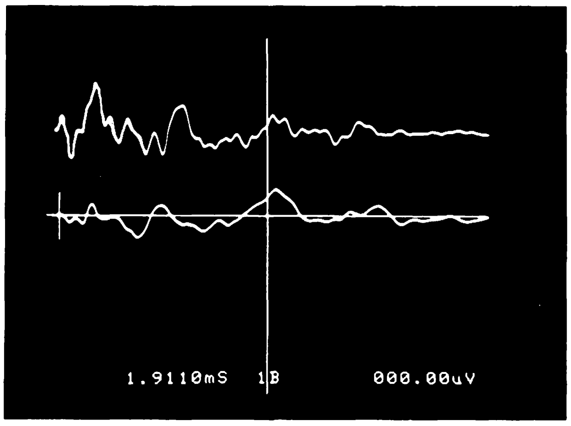


Figure 7-21

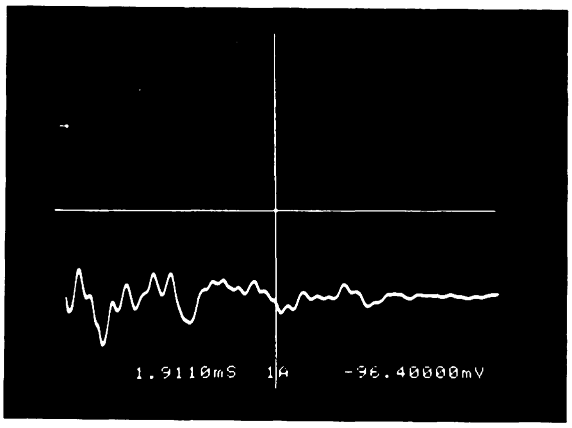


Figure 7-22

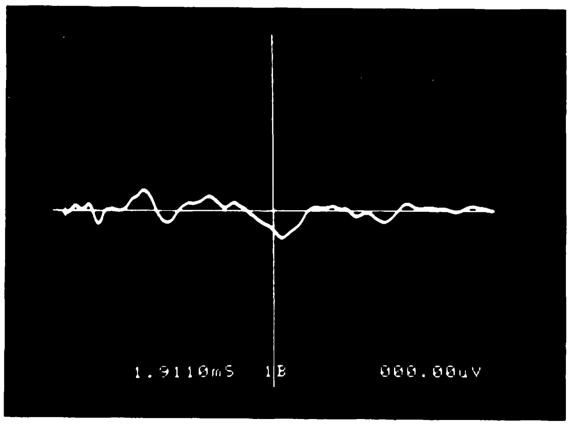


Figure 7-23

● SUB

Subtracts one data group from another. Data groups can also be added if the Subtrahend is inverted before executing the SUB function. The SUB function can only be used in the YT mode.

Subtracting data groups from each other is basically the process of storing two data groups in associated memory subsections, selecting which data group will be the subtrahend, and then executing the SUB function.

➤ IMPORTANT: For optimum results when executing a SUB function, position the channels' *analog zeros* (Plug-in's Trigger cursors) as close to each other as possible when acquiring the signals.

In addition, when subtracting two data groups of opposite polarities (i.e., two out-of-phase sine waves), the two data groups will, in effect, be added. This may cause the resulting display to "roll-over," displaying the top of the data group at screen bottom, or vice-versa. If a "roll-over" occurs after executing a SUB function, execute a second SUB function (returning the display to its original status) and then execute a DATA MOVE function. This may help to eliminate or minimize the "roll-over" effect. If, however, the resulting "subtracted" data group is too large to be fully displayed on the screen, the signals will have to be acquired a second time using a larger ± VOLTS FULL SCALE setting, or the SUBTRACTION Program available on the Program Diskettes must be used.

Table 7-6 tabulates the MEMORY switch positions and corresponding subtraction/addition equations. The resulting data group is stored in the subtrahend's subsection selected on the MEMORY switch.

MEMORY SWITCH POSITION	EQUATIONS	
	SUBTRACTION	ADDITION
Q1	Q3 - Q1	Q3 - (-Q1)
Q3	Q1 - Q3	Q1 - (-Q3)
H1	H2 - H1	H2 - (-H1)
H2	H1 - H2	H1 - (-H2)
Q2	Q4 - Q2	Q4 - (-Q2)
Q4	Q2 - Q4	Q2 - (-Q4)

Table 7-6

NOTE: The "ALL" position is not a valid selection when executing a SUB function.

••Subtracting Data Groups

To subtract a data group from another:

#1. Store the data groups to be subtracted in associated subsections. (i.e, Q1 & Q3, Q2 & Q4, or H1 & H2.)

#2. Place the Plug-in into the Hold mode.

#3. XY/YT switch: YT

#4. HORIZONTAL EXPANSION: Off

#5. FUNCTION switch: Sub

#6. MEMORY switch: Place switch to subtrahend subsection position.

#7. EXECUTE button: Press.

Pressing the EXECUTE button again will return the data groups to their original values.

EXAMPLE #7-9

Figure 7-25 illustrates the effect of subtracting one of the data groups in Figure 7-24 from the other.

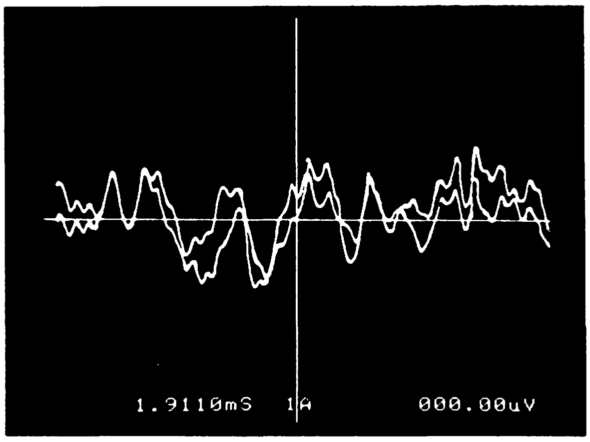


Figure 7-24

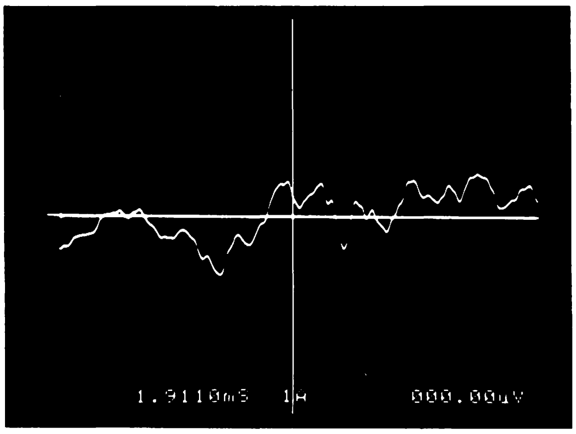


Figure 7-25

••Adding Data Groups

To add two data groups:

#1. Store the data groups to be added in associated subsections, (i.e., Q1 & Q3, Q2 & Q4, or H1 & H2.)

#2. Place the Plug-in into the Hold mode.

#3. XY/YT switch: YT

#4. HORIZONTAL EXPANSION: Off

#5. MEMORY switch: Place switch to subtrahend subsection position.

#6. FUNCTION switch: Invert

#7. EXECUTE button: Press.

#8. FUNCTION switch: Sub

#9. EXECUTE button: Press.

Executing a second SUB function and then an INVERT function restores the data groups to their original values.

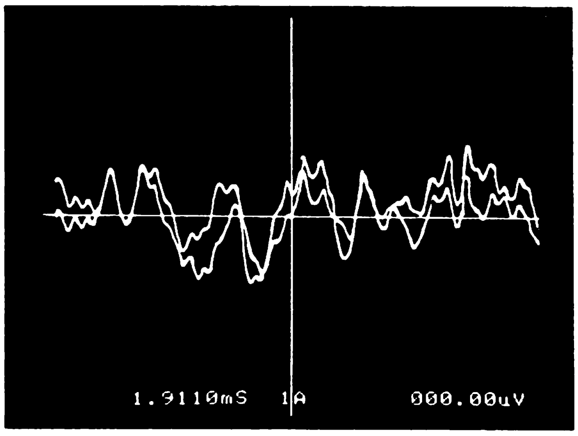


Figure 7-26

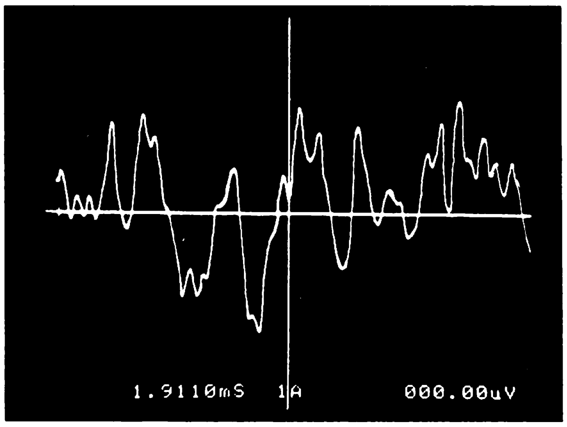


Figure 7-27

EXAMPLE #7-10

Figure 7-27 illustrates the effect of adding the two data groups shown in Figure 7-26.

● DATA MOVE

Typically used to superimpose a stored data group over another for comparison. The data point intersected by the Mainframe's vertical cursor repositions to the level of the horizontal cursor. All other data points shift by the same amount. The DATA MOVE function can only be used in the YT mode.

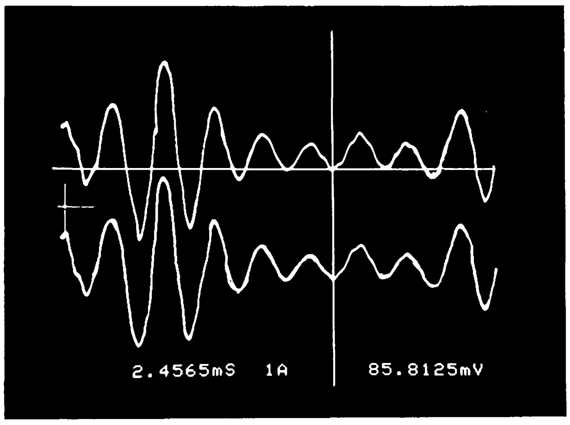


Figure 7-28

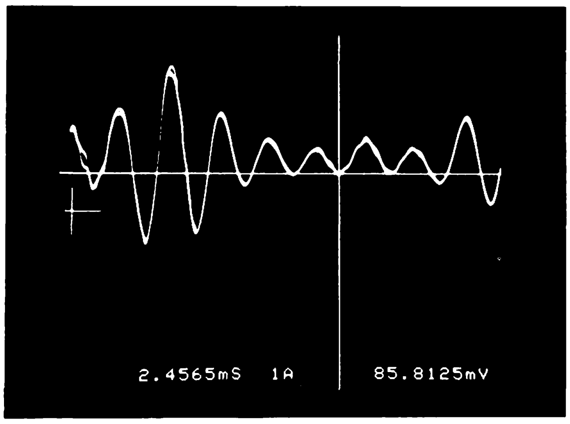


Figure 7-29

●●Data Moving One Data Group For Visual Comparison With Another

To data move a data group:

#1. Store the data groups in associated subsections, (i.e., Q1 & Q3, Q2 & Q4, or H1 & H2.)

#2. Place the Plug-in into the Hold mode.

#3. MEMORY switch: Display both data groups.

#4. Position the horizontal cursor at the level to which the data group is to be moved.

#5. MEMORY switch: Display the data group to be moved.

#6. Position the vertical cursor over the data point that is to be vertically repositioned.

#7. FUNCTION switch: Data Move

#8. EXECUTE button: Press.

#9. MEMORY switch: Display both data groups.

EXAMPLE #7-11

Figure 7-29 illustrates the effect of data moving one of the data groups in Figure 7-28.

● RESET NUMERICS

The letters "RN" appear below the status line on the display screen when the RESET NUMERICS function is selected. They disappear from the screen when the FUNCTION switch is placed to a different position.

••With AUTOCENTER and YT Modes On

Provides a simple means by which measurements can be made relative to a new time and voltage origin, (0,0).

The new (0,0) origin can be at any point on the screen and is determined by the position of the Mainframe's crosshair when the RESET NUMERICS function is executed. This permits easy measurements of peak-to-peak voltages, time relationships between any two points, and any other inspections that require selectable (0,0) origins.

The vertical position of the crosshair determines the zero voltage level (V=0). The horizontal position of the crosshair determines the zero time origin (T=0). Therefore, if the crosshair is superimposed over a data point, as it will be in the AUTOCENTER mode, that data point will become the new (0,0) origin when the RESET NUMERICS function is executed.

The Plug-in's Trigger cursor will immediately "jump" to the position of the Mainframe's crosshair as soon as the EXECUTE button is pressed. This allows the operator to inspect other points of interest on the displayed data group without losing track of the new (0,0) origin.

The time and voltage numerics will return to the absolute values relative to the original (0,0) origin when the FUNCTION switch is placed to a different position.

••With AUTOCENTER and XY Modes On

The left numerics (X-axis' voltage) and right numerics (Y-axis' voltage) reset to (0,0), corresponding to the data point coordinate intersected by the Mainframe's crosshair, when the RESET NUMERICS function is executed and the AUTOCENTER switch is on.

Refer to Page 7-16, XY-YT Switch, for additional information on the XY mode of operation.

EXAMPLE #7-12

Figure 7-30: Typical display with AUTOCENTER selected.

Figure 7-31: The same display after executing the RESET NUMERICS function. The Plug-in's trigger crosshair has repositioned to the Mainframe's crosshair and both numerics have reset to zero.

Figure 7-32: The crosshair has been repositioned and the numerics reflect the selected data point's values relative to the new origin.

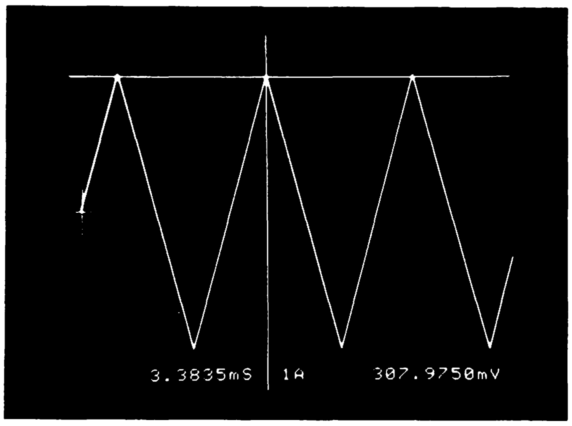


Figure 7-30

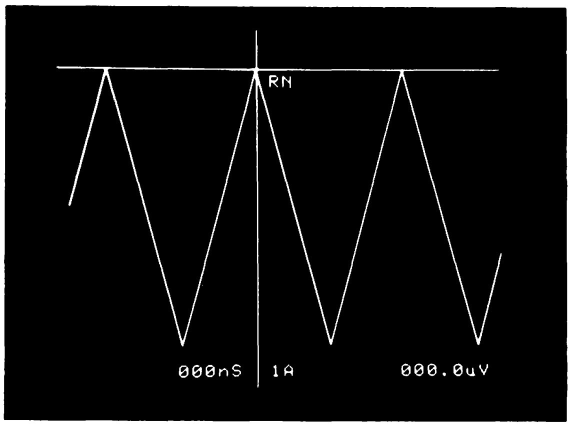


Figure 7-31

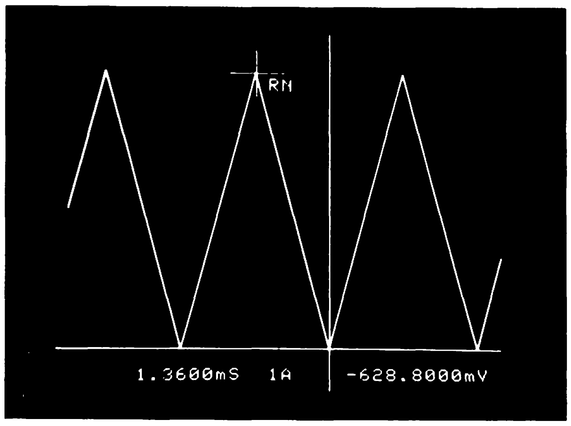


Figure 7-32

••With Autocenter Off

The left and right numerics will always reset to zero when the RESET NUMERICS function is executed.

However, when in the YT mode and with AUTOCENTER off, only the time numerics will be affected when the vertical cursor is moved to a new point of interest. The voltage numerics will remain at zero (the new position of the horizontal cursor) unless the horizontal cursor is moved.

NOTE: The AUTOCENTER switch must be on when operating in the XY mode.

EXAMPLE #7-13

Figure 7-33: Typical display with AUTOCENTER turned off.

Figure 7-34: The same display after executing the RESET NUMERICS function. The Plug-in's Trigger cursor has repositioned to the Mainframe's crosshair and both numerics have reset to zero.

Figure 7-35: The vertical cursor has been repositioned and the time numerics reflect the selected data point's time coordinate with respect to the new time zero origin. The voltage numerics will remain at zero unless the horizontal cursor is moved.

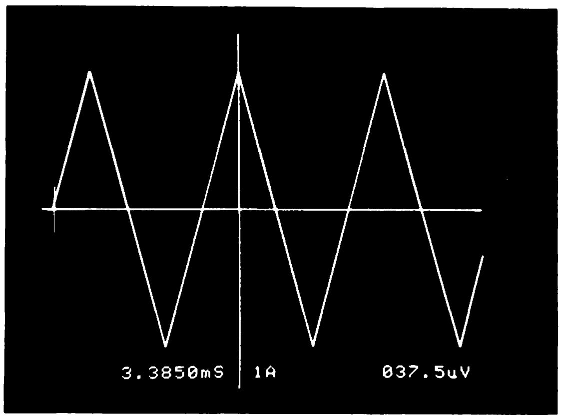


Figure 7-33

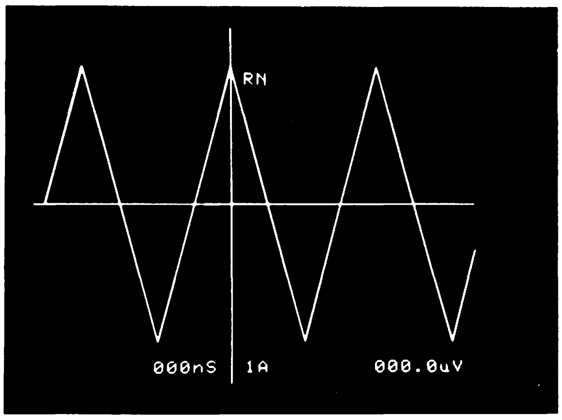


Figure 7-34

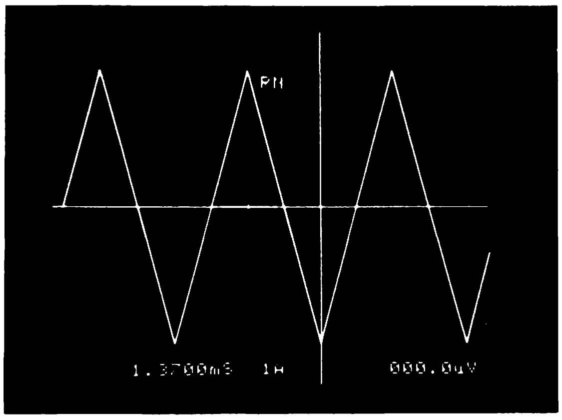


Figure 7-35

● GRID

An electronic graticule appears on the screen when the GRID position is selected on the FUNCTION switch. The Plug-in's Trigger cursor remains displayed. However, the Mainframe's vertical and horizontal cursors disappear.

The time numerics reflects the time per vertical line and the voltage numerics reflects the volts per horizontal line.

NOTE: The grid expands to the horizontal limits of the display screen when the HORIZONTAL EXPANSION switch is turned on. This occurs because all (16K) words of memory are used during expansion only. Regardless of whether or not expansion is in use, the time numerics automatically compensate for the difference in distances between the vertical lines.

This function is very useful when photographs are being used to permanently record the displays.

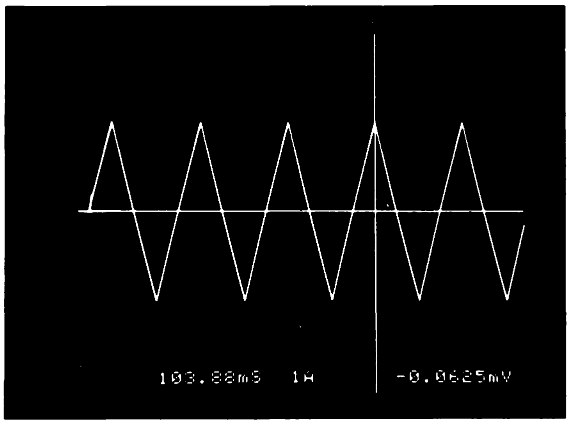


Figure 7-36

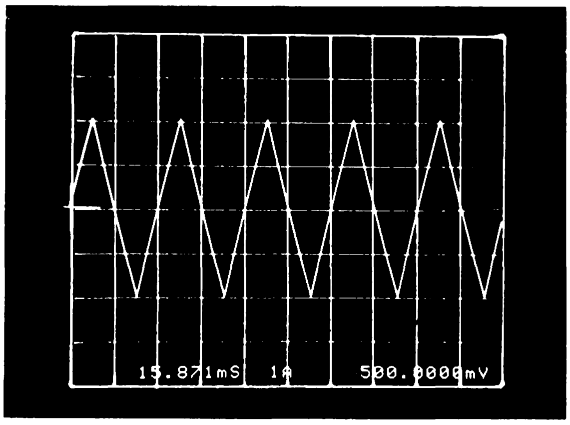


Figure 7-37

EXAMPLE #7-14

Figure 7-35: Typical display of an input signal. The Time Per Point was 10 uSec's and the Volts Full Scale was ±2 volts.

Figure 7-36: The same display after selecting the GRID position.

● PEN

NOTE: The following descriptions apply only to the XY and Strip Chart (YT) recorders. Refer to the tab labeled *Digital Plotter* for information on the digital plotter.

The PEN controls, Figure 7-38, are mounted on the rear panel of the Mainframe. These permit the recording of displayed data groups on either an XY or Strip Chart (YT) pen recorder.

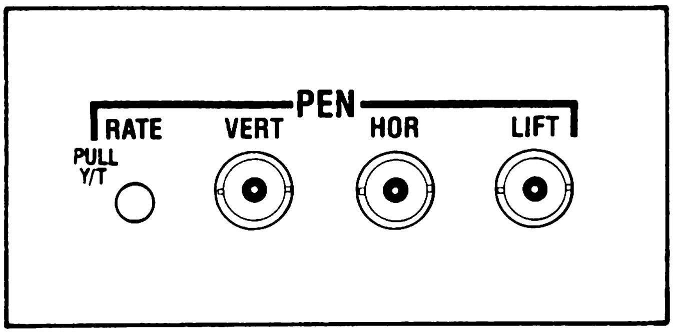


Figure 7-38

•• Rate Control

The RATE control is a dual function device. It is used to select whether the outputs of the PEN BNCs will drive either an XY or strip chart (YT) recorder. To select an XY recording, press the RATE control in. For a strip chart (YT) recording, pull the control out.

In the XY mode, the readout rate is automatically varied to read data out at a higher rate in featureless regions and as slow as one point in two seconds whenever substantial pen excursions are involved. The RATE control allows the operator to adjust this speed range to adapt to very slow or faster pen recorders.

In the YT mode, the RATE control adjusts the readout rate to suit the particular strip chart (YT) recorder in use.

••Vertical & Horizontal BNCs

The VERT and HOR output BNCs are at approximately zero volts before the pen readout is executed.

On an XY recorder, this corresponds to a vertical, negative full scale position on the paper and the left-most part of the waveform.

The VERT and HOR output BNCs will return to approximately zero volts when the pen recording is completed.

••Lift BNC

The LIFT BNC's output voltage, before the pen readout is executed, depends upon which version of Mainframe is present:

a. VERSION 1.0 thru 1.9 - The output is approximately 5 volts.

b. VERSION 2.0 and above - The output is rated up a a maximum of 30 volts at 200 milliamps.

To determine which version of Mainframe is present:

#1. Place the FUNCTION switch to any position other than PEN or PGRM.

#2. Simultaneously press and hold the left and right CURSOR buttons and then -

#3. Press and hold the EXECUTE button.
   a. The Mainframe's version number will be displayed on the screen.

The LIFT BNC's output will drop to approximately zero volts when the pen readout is executed, lowering the pen nib onto the paper. Upon completion of the pen recording, the output voltage will once again rise and the pen nib will rise off of the paper.

The LIFT BNC output is used for connection to the EXTERNAL or REMOTE PEN LIFT input on recorders with this option.

••Border Confirmation

The full display border limits within which the displayed waveform will be duplicated on the paper can be confirmed by:

#1. FUNCTION switch: Pen

#2. AUTOCENTER switch: Place to the "ZERO" position and hold.

#3. EXECUTE button: Press.

#4. AUTOCENTER switch: Release.

The pen will move from the lower left border limit to the upper right border limit and then back again. The pen will remain in the "up" position during this border limit confirmation.

NOTE: The vertical full scale limit will be equal to the ±VOLTS FULL SCALE switch setting. The horizontal full scale limit will be equal to the horizontal full scale of the display screen.

If the border limits must be corrected, the above procedure must be repeated for each confirmation.

NOTE: A border will not be drawn on the paper.

••Reproduction of Waveforms

After confirming the border limits, the displayed waveform can be reproduced by pressing the EXECUTE button. The AUTOCENTER switch must be in the "OFF" position and the FUNCTION switch in the "PEN" position.

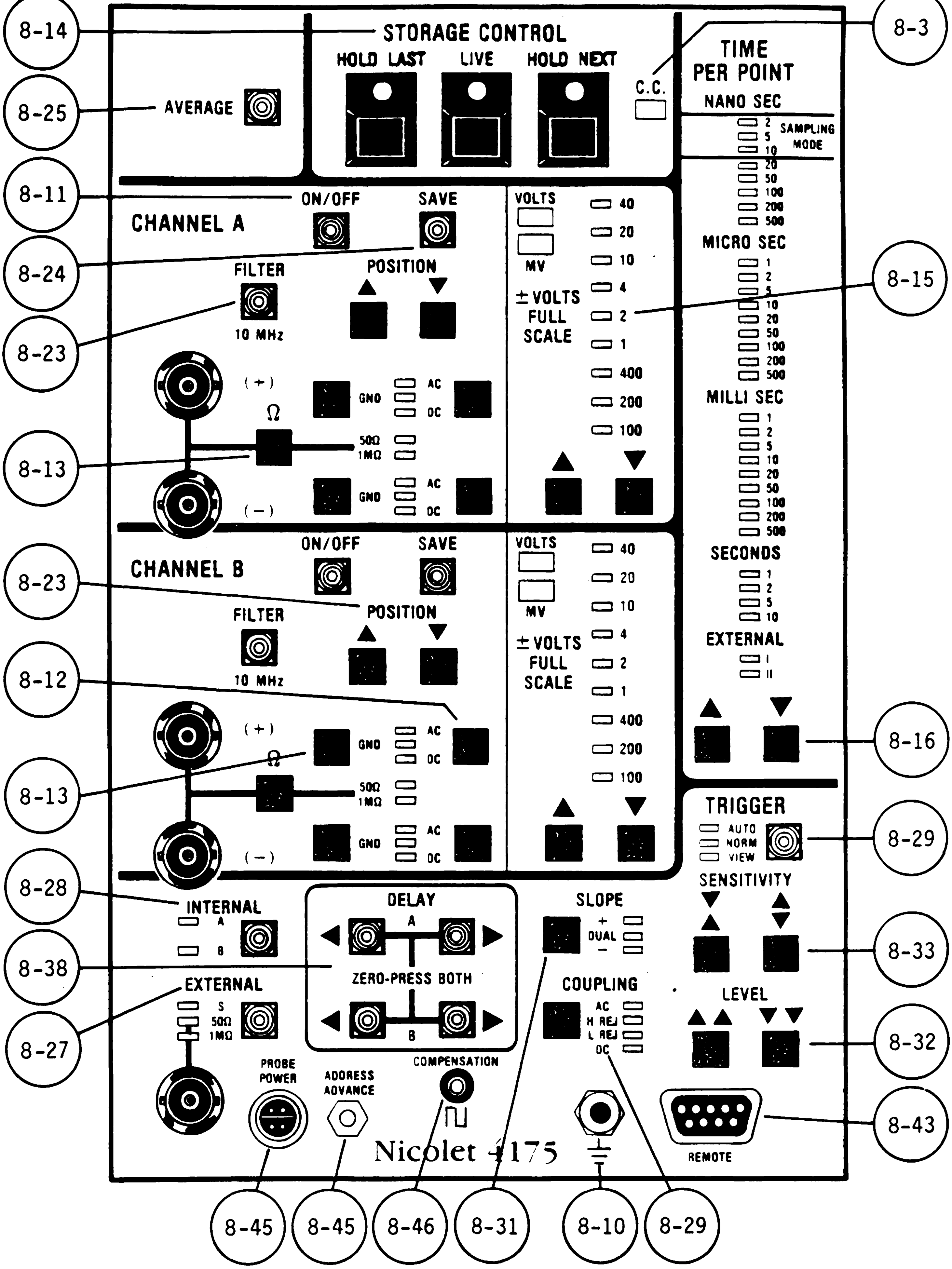
If display expansion is in use, only that portion of the displayed waveform will be reproduced by the pen recorder.

The pen recording will not include the horizontal or vertical cursors, trigger cursor, or numerics.

If a pen recording of two superimposed waveforms is required, first record one, then the other. Otherwise the pen will alternate vertically between the data points of each waveform.

Moving the FUNCTION switch to a different position will abort the pen recording.

Mc 4175 Plug-in



INTRODUCTION

The Model 4175 Plug-in includes two 8-bit, 20 nanosecond digitizers. Other Plug-in features include -

- Equivalent time sampling to 2 nanoseconds/point for repetitive signals.
- Analog bandwidth:
  50 ohm input --- 0.5 Hz to 75 MHz
  1 Megohm input - 3 KHz to 75 MHz
- Differential amplifier operation to 5 MHz.
- 15,872 (16K) word memory.
- Positive, negative, or dual slope triggering.
- Normal, Pre- and Post-trigger, and Delayed trigger displays.
- A Trigger View mode to select the trigger's qualifying characteristics.
- Sweep Averaging and 10 MHz Filter to reduce the effects of "noise" on the signals.
- A Save Reference mode to compare "live" and saved signals.
- 50 ohm or 1 Megohm coupling.
- Complete controllability via GPIB or RS232 interface.
- Test point compensation.
- A plus/minus probe power output.

➤IMPORTANT: If the front panel controls "scramble" when power is applied (or during normal operation)-
#1. Turn the power off.
#2. Press and hold all four DELAY buttons simultaneously.
#3. Turn the power on.
This will override the Power Off Memory feature (page 8-2) and make the 4094 operational again.

➤ **IMPORTANT:** The term "Hold Mode" signifies that the plug-in's Hold Last LED is on while the Live and Hold Next LEDs are off.

The Hold mode can be selected by pressing the Hold Last button if the plug-in is not sweeping. If a sweep is in progress, the Hold mode can be selected by:
#1. HOLD LAST button: Press and hold,
#2. LIVE button: Press momentarily,
#3. HOLD LAST button: Release.

NOTE: This section describes single plug-in operation. Refer to the "Multiple Plug-ins" tab when more than one plug-in is being used. In addition, all of the 4175's front panel controls are controllable via the 4094's computer interfaces (see Section 13, page 13-63b).

OVERVOLTAGE

► **IMPORTANT:** The amplifiers are limited to a ±5Vrms (maximum) input voltage when the 50 ohm input impedance modes are selected.

If a voltage greater than ±5Vrms occurs, the LEDs associated with the channel inputting the overvoltage will flash, the amplifiers will be disconnected from the input, and the plug-in will go to the Hold Mode (Live LED off, Hold Last LED on).

EXAMPLE

If a voltage greater than ±5Vrms is input to channel A, the 4175 will enter the Hold Last mode and all of the front panel LEDs associated with channel A will flash. Likewise, the channel B (or trigger section) LEDs will flash if they experience an overvoltage at their inputs.

To return to normal operation:

#1. Lower the input voltage below the ±5Vrms limit.

#2. Press the Live button.

POWER OFF MEMORY

The 4175 plug-in retains its front panel settings if power is removed from the 4094. The original front panel settings selected before the power was removed will return when power is reapplied.

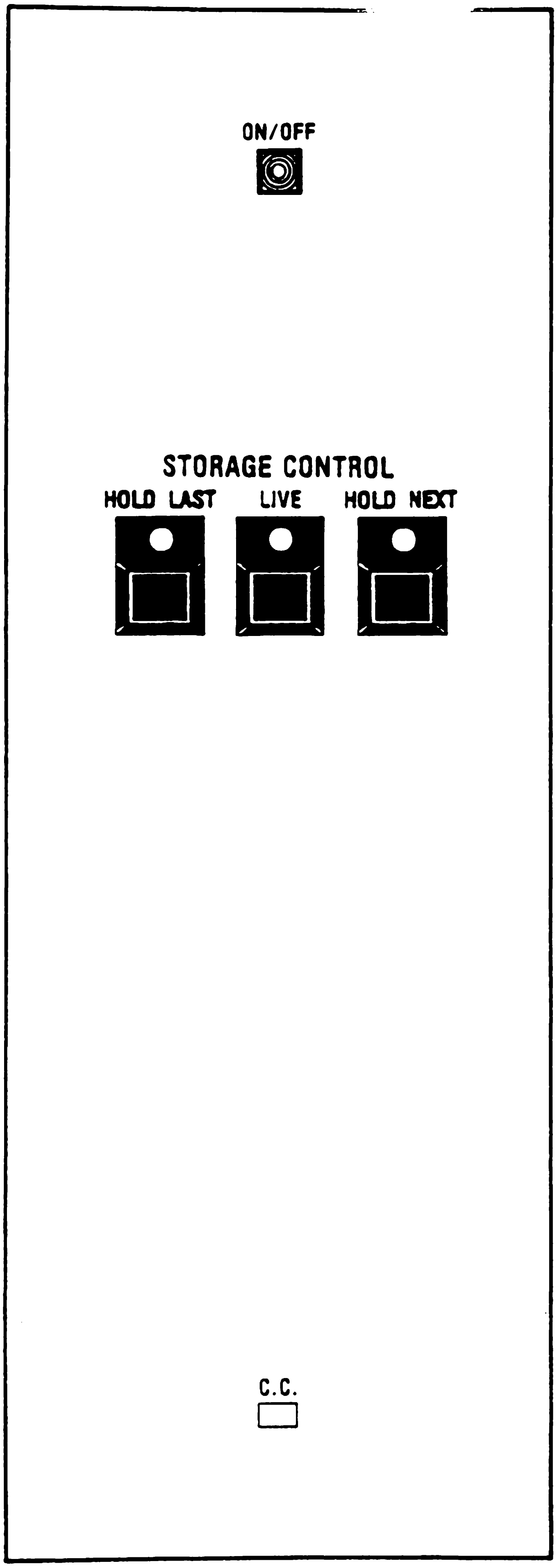
NOTE: If the oscilloscope "beeps" five times when power is applied, the oscilloscope is still operational, but the Power Off Memory function may not retain the 4175's front panel settings if power is removed. Contact:

Nicolet Instruments Corporation
Oscilloscope Division, Service Dept.
Madison, Wisconsin 53711
Telephone (608) 273-5010

If overseas, contact your local Nicolet representative.

MASTER RESET

If the front panel controls become "scrambled" when power is reapplied; turn power off, press and hold all four DELAY buttons, and turn power on to reset the plug-in. This will override the "Power Off Memory" feature described above, placing the 4175's front panel controls in their most protective input voltage states (inputs grounded, ac coupling, ±40 Volts Full Scale range, etc).



CHANNEL ON/OFF BUTTONS

The channel On/Off button turns the channel on, enabling it to capture data for display. The button lights when the channel is turned on.

STORAGE CONTROL BUTTONS

The Storage Control buttons determine whether the displayed data groups will remain "live" or be stored in the display memory.

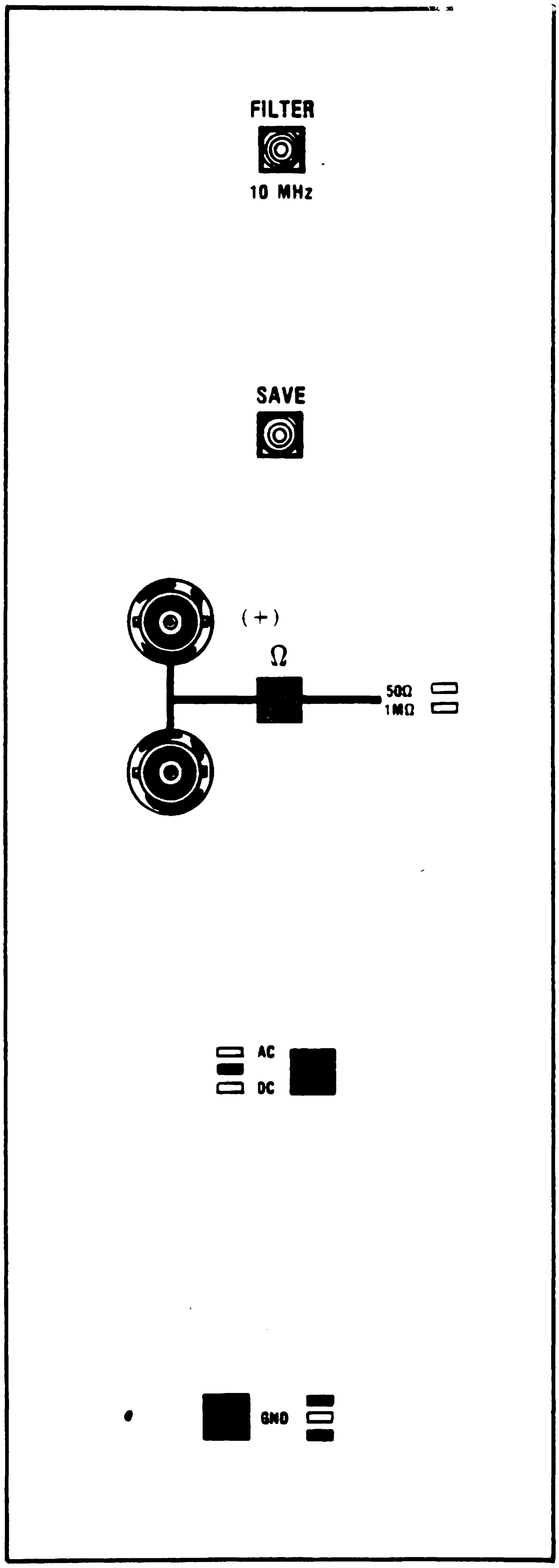
LIVE - New signals are captured and displayed each time a valid trigger initiates a sweep.

HOLD NEXT - The next valid trigger after the button is pressed triggers a final sweep. Data captured during this sweep is stored in memory and displayed on the screen.

HOLD LAST - Data captured during the last sweep (including a sweep already in progress when the button was pressed) is stored in memory and displayed on the screen.

C.C. LED

When the C.C. LED is illuminated, the scope is under computer control and the front panel controls will have no effect.



FILTER BUTTON

Turn on to filter high frequency "noise" from a low frequency input signal. The filter is on when the button is illuminated.

SAVE BUTTON

Turn on to compare "live" and saved signals (the channel must be turned on). SAVE is on when it is lighted.

Ω BUTTON

Selects whether the amplifier's input impedance is 50 ohms or 1 Megohm.

NOTE: The 50 ohm input impedance is limited to a $\pm$5Vrms (maximum) input. (See Overvoltage, page 8-2.)

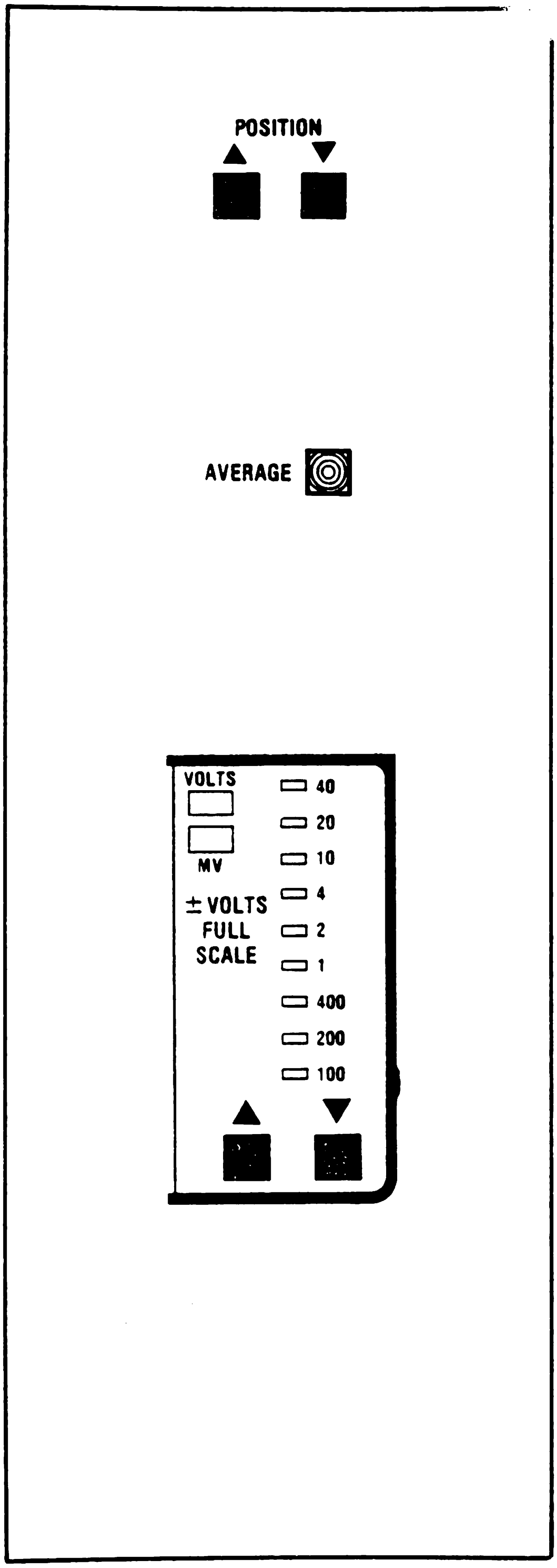
DC/AC BUTTON

DC - Allows both ac and dc signal components to enter the amplifier.

AC - Blocks the dc component while allowing the ac component to enter the amplifier.

GND BUTTON

Grounds the amplifier's positive or negative input, but does not affect the selected input impedance or coupling.



POSITION BUTTONS

Vertically positions the trace in the direction of the arrows. Press both buttons simultaneously to return the trace to screen vertical center.

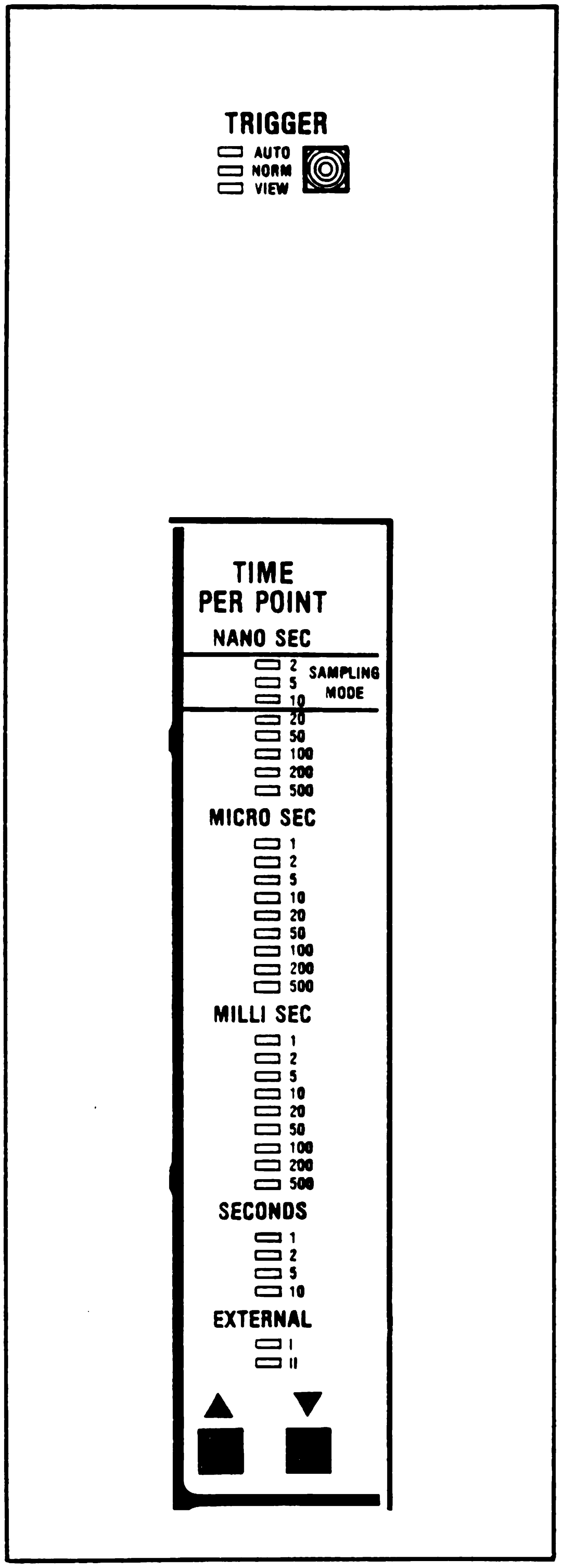
AVERAGE BUTTON

Reduces "noise" on recurrent signals by averaging (from sweep to sweep) voltage samples captured equidistant with respect to the trigger points.

VOLTS FULL SCALE

Allows the oscilloscope to accept input signals ranging from ±100 millivolts to ±40 volts full scale. The range selected is identified by an illuminated LED.

NOTE: The 50 ohm input impedance is limited to a ±5Vrms (maximum) input. (See Overvoltage, page 8-2.)



TRIGGER BUTTON

The Trigger button lights throughout each sweep, confirming a sweep has been triggered. The Trigger button selects whether sweeps will be triggered automatically in the absence of a valid trigger, or solely by an input signal.

AUTO - Internally triggered.

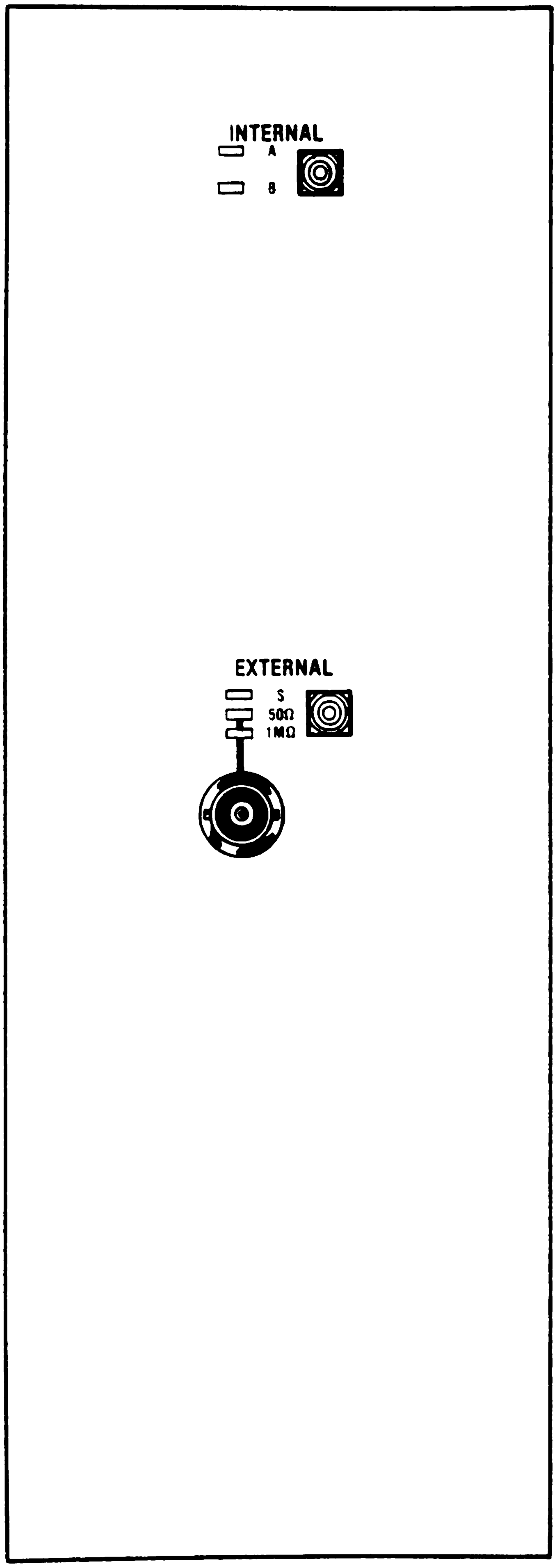
NORM - Externally triggered.

VIEW - The View mode is used to select specific characteristics that will qualify the signal as a valid trigger. It can be used with the Auto or Normal modes. To turn VIEW on or off, the plug-in must be in the Hold Mode, (Live off, Hold Last on).

TIME PER POINT

Press the Time Per Point Up/Down buttons to select the time resolution of the signal to be captured. The selected Time Per Point is indicated by an illuminated LED.

NOTE: Changing the Time Per Point setting while in the Live mode causes the scope to start a new sweep. Sweep speeds are expressed as time-per-point rather than time-per-centimeter.



INTERNAL BUTTON

Selects which channel (A or B) will derive triggers.

(A) - Triggers are derived from signals input to channel A.

(B) - Triggers are derived from signals input to channel B.

Internal triggering is activated when the Internal button is illuminated.

EXTERNAL BUTTON

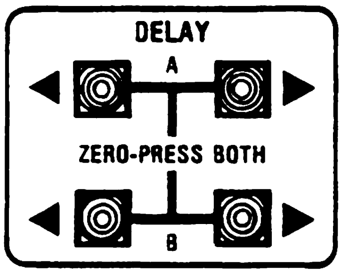
External triggering is selected when the External button is lighted.

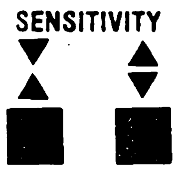
(S) - Select the "S" position on each of the "slave" plug-ins when master/slaving multiple plug-ins triggered by a common signal input to the "master" plug-in.

50Ω - Triggers are derived from signals input to the EXT input BNC. The input impedance is 50 ohms.

NOTE: The 50 ohm input impedance is limited to a ±5Vrms (maximum) input. (See Overvoltage, page 8-2.)

1MΩ - Triggers are derived from signals input to the EXT input BNC. The input impedance is 1 megohm.





TRIGGER DELAY BUTTONS

Selects whether post-trigger events (Zero Trigger), both pre- and post-trigger events (Cursor Trigger), or events occurring after a specific time delay (Delayed Trigger) are displayed.

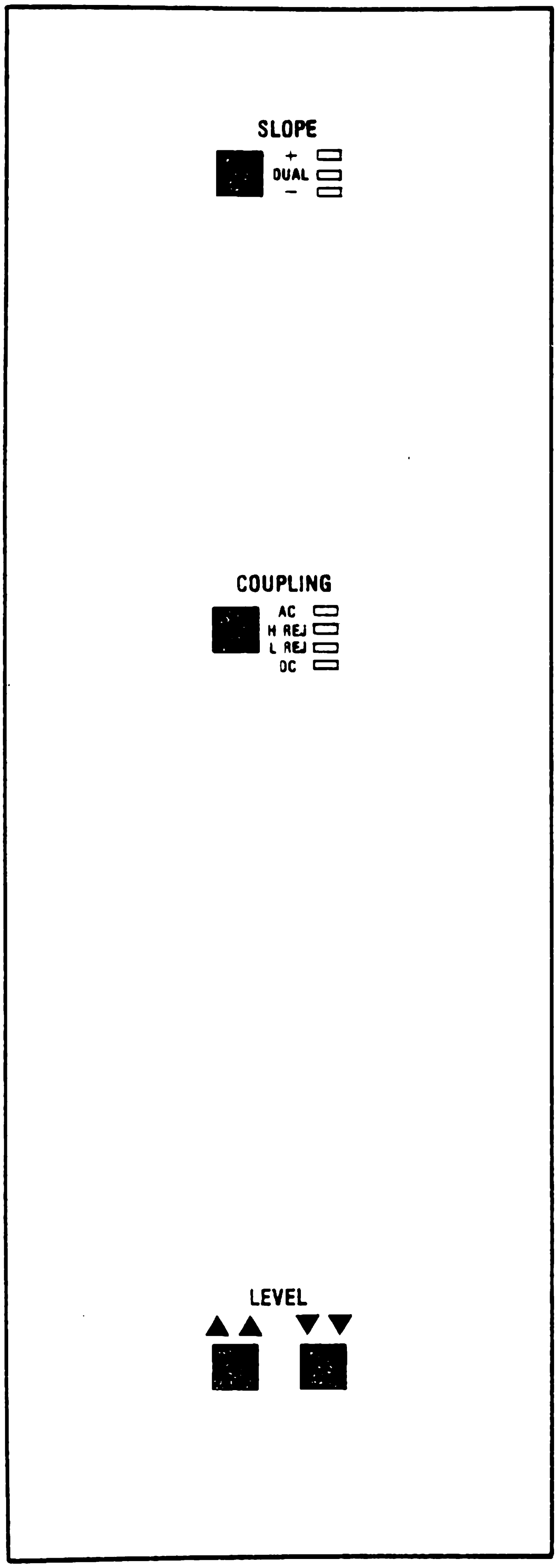
Zero Trigger - Press the (◀A & A▶) buttons at the same time for channel A. Press (◀B & B▶) for channel B. Zero triggering is selected when both buttons (e.g., ◀A & A▶) are off.

Cursor Trigger - Press (A▶) for channel A, or (B▶) for channel B. Cursor triggering is selected when (A▶) and/or (B▶) are lighted.

Delayed Trigger - Press (◀A) for channel A, or (◀B) for channel B. Delayed triggering is selected when (◀A) and/or (◀B) are lighted.

TRIGGER SENSITIVITY BUTTONS

The Trigger SENSITIVITY buttons adjust the "window" (voltage span) that the signal must pass through before it can qualify as a valid trigger. Press both buttons to close the "window".



TRIGGER SLOPE BUTTON

Selects the signal's voltage transition (slope) that will qualify it as a valid trigger.

(+) - Positive-going only.

(-) - Negative-going only.

DUAL - Either positive-going or negative-going voltage transitions.

TRIGGER COUPLING BUTTON

Determines whether or not the dc component of the trigger signal will be blocked.

AC ---- The dc component is blocked while the ac component passes into the trigger circuit.

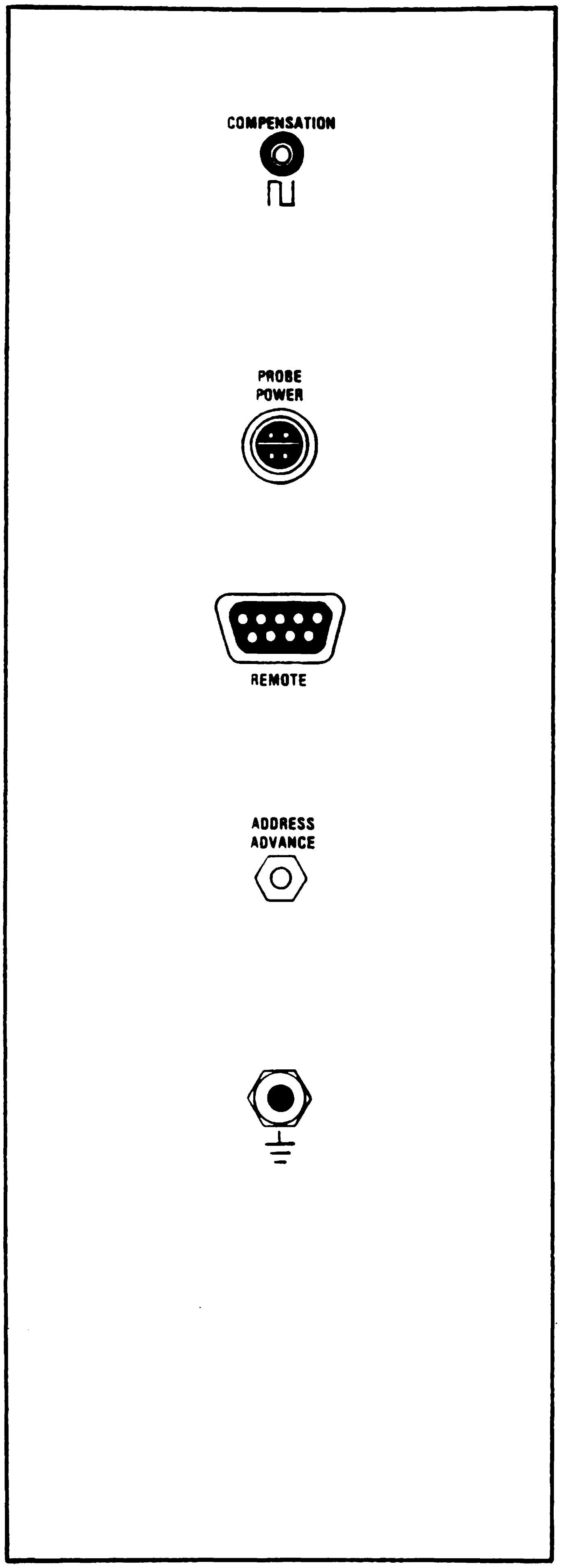
H REJ - Frequencies above 10 MHz are rejected.

DC ---- Ac and dc components are input to the trigger circuit.

L REJ - Frequencies less than 10 Hz are rejected.

TRIGGER LEVEL BUTTONS

Adjusts the voltage level that must be crossed by the triggering signal to qualify it as a valid trigger. Press both buttons to center the trigger level on the screen.



COMPENSATION POINT

Touch the test probe to the compensation point when compensating the X10 and X100 probes for the best square wave response times.

PROBE POWER CONNECTOR

Provides ±15, +5 Vdc, ground outputs.

REMOTE CONTROL CONNECTOR

Permits limited remote control of the plug-in.

ADDRESS ADVANCE INPUT

Address advance input for External I & II modes.

GROUND

Chassis ground.

CHANNEL BUTTONS

Press the channel's ON/OFF button (lighting the button) to capture/display data with that channel.

For example, the Channel A button must be illuminated to capture data with channel A.

NOTE: The channel must be turned on to use its Save function.

Turn off the unused channel when capturing data with a single channel. This allows all 15,872 display memory addresses to record the signal if the mainframe's MEMORY switch is in the "ALL" position.

NOTE: The channel On/Off buttons are recognized by the scope at the end of a sweep, or after the sweep has been reset by pressing the Live button.

The number of addresses recording the input signal is determined by the number of channels turned on and the position of the Memory switch. See Table 8-1.

NOTE: Table 8-1 is for single Plug-in operation only.

NUMBER OF ACTIVE CHANNELS	MEMORY SWITCH POSITION		
	ALL	HALVES	QUARTERS
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-1

DC/AC BUTTONS

The DC/AC buttons determine whether both ac and dc components will be input to the amplifiers, or ac components only.

DC - Both ac and dc components of the input signal enter the amplifier.

AC - Dc components are blocked. Ac components enter the amplifier.

> **CAUTION** - Do not allow the input signal to exceed the maximum, allowable input voltage (with respect to ground) listed under the Specifications tab.

DIFFERENTIAL AMPLIFIERS

The differential amplifier mode displays the voltage difference between two signals input to a channel's (+) and (-) input BNCs.

To select the differential mode:

#1. Input two signals to the channel's (+) and (-) input BNCs.

#2. Select either AC or DC coupling using the amplifier's AC/DC buttons associated with the inputs.

NOTE: Differential operation is not recommended when frequencies exceed 5 MHz.

SINGLE-ENDED AMPLIFIERS

Single-ended amplifiers display input characteristics as they appear at the channel's input BNC.

To select the single-ended mode:

#1. Input only one signal to the channel, either the (+) or (-) input BNC.

#2. Select either AC or DC coupling using the amplifier's AC/DC button associated with the input.

#3. Ground the unused input by pressing the associated GND button.

GND BUTTON

Both ac and dc components are blocked from entering the amplifier when the GND LED is lighted.

NOTE: Always ground unused amplifier inputs to avoid unwanted "noise."

(Ω) INPUT IMPEDANCE BUTTON

The amplifier's input impedance can be changed from 50 ohms to 1 megohm by pressing the (Ω) button until the desired impedance LED lights on the front panel.

(50Ω) - Select the 50 ohm input impedance. The 50 ohm input impedance is limited to a $\pm$5Vrms input signal. (See Overvoltage, page 8-2.)

NOTE: The 50 ohm input impedance is recommended when acquiring high speed signals ($\geq$ 5 MHz) as it improves noise performance. However, to avoid excessive signal attenuation, the source impedance of the signal must be low compared to 50 ohms.

(1MΩ) - Select the 1 megohm input impedance when acquiring slow speed input signals, and/or when the source impedance of the signal is high.

STORAGE CONTROL BUTTONS

The Storage Control buttons (LIVE, HOLD NEXT and HOLD LAST) determine whether or not the display memory will be updated with new data each time a valid trigger initiates a sweep.

THE LIVE BUTTON

The Live mode is activated by pressing the LIVE button. A new sweep is initiated each time a valid trigger is received.

Pressing the LIVE button erases data from the screen, (except for data saved by the channels' SAVE modes if they are turned on) readying it for the next display. It also serves as a "master reset," enabling the plug-in to acknowledge any changes to the plug-in's front panel settings since the last sweep.

THE HOLD NEXT BUTTON

To select the Hold Next mode, press the Hold Next button.

The next valid trigger to occur after pressing the Hold Next button initiates a single sweep, updating the display memory with new data. The plug-in enters the Hold Mode at the end of the sweep, inhibiting any more sweeps from being triggered.

THE HOLD LAST BUTTON

Press the HOLD LAST button to select the Hold Last mode.

Data captured since the last valid trigger (including a sweep already in progress when the button is pressed) is stored in memory. The plug-in enters the Hold Mode at the end of the last triggered sweep, inhibiting any further sweeps from being triggered.

NOTE: To protect data stored in portions of the display memory, place the plug-in into the Hold Mode (LIVE LED off) before repositioning the mainframe's MEMORY switch. If this is not done, data stored in the display memory will be replaced if a valid trigger occurs.

REMOTE CONTROL

Refer to page 8-43, "Remote Control Connector" descriptions.

VOLTS FULL SCALE

Allows input signals ranging from ±100 millivolts to ±40 volts full scale to be measured when the X1 probe is used.

NOTE: The 50 ohm input impedance is limited to a ±5Vrms input signal regardless of the selected Volts Full Scale range. (See Overvoltage, page 8-2).

THE X10 PROBE

The optional X10 probe allows a maximum input voltage of ±400 volts full scale. The correct voltage range is registered automatically when the BNC's grounding ring is used. Refer to tab "Accessories" for further information on the optional X10 probe.

NOTE: The X10 probe cannot be used with the 50 ohm input.

VOLTAGE LEVELS

Up to 256 voltage levels can be displayed when Vertical Expansion is turned off.

If the zero volts reference is at screen vertical center, positive voltages are displayed above the zero volts level with up to 127 levels. Negative voltages are displayed below the zero volts level with up to 128 levels. (See Figure 8-1.)

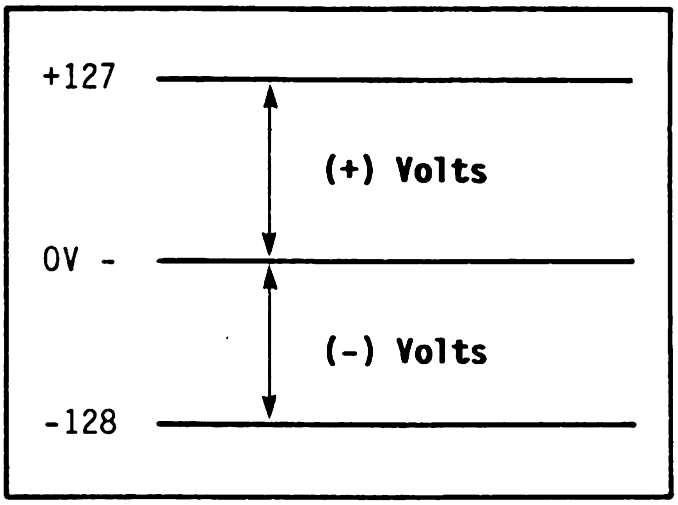


Figure 8-1

VOLTS FULL SCALE	VOLTS PER LEVEL
100 mV	0.8 mV
200 mV	1.6 mV
400 mV	3.2 mV
1 V	8 mV
2 V	16 mV
4 V	32 mV
10 V	80 mV
20 V	160 mV
40 V	320 mV

Table 8-2

Table 8-2 tabulates the Volts Full Scale ranges and corresponding Volts-Per-Level factors for the X1 probe.

TIME PER POINT BUTTONS

The Time Per Point buttons are used to select the time resolution of the displayed signal. The faster the time-per-point setting when the signal is captured, the higher its time resolution.

Holding the Time Per Point button in "runs" the time-per-point in the direction of the arrow. Tapping the button "steps" the time-per-point.

THE NORMAL MODE

The Time Per Point setting determines the rate at which the plug-in will sample and digitize the input signal.

EXAMPLE #8-1

Figure 8-2: The input signal.

Figure 8-3: The signal superimposed by the 50 nanosecond sampling rate.

Figure 8-4: The resulting digitized samples represented by dots.

Figure 8-5: Every other sample (large dots) are displayed when the Time Per Point is set to 100 nSec.

Figure 8-6: Every tenth sample (large dot) is displayed when the Time Per Point is set to 500 nSec.

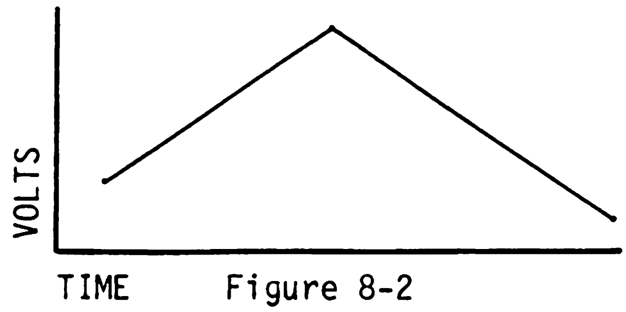


Figure 8-2

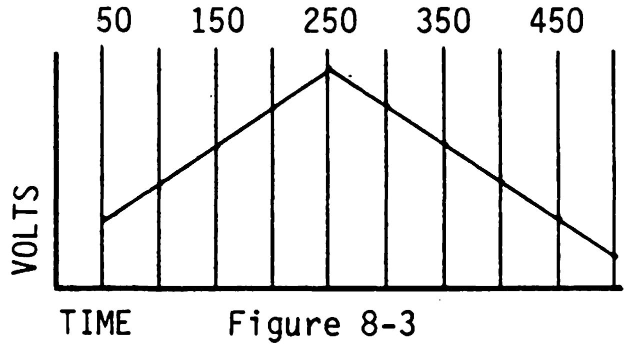


Figure 8-3

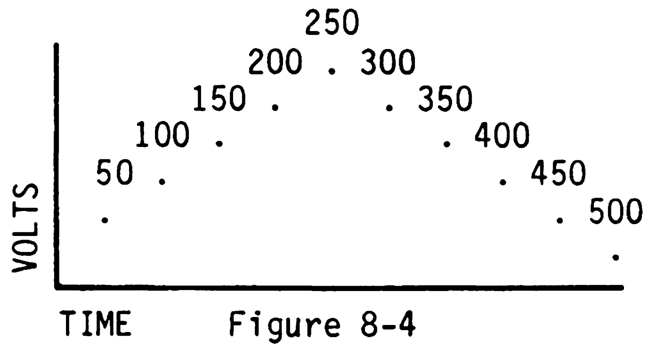


Figure 8-4

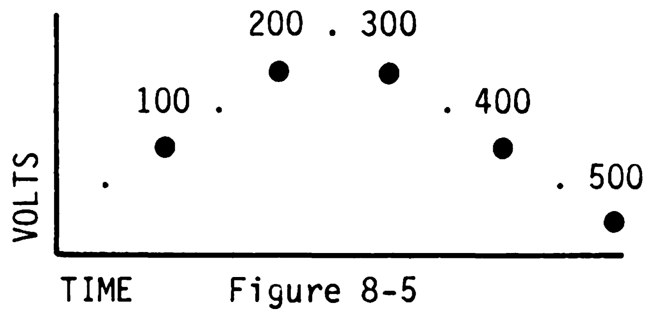


Figure 8-5

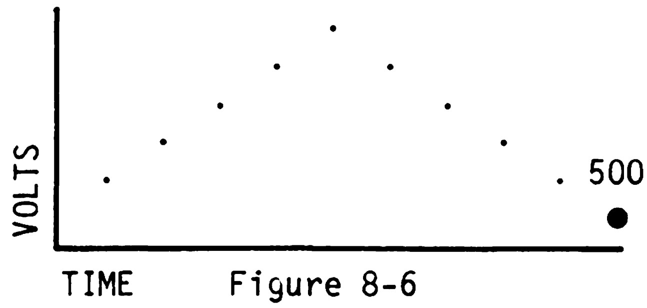


Figure 8-6

THE SAMPLING MODE

The input signal can be sampled at an effective 2, 5, or 10 nanoseconds rate.

In this mode, the digitizer is continuously sampling the input signal at its maximum rate of 50 MHz (20 nanoseconds per point). By sampling several sweeps at selected timing skews of 2, 5 or 10 nanoseconds, a composite display can be constructed of the input signal.

➤ **IMPORTANT:** The Sample Mode requires recurrent signals to complete each sweep.

EXAMPLE #8-2

Figure 8-7: The input signal.

Figure 8-8: The first (1) and second (2) set of samples superimposed over the signal.

Figure 8-9: The resulting first (1) set of samples.

Figure 8-10: The resulting second (2) set of samples.

Figure 8-11: The composite waveform from the first (1) and second (2) samples.

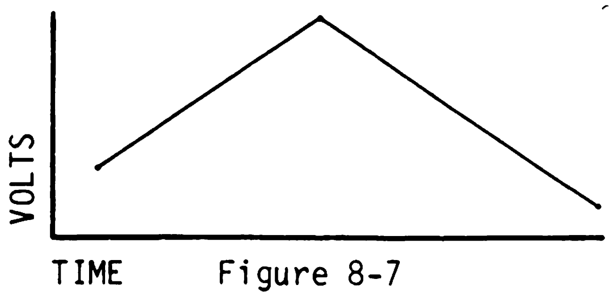


Figure 8-7

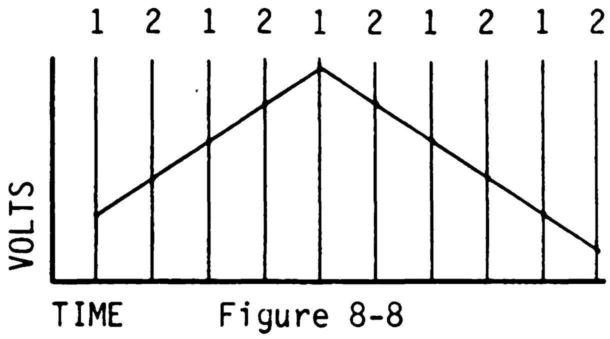


Figure 8-8

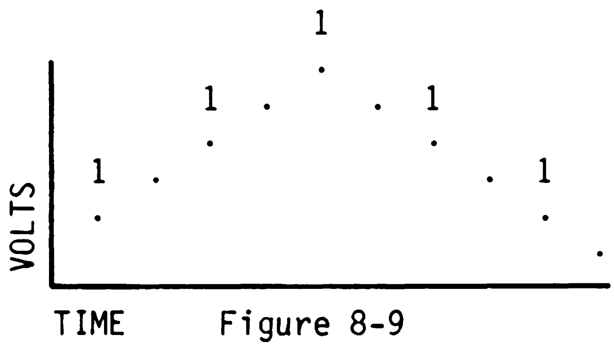


Figure 8-9

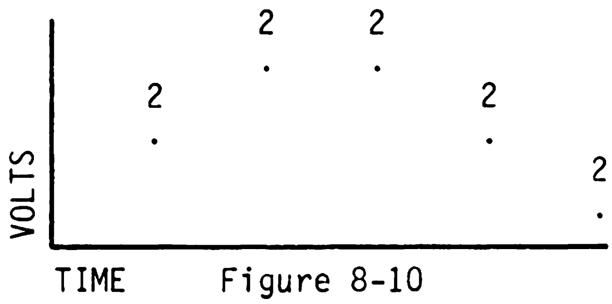


Figure 8-10

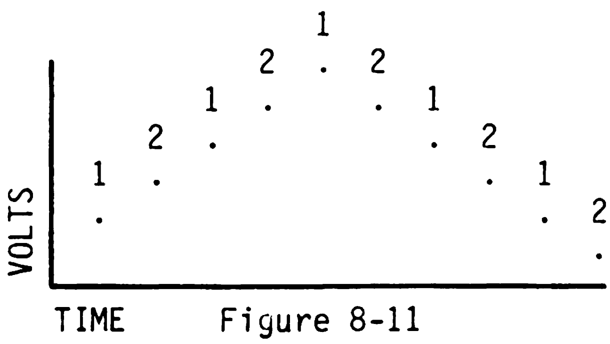


Figure 8-11

THE MEMORY ADDRESSES

The number of addresses (words) allotted to record the input signal depends on:

#1. The number of channels turned on.

#2. The position selected on the mainframe's MEMORY switch.

Table 8-3 tabulates the approximate number of memory addresses used to record each input signal.

NUMBER OF ACTIVE CHANNELS	MEMORY SWITCH POSITION		
	ALL	HALVES	QUARTERS
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-3

NOTE: Table 8-3 is for single Plug-in operation only.

APPROXIMATE SWEEP TIMES

Table 8-4 (page 8-19) lists the approximate sweep times for single-channel measurements.

For multiple channel measurements, divide the times listed in Table 8-4 by the following factors.

Two channels ------------------ (2)

Three or four channels --------- (4)

TIME PER POINT SETTING	MEMORY SWITCH POSITIONS (Data Points Per Sweep)		
	ALL (16K pts/sweep)	H1/H2 (8K pts/sweep)	Q1/Q2/Q3/Q4 (4K pts/sweep)
	Microseconds Per Sweep		
2 nS	31.760	15.880	7.940
5	79.400	39.700	19.850
10	158.800	79.400	39.700
20	317.600	158.800	79.400
50	794.000	397.000	198.500
100	1,588.000	794.000	397.000
200	3,176.000	1,588.000	794.000
500	7,940.000	3,970.000	1,985.000
	Milliseconds Per Sweep		
1.0 μS	15.880	7.940	3.970
2.0	31.760	15.880	7.940
5.0	79.400	39.700	19.850
10.0	158.800	79.400	39.700
20.0	317.600	158.800	79.400
50.0	794.000	397.000	198.500
100.0	1,588.000	794.000	397.000
200.0	3,176.000	1,588.000	794.000
500.0	7,940.000	3,970.000	1,985.000
	Minutes Per Sweep		
1 mS	0.264	0.132	0.066
2	0.528	0.264	0.132
5	1.320	0.660	0.330
10	2.640	1.320	0.660
20	5.280	2.640	1.320
50	13.200	6.600	3.300
100	26.400	10.320	6.600
200	52.800	26.400	10.320
500	132.000	66.000	33.000
	Hours Per Sweep		
1 S	4.400	2.200	1.100
2	8.800	4.400	2.200
5	22.000	11.000	5.500
10	44.000	22.000	11.000

Table 8-4

THE EXT I & II POSITIONS

Select the EXT I (Fast) and EXT II (Slow) time-per-point positions when:

#1. The desired time-per-point is not available, or

#2. The sampling rate is generated from a nonlinear time base.

The number of addresses (words) recording the signal depends on:

#1. The number of channels turned on.

#2. The position selected on the mainframe's MEMORY switch.

Table 8-5 tabulates the corresponding number of memory addresses that will record each input signal.

NOTE: Table 8-5 is for single Plug-in operation only.

NO. OF ACTIVE CHANNELS	MEMORY SWITCH POSITION		
	ALL	HALVES	QUARTERS
ONE	15,872	7,936	3,968
TWO	7,936	3,968	1,984

Table 8-5

DISPLAY UPDATE

If the 4175 is operating in the EXT (fast) mode, the plug-in must capture all of the samples required to complete an entire sweep (Table 8-5) before the display screen is updated. All of the samples are stored in a buffer memory until the required number of samples have been captured.

Equation 8-1 calculates the approximate display update delay between the time of the first sample and the final display by multiplying the allotted addresses (from Table 8-5) by the average time period between each sample.

$$\boxed{\text{Time Delay} = (\text{addresses}) \times (\text{period})}$$

Equation 8-1

NOTE: Data is displayed in groups of four (4) data points each when operating in the EXT II (slow) mode.

THE EXT I POSITION (Fast Mode)

Data is delayed from being displayed until enough samples have been captured to complete a full sweep when the EXT I mode is selected, (see Delayed Displays, page 8-20).

Select the EXT I position when the the Address Advance command rate ranges from 10 KHz to 20 MHz.

The EXT I mode requires two external commands:

#1. A valid trigger input to the EXT input BNC.

#2. A TTL input signal input to the Address Advance connector.
NOTE: The signal's rise/fall time must be equal to (or less than) 20 nS.

The trigger initiates the sampling sequence and "captures" the first sample. The remaining samples are captured within 20 nS of each Address Advance command's leading, positive edge.

NOTE: The maximum speed for the EXT I mode is 20 MHz. Both the pulse width and the gap between the Address Advance command's pulses must be greater than 25 nS.

EXAMPLE #8-3

Figure 8-12: The input signal superimposed by Address Advance commands.

Figure 8-13: A valid trigger occurs.

Figure 8-14: The digitized samples (dots) selected for display.

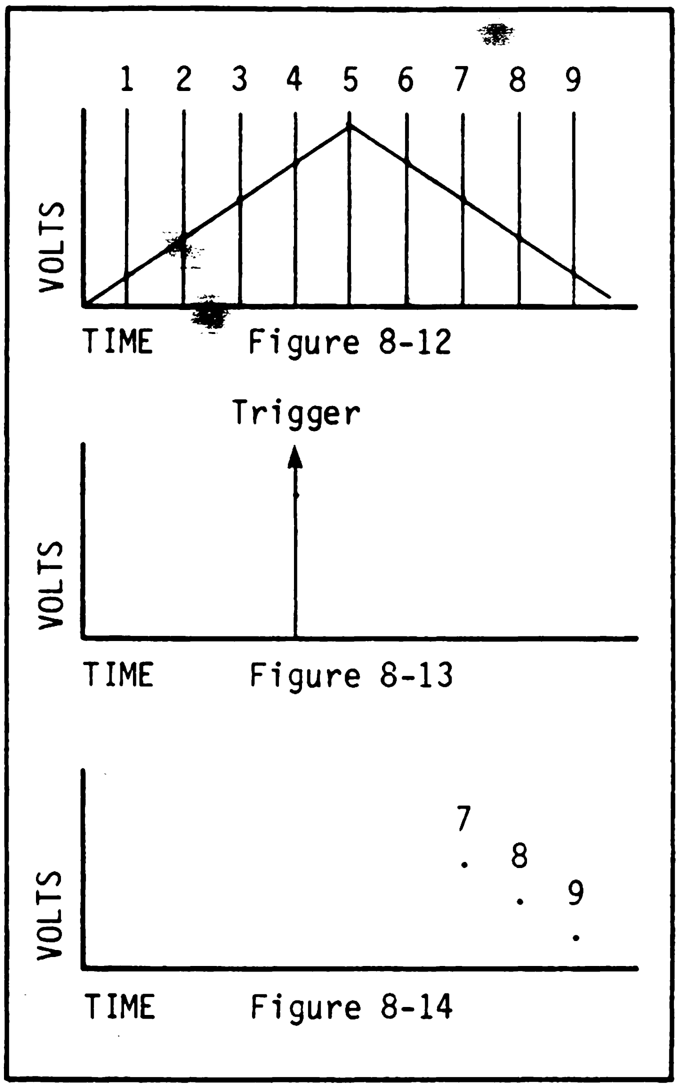


Figure 8-12

Figure 8-13

Figure 8-14

NOTE: The first three Advance Pulses after a valid trigger are used to "synchronize" the logic only. Data collection begins on the fourth Advance Pulse after a valid trigger.

THE EXT II (Slow) POSITION

Data is displayed in groups of four (4) data points each when the EXT II mode is selected.

Select the EXT II position when the Address Advance command rate ranges from Ø to 10 KHz with Averaging off, (DC to 1 KHz with Averaging on).

The EXT II mode requires two external commands:

#1. A valid trigger command input to the EXT input BNC.

#2. A TTL input signal input to the Address Advance connector.
NOTE: The signal's rise/fall time must be equal to (or less than) 20nS.

The trigger initiates the sampling sequence and "captures" the first sample. The remaining samples are captured within 20 nS of each Address Advance commands' leading, positive edge.

NOTE: The maximum speed for the EXT II mode is 10 KHz with Averaging off (1 KHz with Averaging on). Both the pulse width and the gap between the Address Advance command's pulses must be greater than 25 nS.

EXAMPLE #8-4

Figure 8-15: The input signal superimposed by Address Advance commands.

Figure 8-16: A valid trigger occurring at that point in time.

Figure 8-17: The digitized samples (dots) selected for display.

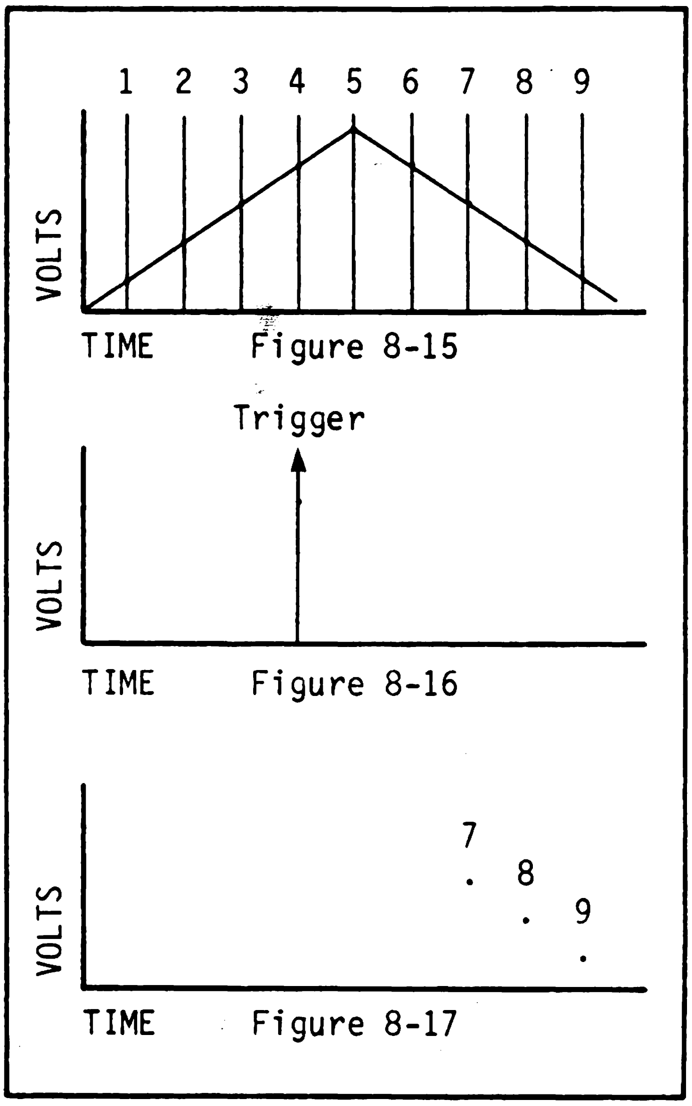


Figure 8-15
Figure 8-16
Figure 8-17

NOTE: The first three Advance Pulses after a valid trigger are used to "synchronize" the logic only. Data collection begins on the fourth Advance Pulse after a valid trigger.

FILTER BUTTON

The 10 MHz (-3dB point) filter rejects high frequency "noise" from the input signal and can be in any signal acquisition mode, including the Average mode.

The 10 MHz filter is activated when the Filter button is illuminated.

POSITION BUTTONS

Vertically repositions a "live" signal on the screen. Pressing both Position buttons simultaneously sets the trace to the center of the screen. Holding the Position button in "auto-steps" the DC level in the direction of the arrow. Tapping the button "steps" the DC level.

The Position buttons do not introduce dc offset voltages to the signal. Rather, it varies the location of the zero volts reference on the screen by up to 60% of the selected Volts Full Scale range.

For example, if the selected Volts Full Scale equals ±1V, the display can be varied from (+1.8 V to -0.2 V) down to (-1.8 V to +0.2 V) by using the Position buttons.

NOTE: The voltage numerics remain unchanged while the Position buttons are being pressed. The small cross-hair follows the offset and the zero reference level is updated only after the button is released <u>and</u> one of the following occurs -

a. A sweep reset occurs
b. Volts Full Scale range is changed
c. Time Per Point setting is changed
d. Live button is pressed.

THE SAVE BUTTON

➤ **IMPORTANT:** The Trigger View mode overrides the Save Reference mode. See IMPORTANT note on page 8-29.

Turn on the Save Reference mode to compare "live" and "stored" signals, providing a reference as the input signal's characteristics are changed.

The Save Reference mode is activated when the SAVE button is illuminated.

Turning Save Reference on "freezes" data stored in alternate display memory addresses while the remaining addresses continue to record "live" signals. The resulting display combines both "live" and "frozen" signals.

A letter "R" suffix is added to the Plug-in/Channel Identifier when "saved" data is being decoded.

The display returns to normal operation when the Save Reference mode is turned off.

EXAMPLE #8-5

Figure 8-18: Typical signal captured before turning on Save Reference.

Figure 8-19: Resulting display after changing the input signal's characteristics.

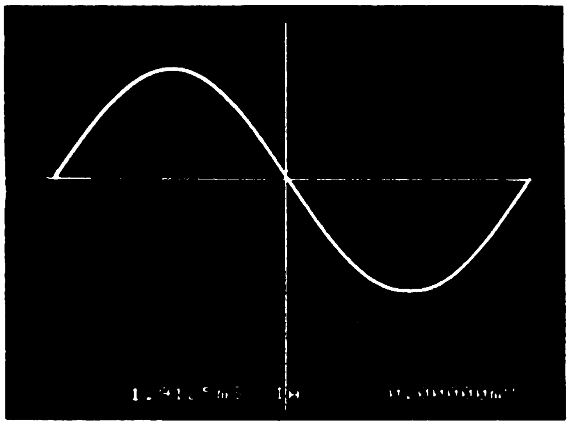


Figure 8-18

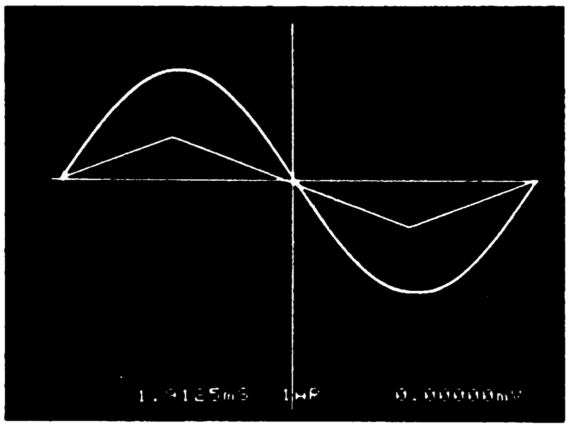


Figure 8-19

THE AVERAGE BUTTON

Turn on the Average mode to reduce the effects of "noise" on recurrent input signals by "sweep" averaging successive sweeps. The sampling rate is determined by the selected Time-Per-Point.

The Average mode is activated when the AVERAGE button is illuminated.

➤ **IMPORTANT:** To function properly, the input signal must be time-locked to a trigger.

The Average mode operates by storing samples from the "first" sweep in the memory until a "second" sweeps occurs. The values captured during the first two sweeps are averaged and the resultant is stored in memory. Values captured with each (new) sweep are averaged with the (old) values stored in memory, (Equation 8-2).

$$\text{Average} = \text{Old} \times \frac{(K-1)}{K} + \frac{\text{New}}{K}$$

Equation 8-2

Old = Averaged values stored in the memory's address.

New = Newest values captured during the current sweep.

K = Values listed in Table 8-6 according to the current sweep number.

	SWEEP IN PROGRESS				
	1	**2**	**3-5**	**6-10**	**11-21**
K =	1	2	4	8	16

Table 8-6

The term "K" is computed from Equation 8-3. The result is rounded off to the nearest, lower power of two.

$$K = \text{Sweep} + \frac{\text{Sweep}}{2}$$

Equation 8-3

NOTE: This type of averaging is called virtual averaging and is similar to "true" or normalized averaging. However, unlike normalized averaging, virtual averaging "weights" each sweep differently because of the use of binary number "K" instead of "N" (Number of sweeps). The result is identical if the variations in voltages (from sweep to sweep) are due entirely to "noise" and not because of signal changes.

EXAMPLE #8-6

Figure 8-20: First sweep sampled at 1V1, 1V2, ... 1Vx.

Figure 8-21: Second sweep sampled at 2V1, 2V2, ... 2Vx.

Figure 8-22: Third sweep sampled at 3V1, 3V2, ... 3Vx.

If -
1V1 = 8V, 2V1 = 10V, and 3V1 = 8V, the first data point's average value from all three sweeps would equal 8.75 volts.

$$AV1 = 0V \times \frac{(1-1)}{1} + \frac{8V}{1} = 8V$$

$$AV2 = 8V \times \frac{(2-1)}{2} + \frac{10V}{2} = 9V$$

$$AV3 = 9V \times \frac{(4-1)}{4} + \frac{8V}{4} = 8.75V$$

Figure 8-23: The top "noisy" waveform was captured with Average turned off. The same "noisy" waveform (lower waveform) after several sweeps with the Average mode turned on.

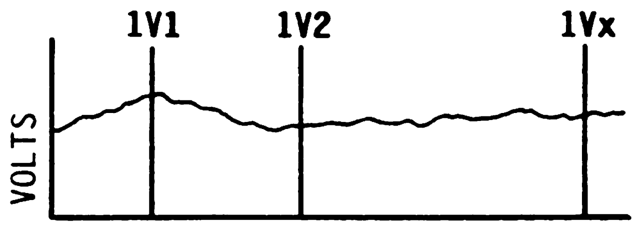


Figure 8-20

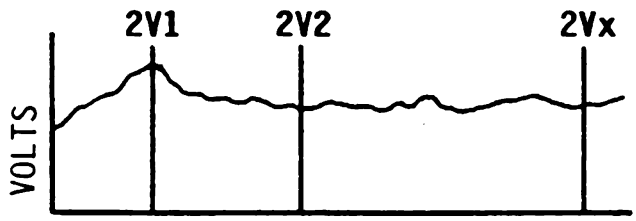


Figure 8-21

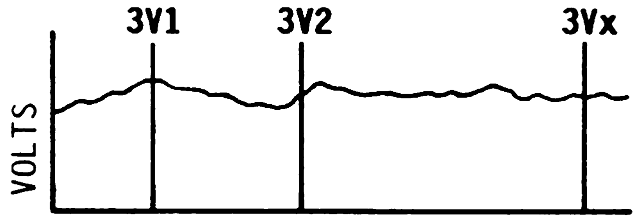


Figure 8-22

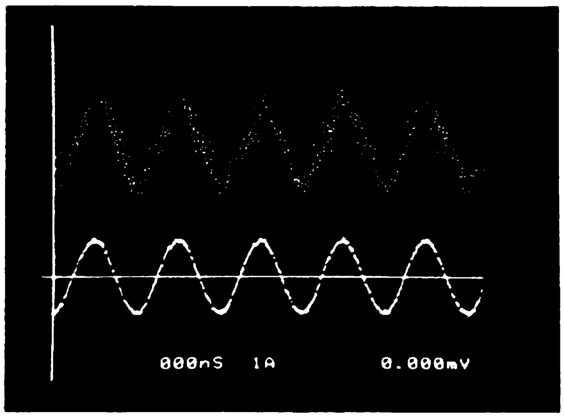


Figure 8-23

THE EXTERNAL BUTTON

Select the External trigger mode when triggers are input to the EXT input BNC. The External trigger mode is activated when the EXTERNAL button is illuminated.

The amplitude of the signal must be ±40 mV (minimum) to qualify as a valid trigger.

NOTE: This value degrades with increasing frequencies due to inherent roll-off of trigger amplifiers.

50 - Select the 50 ohm input impedance when using high speed trigger sources to initiate sweeps. The 50 ohm impedance is valid with ±5Vrms (maximum) inputs only.
(See Overvoltage, page 8-2.)

NOTE: The source impedance of the trigger signal must be low compared to 50 ohms to avoid excessive attenuation.

NOTE: It is preferable to use the external 50 ohm mode when using the Sampling Mode (i.e., T.P.P. = 2nS, 5nS, 10nS).

1M - Select the 1 megohm input impedance when acquiring slower speed signals and/or when the source impedance of the trigger is high. Up to 120 volts peak-to-peak can be input to the EXT input when the 1 megohm input is selected.

S -- A common signal input to a "master" plug-in can be used to trigger sweeps on several "slave" plug-ins.

The **master** plug-in's trigger source must be set according to the plug-in model being used.

4562/4851 - Set the Source switch to A, B, or EXT.

4175 ------ Select Internal (A or B) or External (50Ω or 1MΩ).

The **slave** plug-ins' trigger source must be set according to the plug-in model being used.

4562/4851 - Set the Source switch to "S".

4175 ------ Select External and "S".

INTERNAL BUTTON

Select the Internal trigger mode when triggers are to be derived from signals input to the channel A or channel B input BNCs.

Triggering sweeps in this manner enables the signal to be conditioned before entering the trigger detection circuit. It is also enables the trigger's characteristics to be viewed on the screen if desired.

The signal must be at least 5% of the selected Volts Full Scale to qualify as a valid trigger source.

A - Select "A" when triggers are being derived from signals input to the channel A amplifier.

NOTE: Channel B sweeps will also be triggered (if channel B is turned on) when valid triggers are input to the channel A amplifier (even if channel A is turned off).

B - Select "B" when triggers are being derived from signals input to the channel B amplifier.

NOTE: Channel A sweeps will also be triggered (if channel A is turned on) when valid triggers are input to the channel B amplifier (even if channel B is turned off).

THE COUPLING BUTTON

Determines whether or not dc components will be attenuated at the EXT input BNC.

AC - Signals are capacitively coupled to the trigger detection circuit. DC components and frequencies of approximately 2 hertz (or less) are attenuated while ac components pass when the input impedance of 1 megohm is selected only. (Frequencies of approximately 1 KHz are attenuated when the 50 ohm input impedance is selected.)

DC - Both ac and dc components are coupled to the trigger detection circuit.

L REJ - Rejects frequencies less than 10 KHz.

H REJ - Rejects frequencies greater than 10 MHz.

Coupling Selections

The following coupling selections can be made.

1. AC
2. AC, LF
3. AC, HF
4. AC, LF, HF
5. DC
6. DC, HF

THE TRIGGER BUTTON

Selects whether sweeps will be triggered automatically in the absence of a valid triggers (AUTO) or solely by an external source (NORM). The Trigger button also selects the trigger (VIEW) mode which forces Auto triggering.

AUTO - Sweeps are automatically triggered in the absence of a valid trigger.

NORM - Sweeps are triggered by valid triggers only.

VIEW - Used to select specific triggering characteristics.

NOTE: The plug-in must be in the Hold Last mode to turn View on or off.

➤ **IMPORTANT:** Data displayed on the screen when the View Mode is turned on will be lost. If the data is important, record the data on a diskette or place the mainframe's MEMORY switch to an unimportant "half" or "quarter" position.

In addition, the View Mode overrides the save reference and the trigger delay functions. However, the trigger delays will return when the scope exits the View mode.

The View display consists of two horizontal lines, a Trigger cursor at screen center, and a letter "V" suffix added to the Plug-in/Channel identifier (e.g., 1AV). If external triggering is selected, the Channel identifier is replaced with an "E", (e.g., 1EV).

The two lines (upper & lower threshold) are used to set the requirements that must be met to qualify the signal as a valid trigger.

a. Slope (page 8-31),
b. Minimum amplitude (page 8-32),
c. Minimum voltage change (page 8-33).

All three requirements must be met by the signal before a sweep can be triggered.

To select the VIEW mode:

#1. Place the plug-in into the Hold mode (Live LED off, Hold Last LED on).

#2. Protect important data stored in the display memory.

#3. VIEW mode: On

#4. Press the Live button.

EXAMPLE #8-7

Figure 8-24: Typical VIEW display with "positive" slope selected.

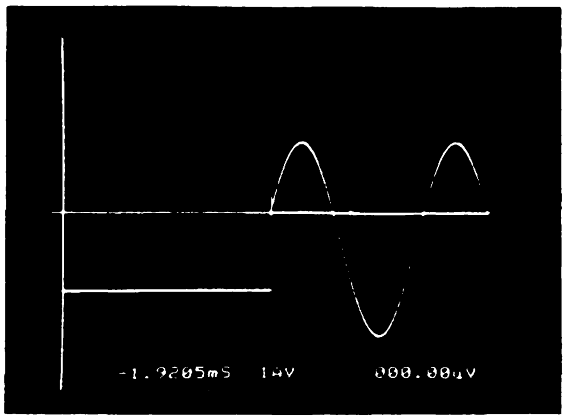


Figure 8-24

THE SLOPE BUTTON

NOTE: See IMPORTANT note on page 8-29 before selecting the VIEW mode.

Determines whether positive and/or negative going voltage transitions will qualify the signal as a valid trigger.

(+) - The signal's voltage must be increasing to qualify.

DUAL - Either increasing or decreasing voltage values qualify.

(-) - The signal's voltage must be decreasing to qualify.

EXAMPLE #8-8

Figure 8-25: A (+) slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-26: A (-) slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-27: A DUAL slope display. The signal qualifies as a valid trigger at either (T1) or (T2).

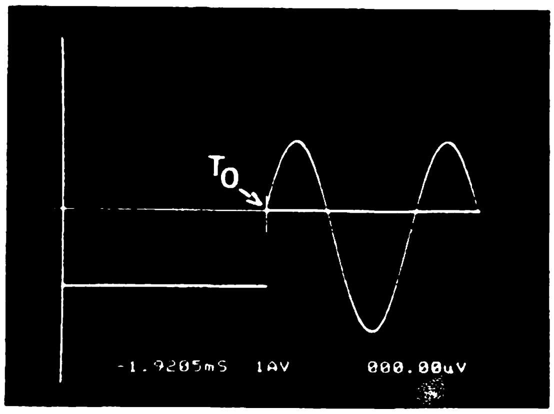


Figure 8-25

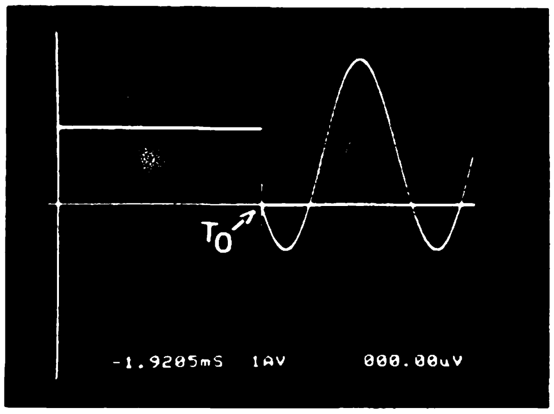


Figure 8-26

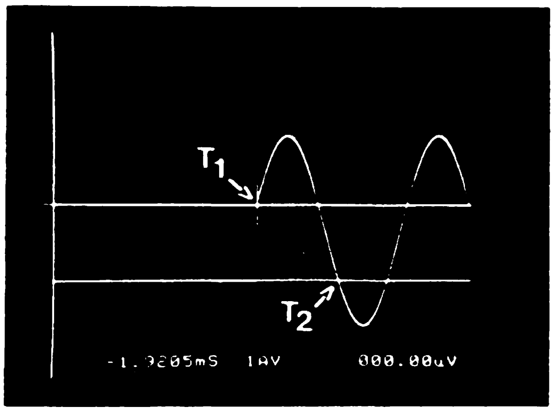


Figure 8-27

THE LEVEL BUTTONS

NOTE: See IMPORTANT note on page 8-29 before turning on the VIEW mode.

The Level control adjusts the threshold level that must be crossed by the signal to qualify it as a trigger. Pressing both buttons simultaneously sets the level to "0" volts. Holding the Level button in "runs" the level in the direction of the arrow. Tapping the button "steps" the level.

(+) - The signal must cross the lower to upper threshold levels to qualify.

(-) - The signal must cross the upper to lower threshold level to qualify.

DUAL - The signal can cross either threshold level to qualify.

EXAMPLE #8-9

Figure 8-28: A (+) slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-29: A (-) slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-30: A DUAL slope display. The signal qualifies as a trigger at either point (T1) or (T2).

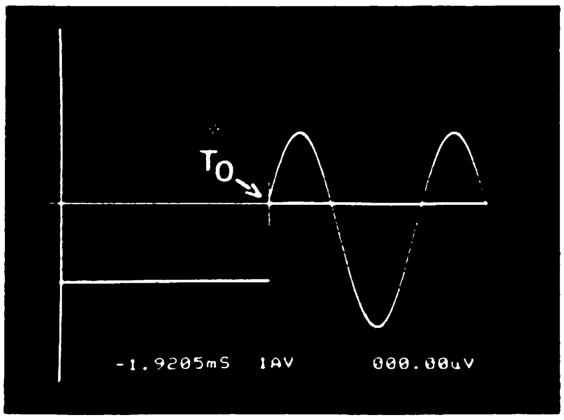


Figure 8-28

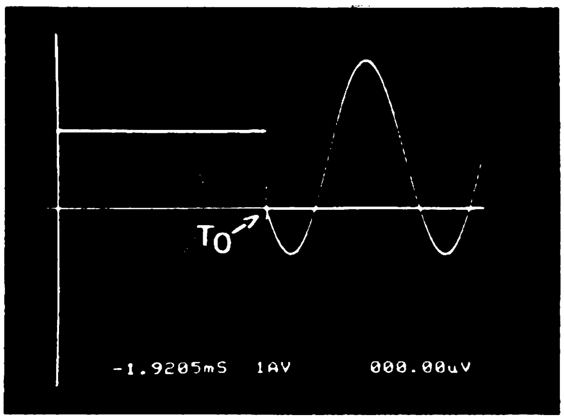


Figure 8-29

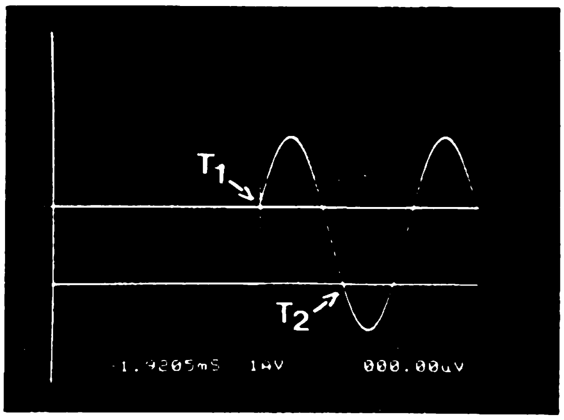


Figure 8-30

THE SENSITIVITY BUTTONS

NOTE: See IMPORTANT note on page 8-29 before turning on the VIEW mode.

Adjusts the window (distance between the two threshold levels) that must must be crossed by the signal to qualify it as a valid trigger when either (+) or (-) slope triggering is selected.

(▲▼): Widens the window.

(▼▲): Narrows the window.

NOTE: Maximum sensitivity is selected by pressing both buttons simult-aneously.

Holding the Sensitivity button in "runs" the window's gap in the direction of the arrows. Tapping the button "steps" the window's gap.

The "window" voltage can be adjusted from a range of 40 millivolts to 10 volts when triggering via the EXT input BNC, and from 2% to 98% of the Volts Full Scale when triggering via the channel A or B amplifiers. The (▲▼) button increases the "window" and the (▼▲) button decreases the window.

To inspect the upper and lower level voltage values, turn Autocenter on and press the left/right cursor buttons.

EXAMPLE #8-10

Figure 8-31: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.

Figure 8-32: The dashed line on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger.

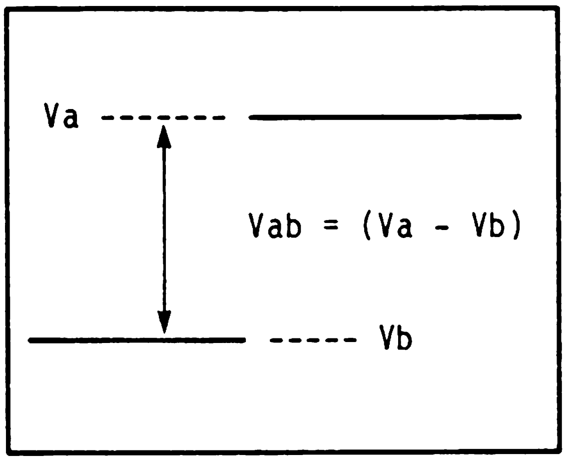


Figure 8-31

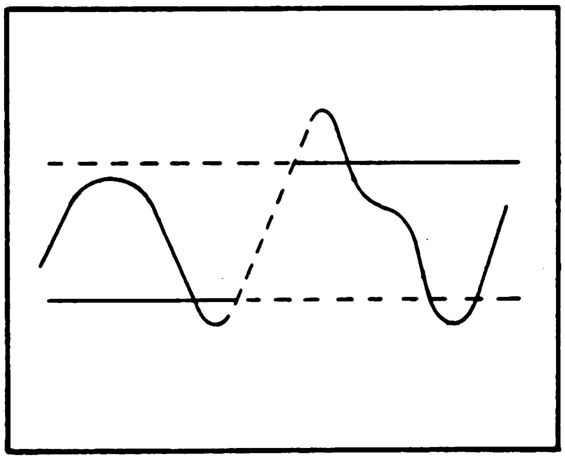


Figure 8-32

RECURRENT TRIGGERING

(+) or (-) SLOPE TRIGGERING

After the first sweep has been triggered, the signal's slope must reverse, pass through the "window," reverse again, and then pass through the "window" once more to trigger another sweep.

EXAMPLE #8-11

Assume that (+) Slope triggering is selected and the VIEW mode is on.

Figure 8-33: The first positive slope (solid line) starts below the lower threshold level, passes through the "window," and initiates a trigger at point (T1). The dashed lines represent the path that the signal must follow to initiate a second trigger at point (T2).

Figure 8-34: Once again the signal qualifies as a trigger at point (T1). However, a trigger will not occur at point (A) because the second positive slope did not start below the lower threshold. A trigger will occur at point (T2) because the third positive slope began below the lower threshold.

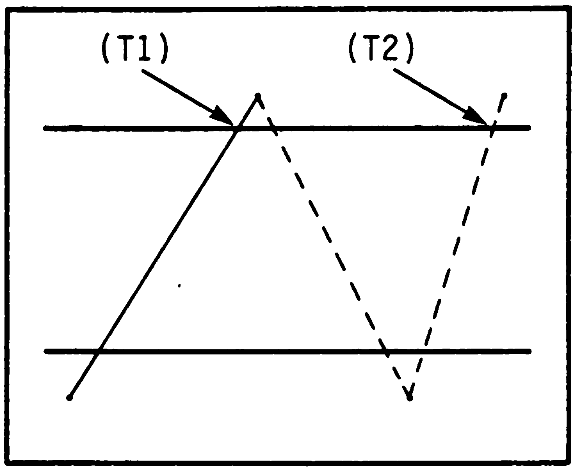


Figure 8-33

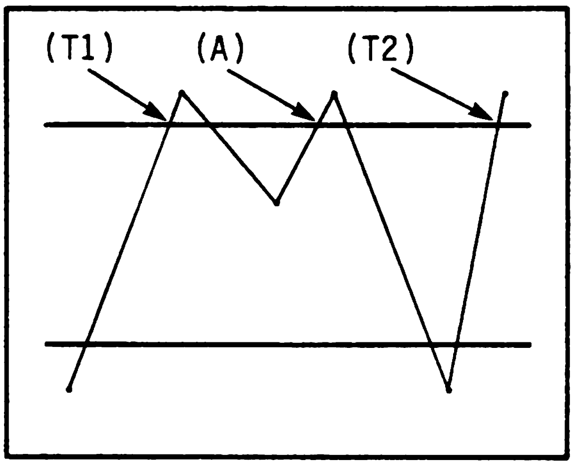


Figure 8-34

DUAL SLOPE TRIGGERING

Recurrent triggers qualify each time the signal crosses either threshold level with the proper slope. The signal must cross the lower level with a negative slope and the upper level with a positive slope to qualify as a valid trigger. The signal does not have to recross through the entire "window."

NOTE: A minimum voltage change of 2% of the selected Volts Full scale range must occur to qualify the signal as a valid trigger.

EXAMPLE #8-12

Assume that DUAL Slope triggering is selected and the VIEW mode is on.

Figure 8-35: Valid triggers occur at points (T1 through T4) each time the signal crosses the threshold levels.

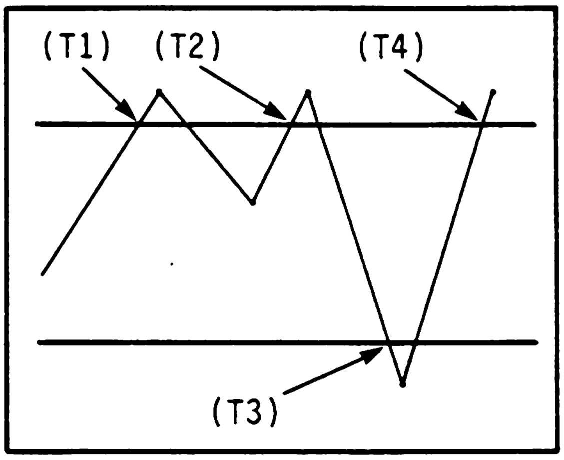


Figure 8-35

ADJUSTING THE TRIGGER

(+) or (-) SLOPE TRIGGERING

#1. SLOPE: (+) or (-)

#2. COUPLING: As required.

#3. AUTO/NORM/VIEW: Auto-View or Normal-View

#4. Trigger signal: Input the signal to the External input BNC or to one of the channels.

#5. SOURCE: Select Internal or External triggering as required.

#6. DC/AC: As required.

#7. LIVE: Press.

#8. POSITION: Adjust the trace for the best placement on the screen.

#9. VOLTS FULL SCALE: As required.

#10. SENSITIVITY: Press both Sensitivity buttons to close the sensitivity window. Then press the "right" Sensitivity button until the "window" exceeds any "noise" spikes present.

#11. LEVEL: Adjust until the upper threshold (+ slope) or lower threshold (- slope) intersects the desired trigger point.

#12. Fine tune the Sensitivity and Level controls as required.

#13. After the Sensitivity and Level have been properly adjusted, select normal (NORM) triggering.

a. The plug-in continues to trigger.

NOTE: The Trigger button illuminates throughout each sweep.

DUAL SLOPE TRIGGERING

#1. SLOPE: Dual

#2. COUPLING: As required.

#3. AUTO/NORM/VIEW: Auto-View or Normal-View.

#4. Trigger signal: Apply the trigger to the External input BNC or to one of the channels-input BNCs.

#5. SOURCE: Select Internal or External triggering as required.

#6. DC/AC: As required.

#7. LIVE: Press.

#8. POSITION: Adjust the trace for the best placement on the screen.

#9. VOLTS FULL SCALE: As required.

#10. SENSITIVITY: Press both Sensitivity buttons to close the sensitivity window.

#11. LEVEL: Position the "window" until it is centered between the desired positive and negative trigger points.

#12. SENSITIVITY: Position the upper and lower threshold levels to intersect the desired positive and negative trigger points.

#13. Fine tune the Level and Sensitivity as required.

#14. After the Sensitivity and Level have been properly adjusted, select normal (NORM) triggering.

a. The plug-in continues to trigger.

NOTE: The Trigger button illuminates throughout each sweep.

THE DELAY BUTTONS

The Delay buttons are used to select post-trigger (Normal), pre-trigger and post-trigger (Cursor), or delayed trigger (Delayed) displays. The display modes can be mixed or matched during multiple channel operation. See Special Procedures, tab 15.

► **IMPORTANT:** Turn the mainframe FUNCTION switch away from RESET NUM when using the Delay buttons.

LIVE MODE (Coarse Adjust)
The trigger cursor moves 1/16th of full screen at the end of each sweep when a DELAY button is pressed during live, single channel operation, (1/8th full screen for live, dual channel operation).

LIVE MODE (High Speed Adjust)
To move the trigger cursor at a high rate, hold the LIVE button in while pressing the DELAY button.

SET-UP MODE (Fine Adjust)
To enter the Set-up mode, place the plug-in into Hold Last (Live LED off), press and hold in the HOLD LAST button and press the HOLD NEXT button. (Hold Last must be pressed first.)

NOTE: The trigger's rate of movement increases the longer a DELAY button is pressed. Release and then press the Delay button to return to a slower rate of movement. The letter "S" suffix is added to the Plug-in/Channel identifier (e.g., 1AS) when the Set-up mode is selected.

► **IMPORTANT:** Operating the DELAY buttons in the Set-up mode (while important data is stored) causes erroneous time numerics due to the altered T=0 origin. The Set-up mode is exited by pressing either the HOLD LAST or LIVE button. However, the time numerics will remain erroneous until a new sweep is triggered.

EXAMPLE #8-13
Figure 8-36: The three types of trigger displays and related sweeps.

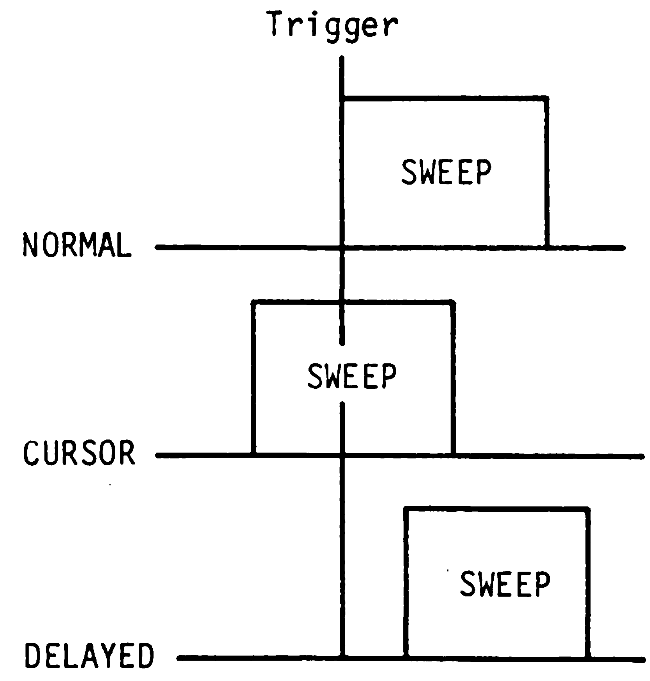


Figure 8-36

THE NORMAL TRIGGER DISPLAY

The trigger time (T=0) is located at the far left side of the screen. Only post-trigger events occurring after a valid trigger are displayed on the screen.

Resetting to Normal Trigger Displays

To reset the plug-in to the Normal display while in the "Set-up" mode, press the channel's (◀) and (▶) DELAY buttons at the same time.

NOTE: If the plug-in is in the LIVE mode and no triggers are occurring, or a long sweep (or delay) has been selected, the channel can be quickly reset to the Normal mode by holding in both the (◀) and (▶) DELAY buttons while tapping LIVE.

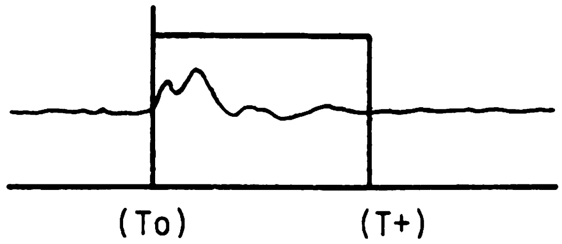


Figure 8-37

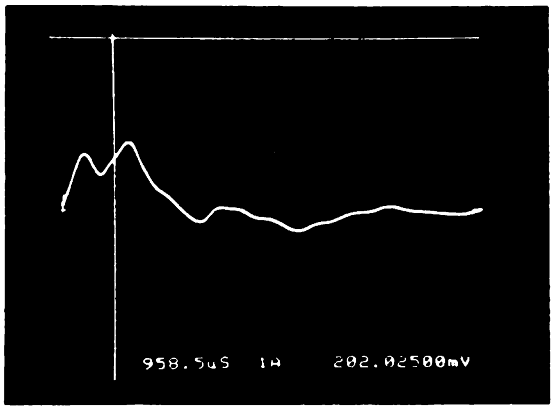


Figure 8-38

EXAMPLE #8-14

Figure 8-37: A single sweep is triggered at point (To) and ends at point (T+).

Figure 8-38: The corresponding Normal trigger display of the captured signal.

CURSOR TRIGGER DISPLAY

To select the Cursor Trigger mode, place the plug-in into the "Set-up" mode (page 8-38) and press the channel's (▶) DELAY button.

The cursor (trigger) moves towards screen right while the (▶) Delay button is pressed. Pre-trigger events are displayed to the left of the cursor and post-trigger events to its right.

NOTE: If the plug-in is in a slow sweep or the sampling mode, a Cursor Trigger display can be quickly set by pressing the Live button while holding in the (▶) or (▶) DELAY buttons.

EXAMPLE #8-15

Figure 8-39: A single sweep starts at point (T-) and ends at (T+). The trigger (To) "locks" the pre-trigger data in memory while the remaining addresses record post-trigger data.

Figure 8-40: The corresponding Cursor trigger display of the captured signal.

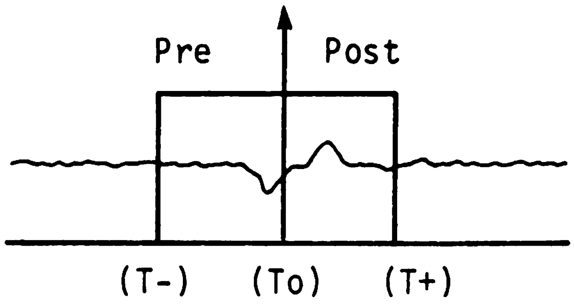


Figure 8-39

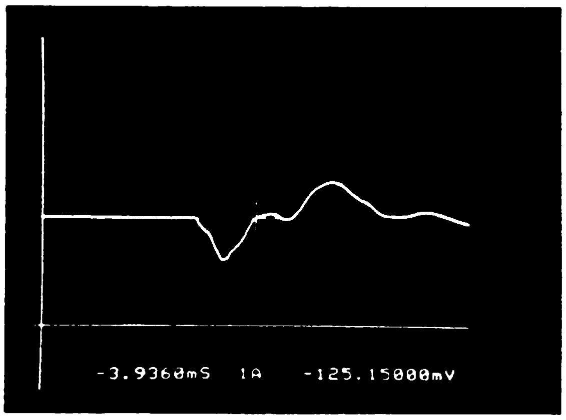


Figure 8-40

DELAYED TRIGGER DISPLAY

NOTE: Move the mainframe vertical cursor to the extreme left-hand side of the screen before turning on the Delayed Trigger mode.

To select the Delayed Trigger mode, place the plug-in into the "Set-up" mode (page 8-38) and press the channel's (◀) DELAY button.

The vertical cursor (trigger) moves off of screen left while the (◀) Delay button is pressed. The left numerics displays the time delay between the plug-in's trigger cursor and the mainframe's vertical cursor. The mainframe's vertical cursor can be moved after the delay has been set to inspect specific data point coordinates.

NOTE: A long delay can be quickly cleared by holding in the channel's (◀) and (▶) DELAY buttons while tapping the Live button. If the plug-in is in a slow sweep or the sampling mode, a delay can be quickly set by pressing the Live button while holding in the channel's (◀) DELAY button.

Equation 8-6 approximates the maximum time delay (Tmax) that can be selected.

$$\boxed{\text{Tmax} = \frac{2^{22} \times (\text{TPP})}{(\text{Channels}) \times (\text{Memory})}}$$

Equation 8-6

(TPP): Time-per-point selection.

(Channels): The number of channels turned on.

(Memory): The position selected on the MEMORY switch:
ALL = 1
Halves = 2
Quarters = 4

EXAMPLE #8-16

Figure 8-41: A valid trigger at point (To) initiates the time delay. After the delay has passed (To - T+), data is captured between times (T+ - T++).

Figure 8-42: The corresponding Delayed trigger display of the signal captured during the sweep.

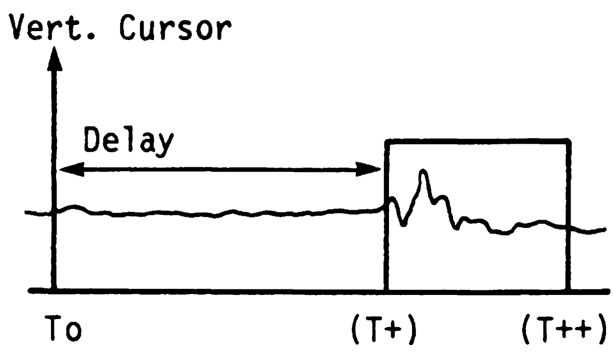


Figure 8-41

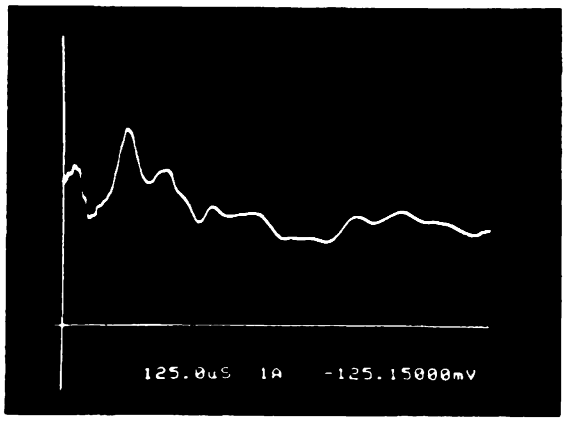


Figure 8-42

THE REMOTE CONTROL CONNECTOR

The remote control connector allows certain functions of the plug-in to be controlled from a remote station. Figure 8-43 identifies the function of each pin.

HOLD LAST, LIVE and HOLD NEXT
The functions of the Storage Control buttons can be simulated by shorting the proper pins to ground through a low resistance output, or with an open collector TTL gate.

NOTE: Use the ground on Pin 9 of the Remote Control Connector.

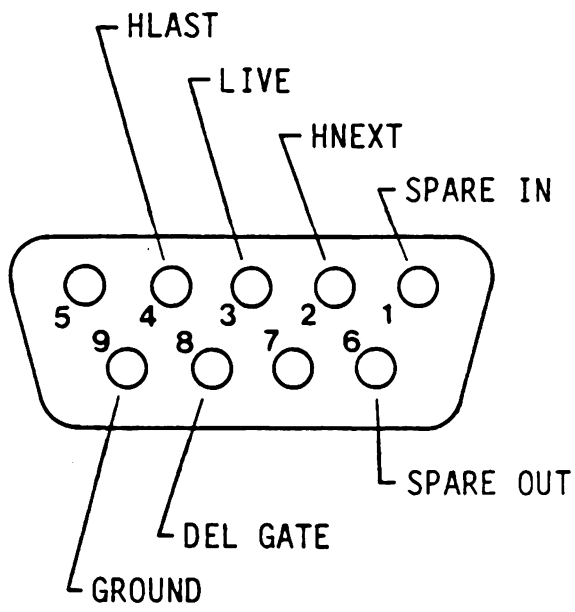


Figure 8-43

DEL GATE

The Delayed Gate output activates when either channel receives a valid trigger.

The output normally rests at 0.4 VDC and rises to +3 VDC when a valid trigger occurs. It returns to 0.4 VDC when the sweep ends.

Figure 8-44 illustrates the three types of triggers and corresponding sweeps and Delayed Gate outputs.

SPARE IN & SPARE OUT

Not currently being used.

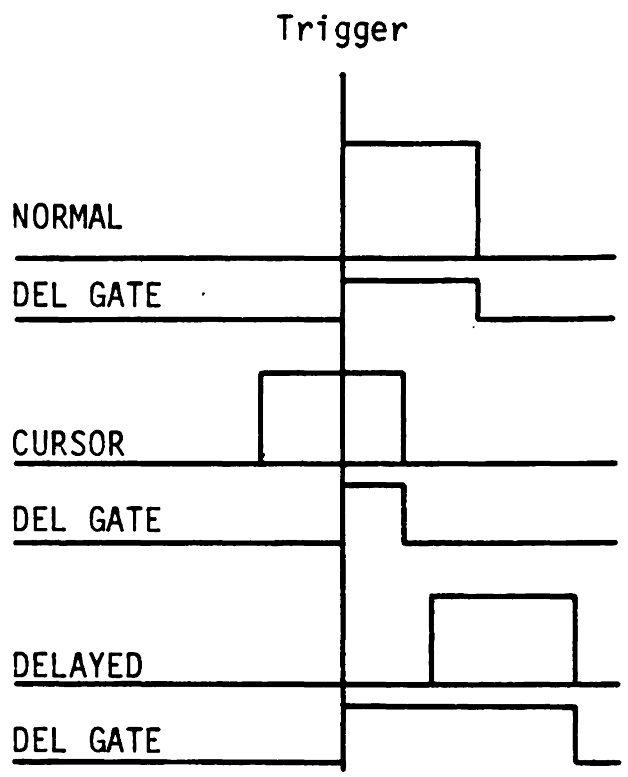


Figure 8-44

ADDRESS ADVANCE CONNECTOR

The Address Advance connector accepts the signal to advance the memory to its next address when the Time Per Point is set to either EXTERNAL I or EXTERNAL II.

The Address Advance signal should normally rest at less than 0.4 VDC and raise to more than 3 VDC each time the memory is to advance on address.

NOTE: Data collection begins on the third (3rd) EP Pulse following a valid trigger. In addition, data is collected and displayed in groups of four (4) data points at a time.

The Address Advance input is factory set to be TTL compatible.

However, the 4175 trigger board may be jumpered to convert it to ECL. Contact your local service representative, or contact the factory for instructions:

Nicolet Instrument Corporation
Oscilloscope Division, Service Dept.
Madison, Wisconsin 53711
Telephone (608) 273-5010

PROBE POWER CONNECTOR

The Probe Power connector furnishes +15, -15, and +5 Vdc output voltages (maximum current = 100 ma).

Figure 8-45 identifies the connector's voltage polarities and ground.

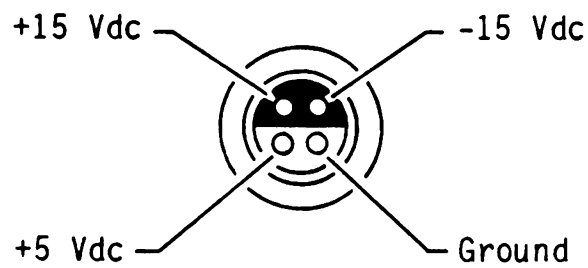


Figure 8-45

COMPENSATION POINT

A square wave signal appears on the screen when the test probe is touched to the Compensation Point. The square wave can be used to compensate the optional X10 and X100 test probes.

Compensate the test probes for the best response time (rise and fall times) on the square wave display.

➤ **IMPORTANT:** Set the Time Per Point to 2 microseconds.

EXAMPLE #8-17

Figure 8-46 illustrates an expanded square wave display.

The top square wave was produced from an uncompensated probe. The bottom square wave was produced with a properly compensated test probe.

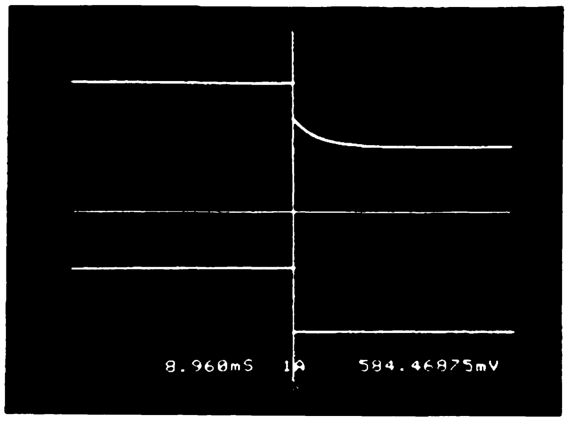
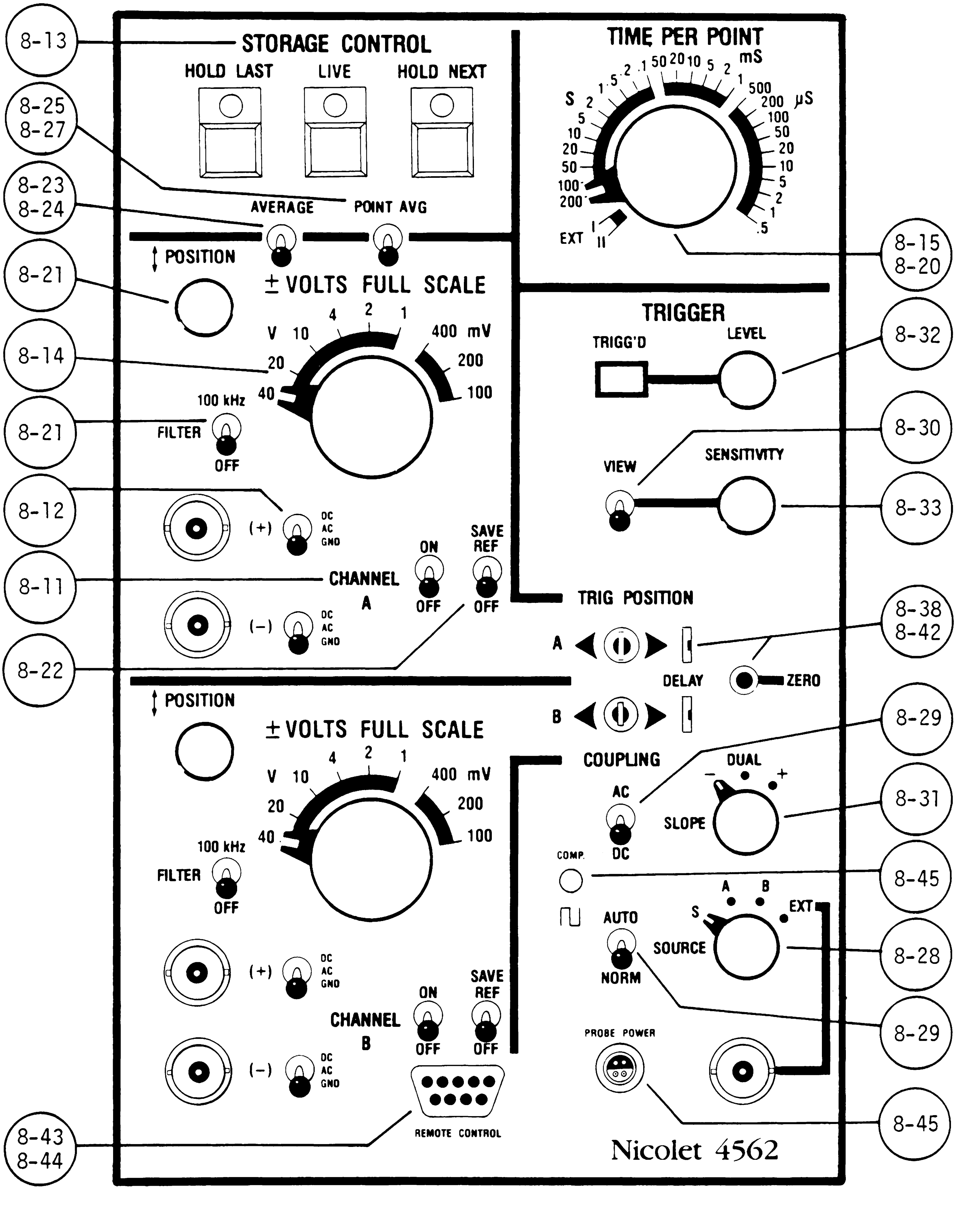


Figure 8-46

Model 4562 Plug-in



INTRODUCTION

The Model 4562, two channel Plug-in includes two high impedance, differential amplifiers; two 12-bit, 500 nanosecond digitizers; and a single 16K word memory.

Other features include -

- Single-ended or differential amplifiers.
- Positive, negative, or dual slope triggering.
- Normal, Pre- and Post-trigger, and Delayed trigger displays.
- A Trigger View mode to assist in the selection of the trigger's qualifying characteristics.
- Sweep Averaging, Point Averaging, and 100 kHz Filter to reduce the effects of "noise" on the signals.
- A Save Reference mode to compare "live" and saved signals.
- Remote control abilities.
- Test point compensation.
- A ±12 VDC probe power output.

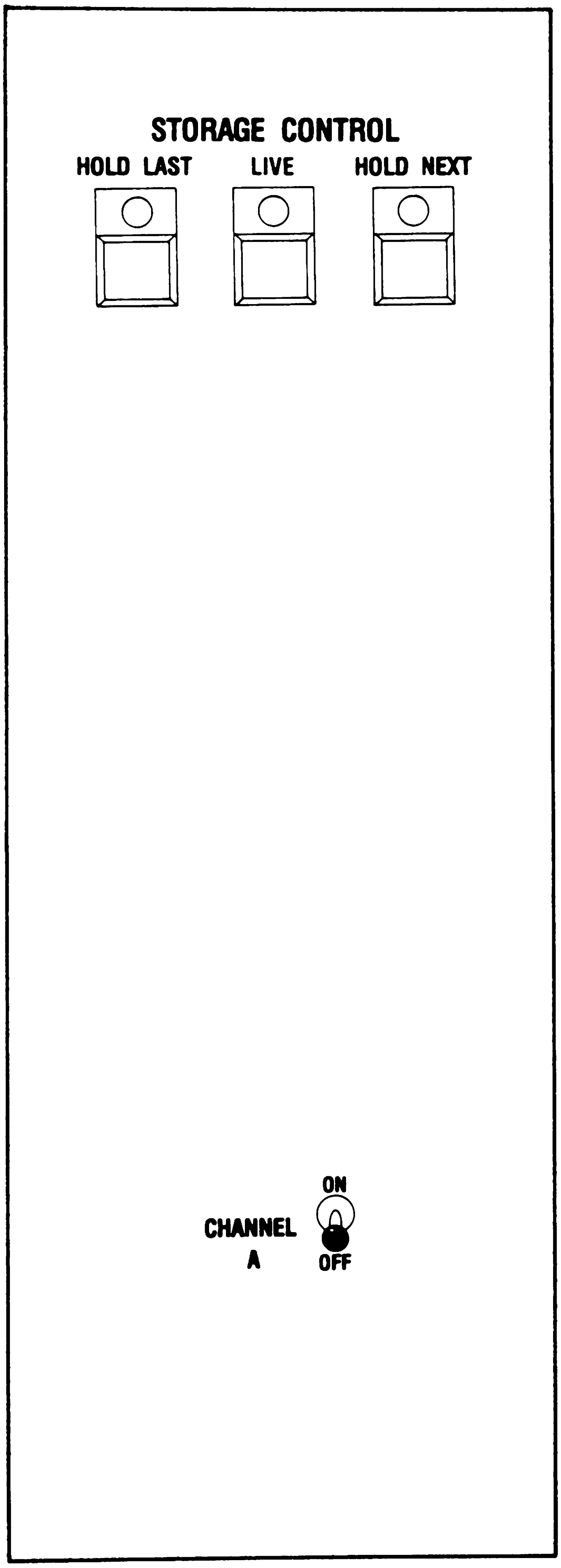
►IMPORTANT: The term "Hold mode," in the following discussions, signifies that the Plug-in's HOLD LAST LED is illuminated only. The Live and Hold Next LEDs are turned off.

The Plug-in should be in the Hold mode whenever a Plug-in parameter is changed. Otherwise, the operator must either press the LIVE button to reset the Plug-in, or wait until after the next sweep is completed before the 4094 will acknowledge the parameter change(s).

The Plug-in is in the Hold mode when only the Hold Last LED is illuminated. If a sweep is not in progress, the Hold mode can be selected by pressing the HOLD LAST button. If, however, a sweep is currently in progress, the Hold mode can be selected by:

#1. HOLD LAST button: Press and hold.
#2. LIVE button: Press momentarily.
#3. HOLD LAST button: Release.

NOTE: The following descriptions are for single Plug-in operation only. Refer to the *Multiple Plug-ins* tab, after reading this section of the manual, for additional information.



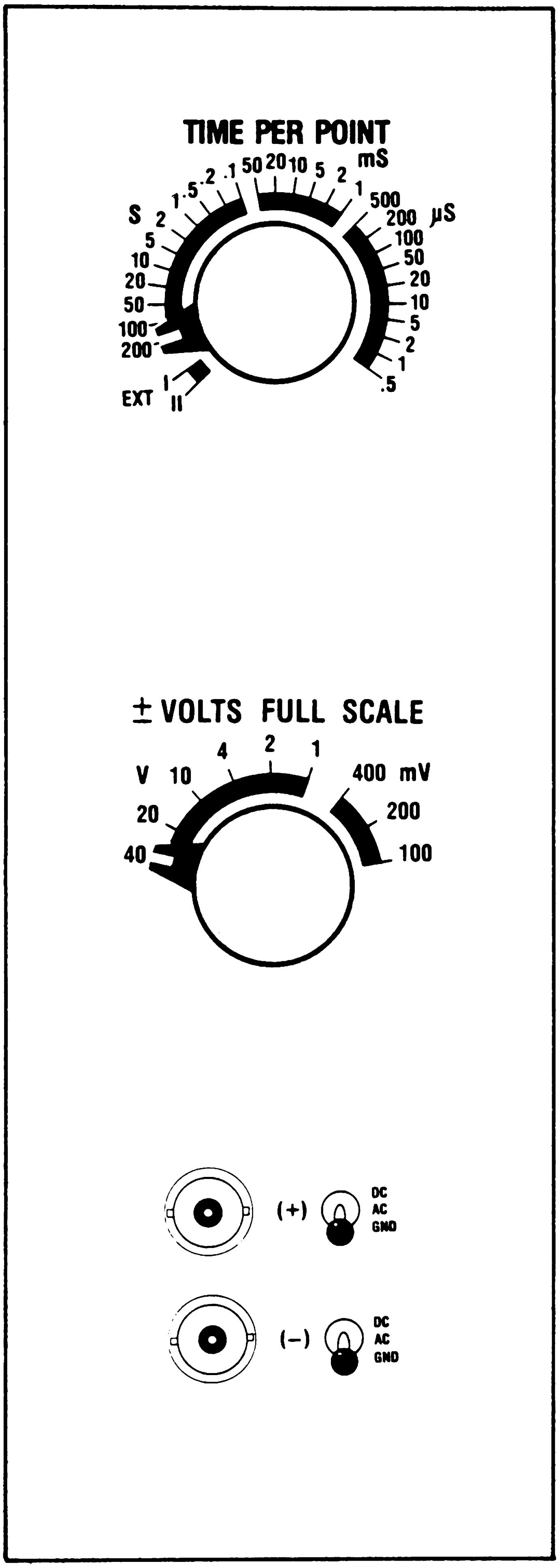
STORAGE CONTROL BUTTONS

The Storage Control buttons determine whether the displayed data groups will remain "live" or be stored in the display memory.

- LIVE - New signals are acquired and displayed on the screen each time a valid trigger is received.
- HOLD NEXT - The signal following the next valid trigger is stored in the display memory and displayed on the screen.
- HOLD LAST - The signal that followed the last valid trigger is stored in the display memory and displayed on the screen; including a signal already in progress at the moment the button is pressed.

CHANNEL SWITCH

The "ON" position allows the display memory to record data acquired by the associated channel and display it on the screen.



TIME PER POINT

Selects the time resolution of the signal to be acquired.

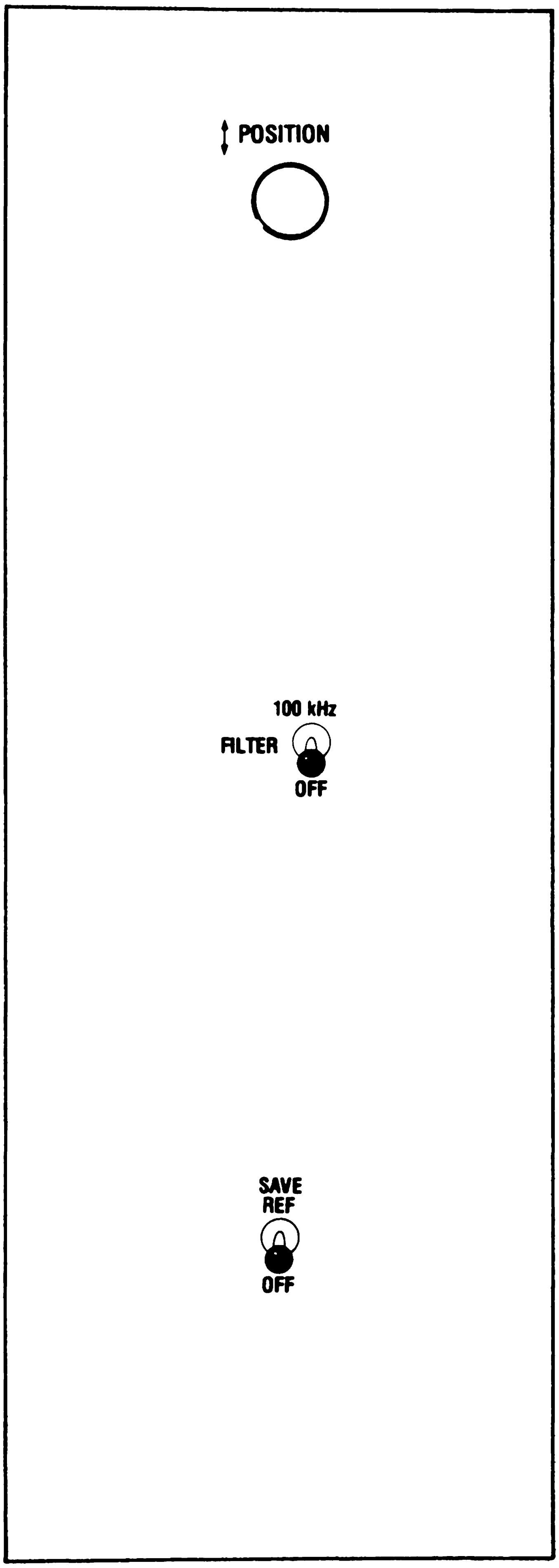
Sweep speeds are expressed as time-per-point rather than time-per-centimeter.

± VOLTS FULL SCALE SWITCH

Allows the oscilloscope to accept input signals ranging from ±100 millivolts to ±40 volts full scale.

DC/AC/GND SWITCH

- GND - Grounds the amplifier's input.
- DC - Allows both ac and dc signal components to enter the amplifier.
- AC - Blocks the dc component. Allows only the ac component to enter the amplifier.



POSITION CONTROL

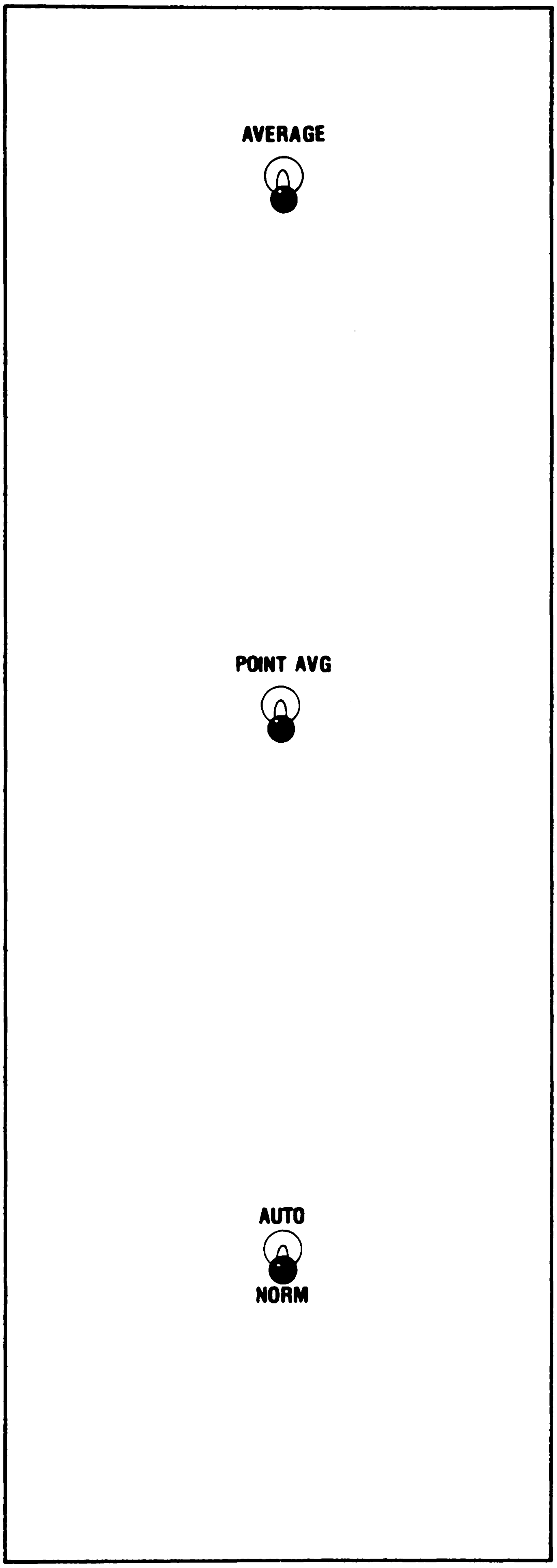
Vertically positions the displayed signal on the screen.

FILTER SWITCH

Filters high frequency "noise" components to ground. Used with low frequency input signals.

SAVE REFERENCE SWITCH

Allows the operator to compare "live" and saved signals in the Live mode.



AVERAGE SWITCH

Reduces "noise" on recurrent signals by averaging (from sweep to sweep) sampled voltages acquired equidistant with respect to each trigger, (T=0).

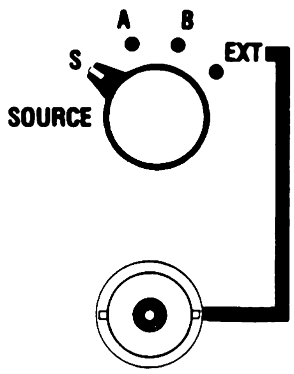
POINT AVERAGE SWITCH

Reduces "noise" on single sweep input signals when the time-per-point is greater than 500 µS by averaging the input signal at a constant sampling rate of 250 µS/point between each displayed data point.

AUTO/NORM SWITCH

Determines whether the trigger will be generated internally in the absence of a valid trigger signal or by an external input signal.

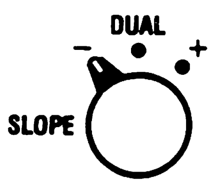
- AUTO - Internally triggered.
- NORM - Externally triggered.



TRIGGER SOURCE SWITCH

Selects the source of the input trigger signal.

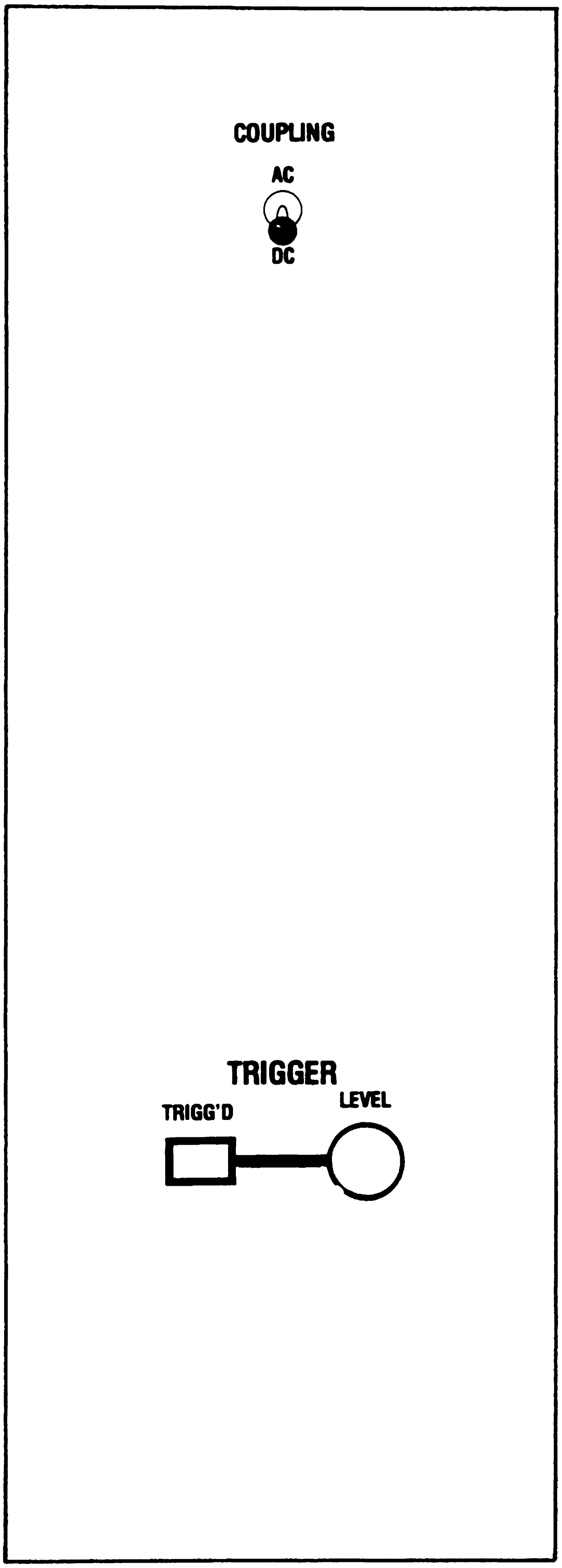
- (S) - "Slave," trigger comes from the "master" Plug-in when multiple Plug-ins are being triggered from a common source. The "master" Plug-in's switch must be in the (A), (B), or (EXT) positions. The "slave" Plug-in(s) must be in the (S) position.
- (A) - Trigger signal is derived from channel A.
- (B) - Trigger signal is derived from channel B.
- EXT - Trigger signal is derived from the EXT input BNC.



TRIGGER SLOPE SWITCH

Selects the signal's voltage transitions that will qualify it as a valid trigger.

- (+) - Positive-going only.
- (-) - Negative-going only.
- DUAL - Either positive- or negative-going voltage transitions.



TRIGGER COUPLING SWITCH

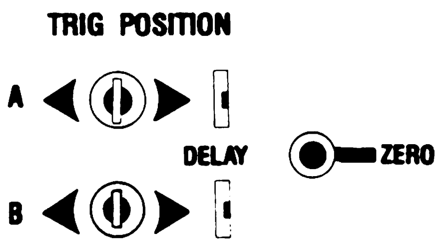
Determines whether or not the dc component of the input signal will be blocked.

- AC - Only the ac component of the signal is applied to the trigger circuit. The dc component is blocked.
- DC - All frequency components of the input signal are applied to the trigger circuit. Used when low frequency input signals are to be inspected or the dc component is of importance.

TRIGGER LEVEL CONTROL & TRIGG'D LED

Adjusts the voltage level that must be crossed by the triggering signal to qualify as a valid trigger.

The green LED indicator illuminates each time a valid trigger initiates a sweep.

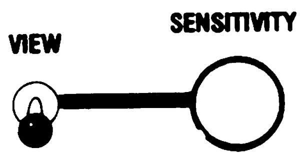


TRIGGER POSITION CONTROLS

Selects whether the screen will display post-trigger events (Normal Trigger), both pre- and post-trigger events (Cursor Trigger), or events that occurred following a specific time delay (Delayed Trigger).

- Normal Trigger - Press the Zero button.
- Cursor Trigger - Press the paddle switch to the right.
- Delayed Trigger - Press the paddle switch to the left.

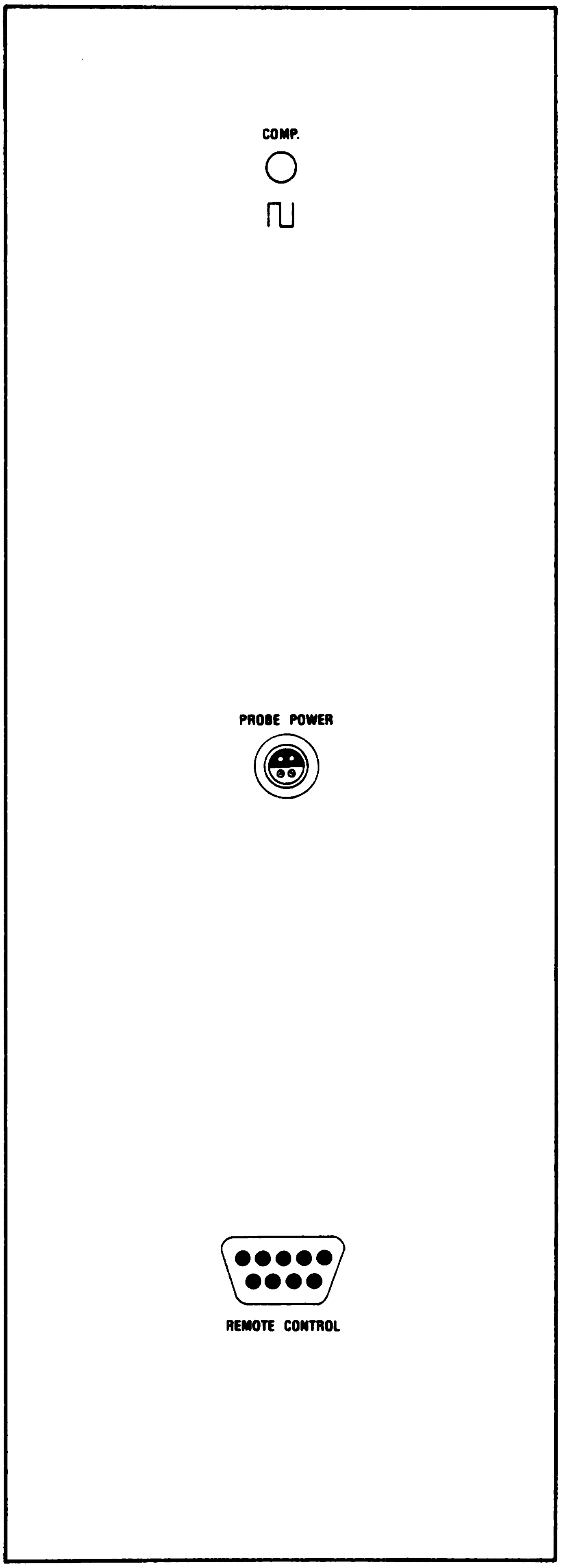
The adjacent LED indicator(s) illuminate when either Cursor or Delayed Trigger modes are selected.



TRIGGER SENSITIVITY & VIEW CONTROLS

The Trigger SENSITIVITY control adjusts the "window" (voltage span) that the signal must pass through before it will qualify as a valid trigger.

The VIEW switch, when turned on, introduces a "trigger adjust" display. This display assists the operator in the selection of specific characteristics that will qualify the signal as a valid trigger.



COMPENSATION POINT

Placing the test probe against the compensation point produces a square-wave display. This display assists the operator in the compensation of the test probe for the best response times.

PROBE POWER CONNECTOR

Provides a +12 and/or -12 VDC output.

REMOTE CONTROL CONNECTOR

Permits remote control of the Plug-in.

CHANNEL SWITCHES

The display memory will not store data unless the ON/OFF switch associated with the channel acquiring data is placed to the "ON" position.

For example, the CHANNEL A switch must be in the "ON" position if channel A is acquiring input signals.

If only one channel (typically channel A) is being used to acquire input signals, turn the unused channel off. This allows the entire display memory of 15,872 addresses to record data if the Mainframe's MEMORY switch is in the "ALL" position.

The number of addresses that will record each input signal depends upon the positions of the CHANNEL and MEMORY switches. Table 8-1 tabulates the number of addresses that will record each input signal.

NOTE: Table 8-1 is for single Plug-in operation only.

CHANNEL SWITCH		MEMORY SWITCH POSITION		
A	B	ALL	HALVES	QUARTERS
ON	OFF	15,872	7,936	3,968
OFF	ON	15,872	7,936	3,968
ON	ON	7,936	3,968	1,984

Table 8-1

DC/AC/GND SWITCHES

This instrument uses high impedance, differential amplifiers. The high impedances (10^6 ohms) and low bias currents (10^{-10} amps) allow high impedance signal sources to be measured because of the light loading effect of the amplifiers.

The DC/AC/GND switches control the operation of the associated amplifiers' inputs.

> CAUTION - Always ensure that the input signals never exceed the maximum, allowable input voltage, with respect to ground, listed under tab *Specifications*.

- DC
  Allows both ac and dc components of the input signal to enter the amplifier.
- AC
  Blocks the dc component. Only the ac component of the signal enters the amplifier.
- GND
  Grounds the amplifier's input. Neither ac nor dc components will enter the amplifier.

NOTE: Always ground an unused amplifier input by placing the associated DC/AC/GND switch to the "GND" position. An ungrounded, unused input will introduce "noise."

Each of the amplifiers can be used as either Differential or Single-ended amplifiers.

- DIFFERENTIAL AMPLIFIERS

Placing the channel's DC/AC/GND switches to either the "DC" or "AC" position allows the amplifier to measure the difference between the voltages applied to the (+) and (-) input BNCs.

- SINGLE-END AMPLIFIERS

Placing one of the channel's DC/AC/GND switches to "GND" and the remaining switch to either "DC" or "AC" allows the oscilloscope to display the voltages applied to the active input.

STORAGE CONTROL BUTTONS

The Storage Control consists of three buttons: LIVE, HOLD NEXT and HOLD LAST.

These buttons determine whether or not data stored in the display memory will be replaced when a valid trigger is received.

● LIVE

Pressing the LIVE button erases the displayed data from the screen, readying it for the next display.

It also serves as a "master reset," enabling the Plug-in to determine whether or not any of the controls have been altered since the last signal acquisition.

➤IMPORTANT: Changes made to the Plug-in's controls, while the LIVE LED is illuminated, will NOT be acknowledged until either the operator presses the LIVE button or the next sweep is completed.

● HOLD NEXT

The Live mode must be activated before the HOLD NEXT button is pressed.

The stored data is replaced when the next valid trigger is received. The Plug-in enters the Hold mode as soon as the sweep is completed.

● HOLD LAST

Pressing the HOLD LAST button allows a sweep currently in progress to be completed and then inhibits any further sweeps.

Data stored in the display memory is protected when only the Hold Last LED is illuminated, (Hold mode).

NOTE: If data stored in portions of the memory is to be saved, ensure that the Live LED is off before repositioning the Mainframe's MEMORY switch. Otherwise, data will be replaced if a valid trigger is received.

●●Hold Mode

The Plug-in should be in the Hold mode (only the Hold Last LED is illuminated) whenever a Plug-in parameter is changed. See IMPORTANT note on Page 8-1.

● REMOTE CONTROL

Refer to Page 8-43, *Remote Control Connector* descriptions.

±VOLTS FULL SCALE SWITCH

Allows signals ranging from ±100 millivolts to ±40 volts full scale to be measured when the X1 probe is used.

A maximum of ±400 volts full scale can be measured when the optional X10 probe is used.

The voltage numerics are directly related to the measured voltages when either the X1 or special X10 probe is used. Refer to tab *Accessories* for information on the special X10 probe.

The screen can display up to 4096 voltage levels when the VERTICAL EXPANSION switch is turned off.

If the zero volts reference is vertically centered on the screen, the positive voltages will be displayed above the zero volts level by up to 2047 levels. Negative voltages will be displayed below the zero volts level by up to 2048 levels. Refer to Figure 8-1.

Table 8-2 tabulates the voltage increment of each level (volts per level) according to the position selected on the ±VOLTS FULL SCALE switch.

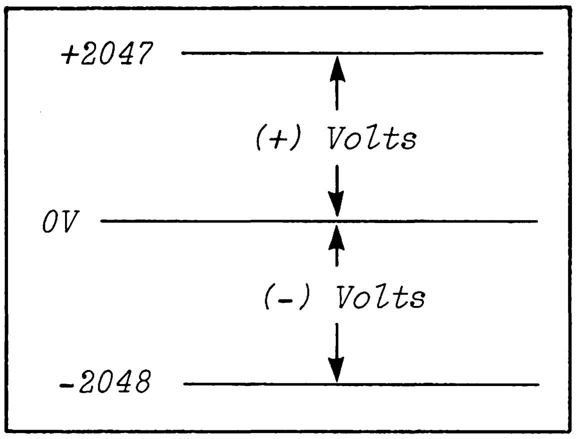


Figure 8-1

± V.F.S.	VOLTS PER LEVEL
100 mV	*50 µV*
200 mV	*100 µV*
400 mV	*200 µV*
1 V	*500 µV*
2 V	*1 mV*
4 V	*2 mV*
10 V	*5 mV*
20 V	*10 mV*
40 V	*20 mV*

Table 8-2

TIME PER POINT SWITCH

Determines the time resolution of the displayed signal. The faster the time-per-point when the signal is acquired, the higher the time resolution.

The Plug-in samples and digitizes the input signal's voltages once every 500 nanoseconds. This sampling rate is preset within the oscilloscope's circuitry. However, which of the sampled voltages will be selected for display is determined by the TIME PER POINT switch.

EXAMPLE #8-1

Figure 8-2: A typical input signal.

Figure 8-3: The 0.5 microsecond sampling rate superimposed over the signal.

Figure 8-4: The resulting digitized samples represented by dots.

Figure 8-5: Assume a time-per-point of 1 uSec. Every other digitized sample (larger dots) are selected for display.

Figure 8-6: Assume a time-per-point of 5 uSec's. Every tenth digitized sample (large dot) is selected for display.

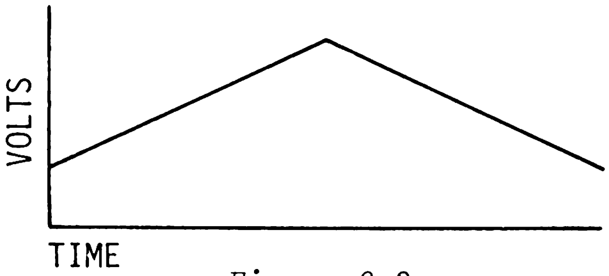


Figure 8-2

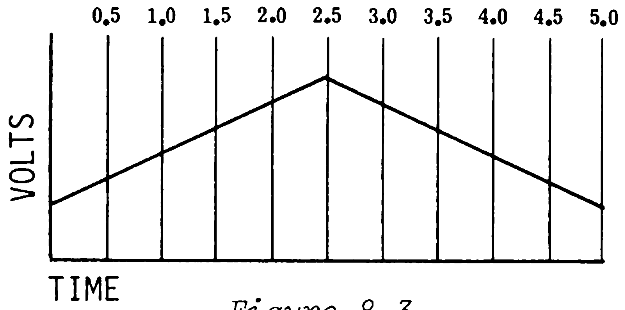


Figure 8-3

Figure 8-4

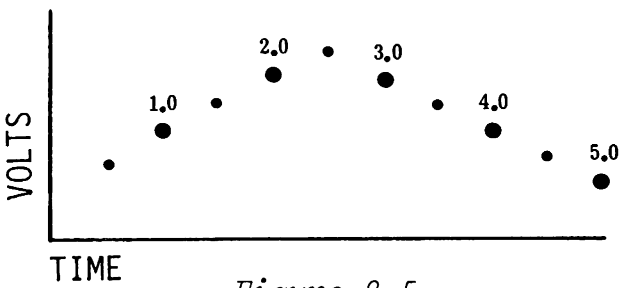


Figure 8-5

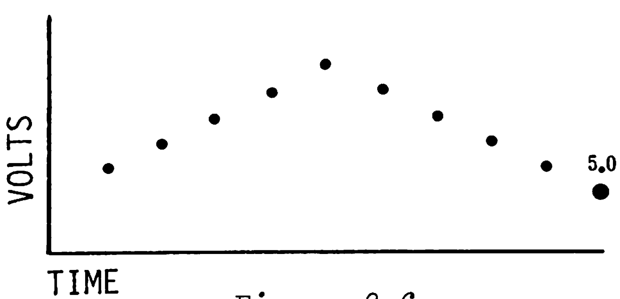


Figure 8-6

The number of allotted addresses (words) with which the display memory will record each input signal depends upon -

#1. The positions of the CHANNEL A and B "ON/OFF" switches; and

#2. The position selected on the Mainframe's MEMORY switch

Table 8-3 tabulates the approximate number of memory addresses that will record each input signal.

CHANNEL SWITCH		MEMORY SWITCH POSITION		
A	B	ALL	HALVES	QUARTERS
ON	OFF	*16K*	*8K*	*4K*
OFF	ON	*16K*	*8K*	*4K*
ON	ON	*8K*	*4K*	*2K*

Table 8-3

NOTE: Table 8-3 is for single Plug-in operation only.

SWEEP TIMES

Table 8-4 tabulates the approximate sweep times for single-channel measurements. For multiple channels, divide the listed times accordingly:

Two channels ------------------- (2)
Three or four channels --------- (4)

TIME PER POINT SWITCH	MEMORY SWITCH POSITIONS (Data Points Per Sweep) ALL (15,872)	H1/H2 (7,936)	Q1/Q2/Q3/Q4 (3,968)
	Milliseconds Per Sweep		
0.5 µS	7.940	3.970	1.985
1.0	15.880	7.940	3.970
2.0	31.760	15.880	7.940
5.0	79.400	39.700	19.850
10.0	158.800	79.400	39.700
20.0	317.600	158.800	79.400
50.0	794.000	397.000	198.500
100.0	1588.000	794.000	397.000
200.0	3176.000	1588.000	794.000
500.0	7940.000	3970.000	1985.000
	Minutes Per Sweep		
1 mS	0.264	0.132	0.066
2	0.528	0.264	0.132
5	1.320	0.660	0.330
10	2.640	1.320	0.660
20	5.280	2.640	1.320
50	13.200	6.600	3.300
	Hours Per Sweep		
0.1 S	0.440	0.220	0.110
0.2	0.880	0.440	0.220
0.5	2.200	1.100	0.550
1	4.400	2.200	1.100
2	8.800	4.400	2.200
5	22.000	11.000	5.500
10	44.000	22.000	11.000
20	88.000	44.000	22.000
50	220.000	110.000	55.000
100	440.000	220.000	110.000
200	880.000	440.000	220.000

Table 8-4

• EXT I & II POSITIONS

The EXT I (fast) and EXT II (slow) time-per-point positions are used when -

#1. The desired time-per-point is not available on the TIME PER POINT switch; or

#2. The sampling rate is generated from a nonlinear time base.

The number of allotted addresses (words) that will record each input signal depends upon -

#1. The positions selected on the CHANNEL A and B "ON/OFF" switches; and

#2. The position selected on the Mainframe's MEMORY switch.

Table 8-5 tabulates the corresponding number of memory addresses that will record each input signal.

NOTE: Table 8-5 is for single Plug-in operation only.

The sampling of the input signal will begin 200 nS to 220 nS (and end 540 nS to 560 nS) after the "EP" command is applied to the Remote Control Connector.

CHANNEL SWITCH		MEMORY SWITCH POSITION		
A	B	ALL	HALVES	QUARTERS
ON	OFF	*15,872*	*7,936*	*3,968*
OFF	ON	*15,872*	*7,936*	*3,968*
ON	ON	*7,936*	*3,968*	*1,984*

Table 8-5

IN EXT I (fast) mode, a delay will occur between the time of the first sample and the time at which a display will appear. This delay occurs because the samples are stored by the Plug-in's buffer memory before being "dumped" into the display memory.

This time delay can be approximated by multiplying the allotted addresses (from Table 8-5) by the average time period between each sample. See Equation 8-1.

$$\text{Time Delay} = (\text{addresses}) \times (\text{period})$$

Equation 8-1

In EXT II (slow) mode, each sample will be displayed as soon as it is acquired, allowing real-time monitoring of slow signals.

● EXT I Position

The EXT I position is used when the sampling rate is between 3.5 µS and 35 µS (or 3.5 µS and 120 µS if averaging is applied). The EXT I mode requires two external commands to acquire samples:

#1. A valid trigger command; and

#2. A TTL input signal (EP command) applied to the Remote Control Connector.

The trigger command initiates the sampling sequence and first data point acquisition, and the "EP" commands determine the sampling rate. Samples are acquired within 220 nS of the leading, positive edge of the "EP" commands. The buffer memory stores all of the data points before "dumping" them into the display memory.

NOTE: The Point Average mode is not operable in the EXT I mode.

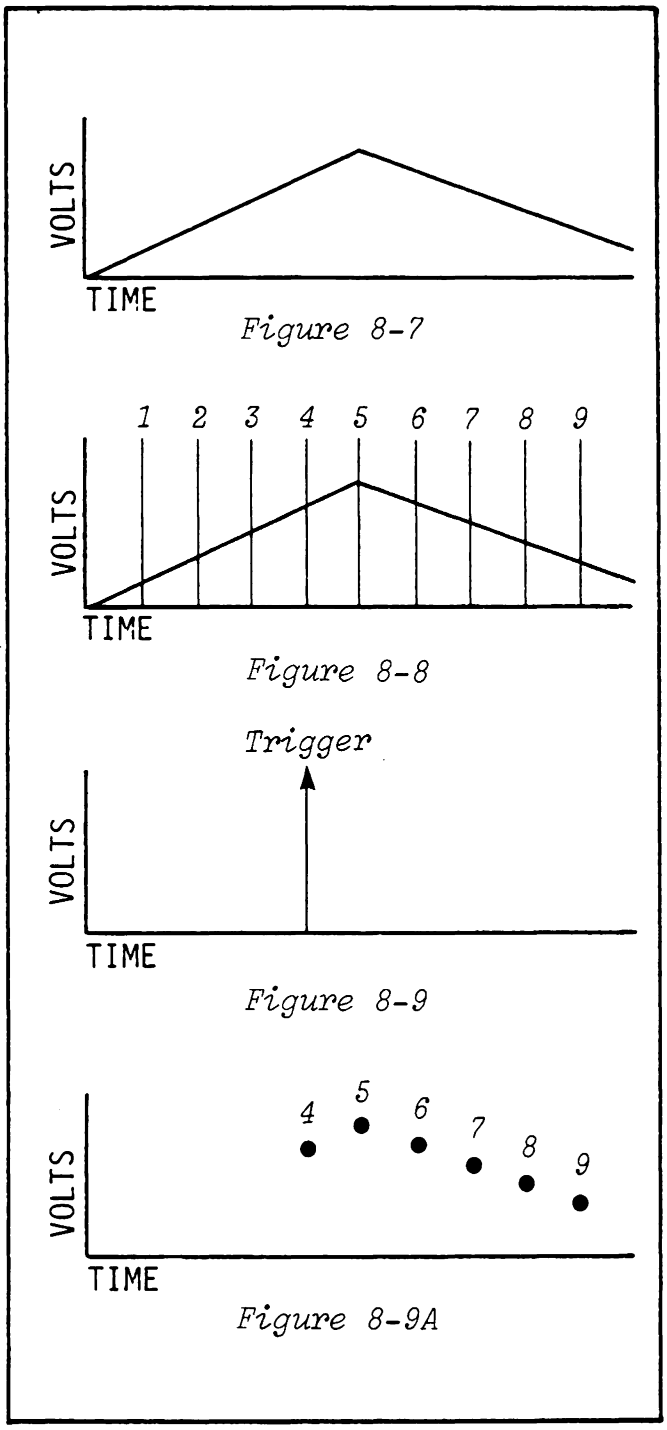


Figure 8-7

Figure 8-8

Figure 8-9

Figure 8-9A

EXAMPLE #8-2

Figure 8-7: Typical input signal.

Figure 8-8: "EP" commands superimposed over the input signal.

Figure 8-9: A valid trigger occurring at that point in time.

Figure 8-9A: The corresponding digitized samples, represented by the dots, that will be stored in the display memory.

● EXT II Position

The EXT II position is used when the sampling rate is equal to, or slower than 35 μS (or 120 μS if averaging is applied). The EXT II mode requires two external commands to acquire samples:

#1. A valid trigger command; and
#2. A TTL input signal (EP command) applied to the Remote Control Connector.

The trigger command initiates the sampling sequence and the first data point acquisition, and the "EP" commands determine the sampling rate. Each data point will immediately appear on the display screen as each one is acquired.

NOTE: The Point Average mode is not operable in the EXT II mode.

EXAMPLE #8-3

Figure 8-10: Typical input signal.

Figure 8-11: "EP" commands superimposed over the input signal.

Figure 8-12: A valid trigger occurring at that point in time.

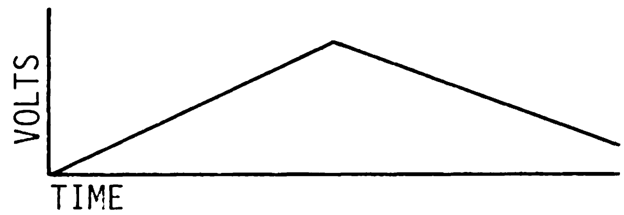


Figure 8-10

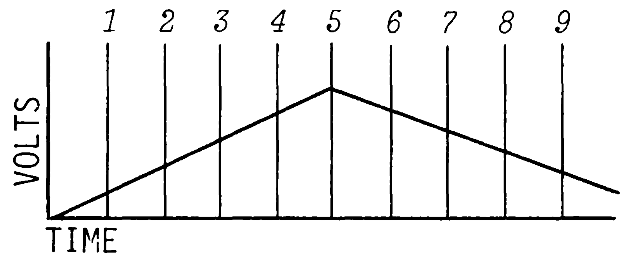


Figure 8-11

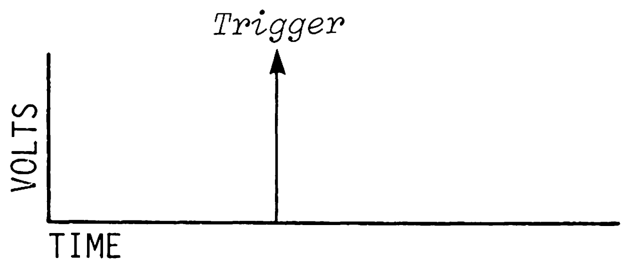


Figure 8-12

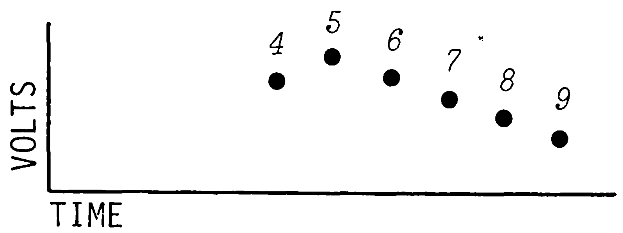


Figure 8-13

Figure 8-13: The corresponding digitized samples, represented by the dots, that will be stored in the display memory.

FILTER SWITCH

Rejects high frequency "noise" components on the input signal.

This feature can be used in any acquisition mode, including Average and Point Average.

NOTE: 100 KHz = -3db/point.

POSITION CONTROL

Vertically repositions a "live" display on the screen.

NOTE: The POSITION control does not introduce a dc offset to the signal. Rather, it varies the location of the zero volts reference on the screen by up to 60% of the selected Volts Full Scale.

For example, if the selected Volts Full Scale equals ±1V, the display can be varied from (+1.6 V to -0.4 V) down to (-1.6 V to +0.4 V) by using the POSITION control.

The voltage numerics will remain unchanged when the POSITION control is used.

SAVE REFERENCE SWITCH

➤IMPORTANT: The Trigger View mode overrides the Save Reference mode. See IMPORTANT note on Page 8-30.

Allows "live" and stored signals to be compared when the Plug-in is operating in the Live mode. This enables the operator to observe the effects of altering the characteristics of the input signal.

Turning the SAVE REFERENCE switch on causes alternate, displayed data point coordinates to become "frozen" in the display memory's addresses. The remaining addresses continue to record changes in the input signal and display these changes superimposed over the "frozen" data points. The reference of the"frozen" display is protected in the Live mode.

In addition, the Plug-in/Channel numerics will also display a letter "R" suffix indicating which data points have been saved ("frozen").

The display returns to normal operation when the switch is turned off.

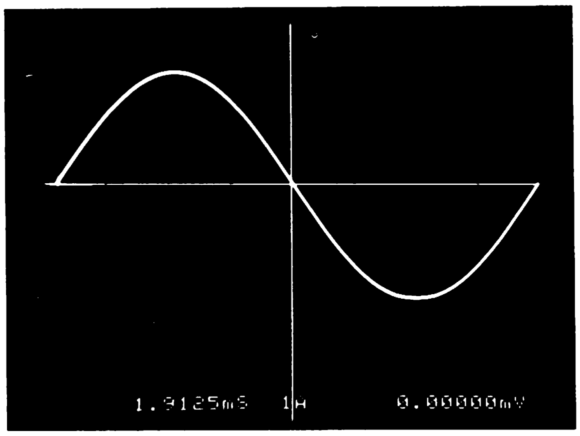


Figure 8-14

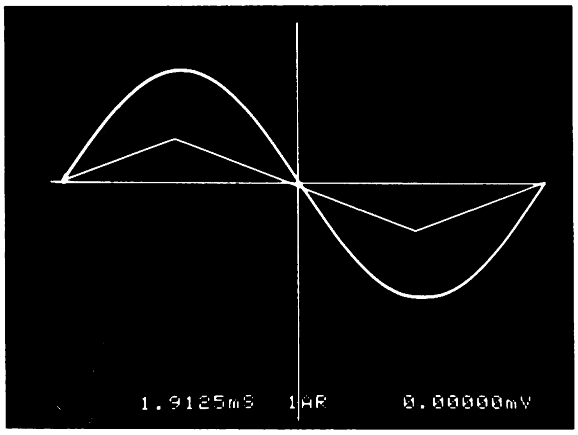


Figure 8-15

EXAMPLE #8-4

Figure 8-14: Typical signal acquired with SAVE REFERENCE turned off.

Figure 8-15: Resulting display of the altered signal superposed over the original signal when the SAVE REFERENCE switch was turned on.

AVERAGE SWITCH

Reduces the effects of "noise" on recurrent input signals by "sweep" averaging successive sweeps.

To function properly, the input signal must be time-locked to an associated trigger signal.

The sampling rate is determined by the selected Time-Per-Point.

Sample voltages acquired during the first sweep are stored in the memory. Then, samples acquired during the second sweep are averaged with those acquired during the first sweep. Each "newer" average, computed from Equation 8-2, updates the memory.

This process of averaging "new" samples with the "old" averages stored in the memory repeats for each sweep.

$$SV_{ave} = \text{Old} \times \frac{(K-1)}{K} + \frac{\text{New}}{K}$$

Equation 8-2

- (Old): The average voltage value currently stored in the memory's address.

- (New): The newest sampled voltage acquired during the current sweep.

- (K): The values tabulated in Table 8-6, corresponding to the sweep in progress.

SWEEP	1	2	3-5	6-10	11-21
K	*1*	*2*	*4*	*8*	*16*

Table 8-6

The term "K" is computed from Equation 8-3. The result is rounded off to the nearest, lower power of two, (2^n).

$$K = \text{Sweep} + \frac{\text{Sweep}}{2}$$

Equation 8-3

NOTE: This type of averaging is called virtual averaging and is similar to "true" or normalized averaging. However, unlike normalized averaging, virtual averaging "weights" each sweep differently because of the use of binary number "K" instead of "N" (Number of Sweeps). If the variations in voltages, from sweep to sweep, are due entirely to "noise" and not because of signal changes, the result is identical.

EXAMPLE #8-5

Figure 8-16: First sweep sampled at 1V1, 1V2, ... $1V_x$.

Figure 8-17: Second sweep sampled at 2V1, 2V2, ... $2V_x$.

Figure 8-18: Third sweep sampled at 3V1, 3V2, ... $3V_x$.

If -
1V1 = 8V, 2V1 = 10V, and 3V1 = 8V, the average value of the first data point displayed (AV_1, AV_2, AV_3) during each of the three sweeps equals:

$$AV_1 = 0V \times \frac{(1-1)}{1} + \frac{8V}{1} = 8V$$

$$AV_2 = 8V \times \frac{(2-1)}{2} + \frac{10V}{2} = 9V$$

$$AV_3 = 9V \times \frac{(4-1)}{4} + \frac{8V}{4} = 8.75V$$

Figure 8-19: The upper display illustrates a "noisy" signal acquired without the Average mode.

The lower display illustrates, after several sweeps, the same "noisy" signal captured with the Average mode.

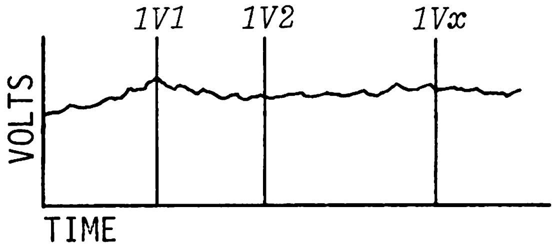


Figure 8-16

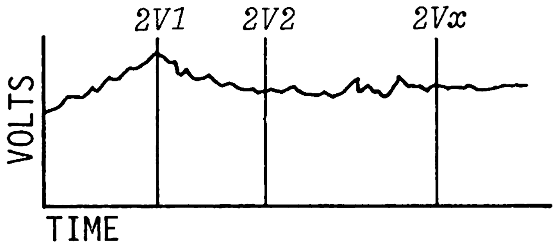


Figure 8-17

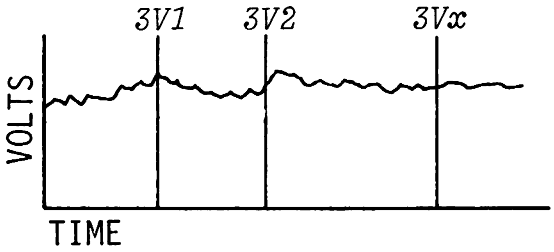


Figure 8-18

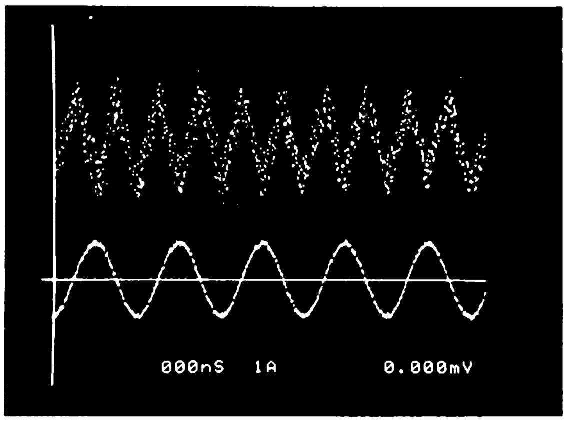


Figure 8-19

4562

POINT AVERAGE SWITCH

Reduces the effects of "noise" on an input signal acquired when the time-per-point is slower than 500 microseconds.

The oscilloscope acquires data at a constant rate of 250 microseconds per sample. As each sample is acquired, it is averaged with the preceding samples within the same sampling period (time-per-point setting).

For example, an average is computed from the values of the first and second samples which, in turn, is averaged with the value of the third sample, etc.

When the last sample within the string has been averaged, the final averaged value is stored in one of the memory's addresses and displayed by a single data point coordinate.

This process repeats until each one of the memory's allotted addresses has recorded an average value.

The point average values are computed by Equation 8-4.

$$PV_{ave} = \text{Old} \times \frac{(K-1)}{K} + \frac{\text{New}}{K}$$

Equation 8-4

- (Old): The average voltage value currently stored in the memory's address.
- (New): The newest sampled voltage acquired within the string.
- (K): The values tabulated in Table 8-7, corresponding to the sample being acquired.

SAMPLE	1	2	3-5	6-10	11-21
K	*1*	*2*	*4*	*8*	*16*

Table 8-7

The term "K" is computed from Equation 8-5. The result is rounded off to the nearest, lower power of two, (2^n).

$$K = \text{Sample} + \frac{\text{Sample}}{2}$$

Equation 8-5

EXAMPLE #8-6

Assume that a string of three samples will be point averaged for each data point coordinate.

Figure 8-20: The first string sampled at 1V1, 1V2, and 1V3 for the first data point to be displayed in the sweep. (Sample 2V1 starts the second string of samples for the second data point.)

If-
1V1 = 6V, 1V2 = 8V, and 1V3 = 4V, the average voltage value of the first data point to be displayed in the sweep will equal 6.25 volts.

Where -

$$PV_1 = 0V \times \frac{(1-1)}{1} + \frac{6V}{1} = 6V$$

$$PV_2 = 6V \times \frac{(2-1)}{2} + \frac{8V}{2} = 7V$$

$$PV_3 = 7V \times \frac{(4-1)}{4} + \frac{4V}{4} = 6.25V$$

Figure 8-21: The upper display illustrates a "noisy" signal acquired without the Point Average mode.

The lower display illustrates, after one sweep, the same "noisy" signal captured with the Point Average mode.

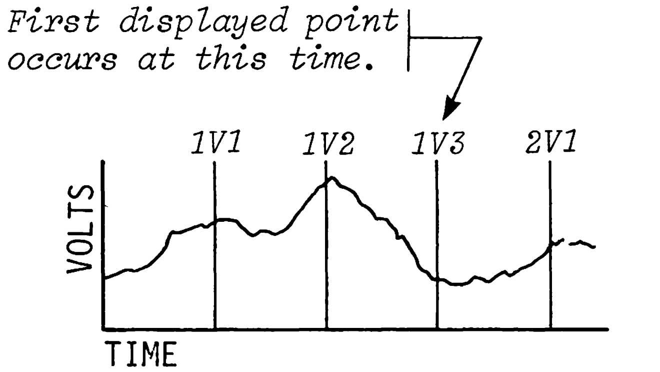


Figure 8-20

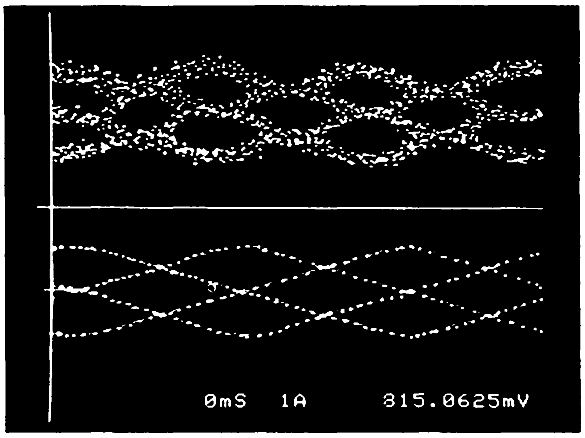


Figure 8-21

● COMBINING AVERAGE & POINT AVERAGE

The "sweep" Average and Point Average modes of operation can be combined if the time-per-point is slower than 500 microseconds. The effectiveness of averaging very "noisy,' repetitive signals is enhanced when both of these modes are combined.

Essentially, Point Averaged values acquired during the first sweep are recorded in the memory's addresses. Then, as each "new" Point Averaged value is acquired in the second sweep, it is "sweep" Averaged with the corresponding value stored in the memory. The resulting average values continually replace the "older" values stored in the memory.

This process of "sweep" Averaging the "older" values stored in the memory with the "newer" Point Averaged values acquired during the current sweep repeats with every sweep, providing additional improvements in the signal to noise ratio.

The FILTER switch can also be used in conjunction with the Average and/or Point Average mode of operation.

SOURCE SWITCH

Selects whether the triggers will be derived from either the channel A or channel B amplifiers, or through the EXT input BNC.

- EXT

Selected when the trigger is applied to the EXT input BNC, enabling a common trigger to simultaneously initiate sweeps on both channels.

The amplitude of the signal must be 400 mV (minimum) to qualify as a valid trigger.

- A or B

Selected to allow amplification of the signal before it enters the trigger detection circuits. The signal must be at least 2% of the selected Volts Full Scale to qualify as a valid trigger.

NOTE: A valid trigger applied to channel A will also initiate a sweep on channel B if the CHANNEL B "ON/OFF" switch is turned on. The opposite is true when a trigger is applied to CHANNEL B.

- S

Selected when multiple Plug-ins will be triggered by a common signal.

The trigger must be applied to the "Master" Plug-in and the position selected on that Plug-in's SOURCE switch (A, B, or EXT) must correspond accordingly.

The remaining Plug-in(s) are referred to as the Slave Plug-ins. The SOURCE switch(es) must be placed to the "S" position.

A trigger applied to the Master Plug-in will also trigger a sweep at the Slave Plug-ins.

AUTO/NORM SWITCH

Determines whether the trigger will be generated internally in the absence of a valid trigger signal or solely by an external source.

● AUTO
Automatically triggers in the absence of a valid trigger.

● NORM
The trigger is externally generated. The next valid trigger to occur, after the preceding sweep has been completed, will initiate a new sweep.

COUPLING SWITCH

Determines whether or not a dc component on the triggering signal being applied to the EXT input BNC will be attenuated.

● AC
Signals are capacitively coupled to the trigger detection circuit. DC components of approximately 2 hertz, or less, are attenuated while the ac component is allowed to pass.

● DC
Both ac and dc components of the signal are coupled to the trigger detection circuitry.

VIEW SWITCH

►IMPORTANT: Displayed data will be erased from the display memory when the VIEW switch is turned on. Precautions must be taken if the displayed data is to be saved. (Such as recording the data on a diskette or placing the MEMORY switch to an empty, or unimportant, "halves" or "quarters" position.) In addition, the View mode will override the Save Reference mode and the functions of the TRIG POSITION controls.

Two horizontal lines appear and the Plug-in's Trigger cursor moves to screen center when VIEW is selected and the Plug-in is operating in the Live mode with sweeps occurring. A letter "V" suffix will be added to the Plug-in/Channel numerics, (e.g., 1AV). If external triggering is selected, the Plug-in number will be followed by an "EV" suffix, (e.g., 1EV).

The configuration and position of the two lines indicate the slope (page 8-31), minimum amplitude (page 8-32), and minimum voltage change (page 8-33) that the signal must experience to qualify as a valid trigger. All three characteristics must be met by the signal before a sweep will be initiated.

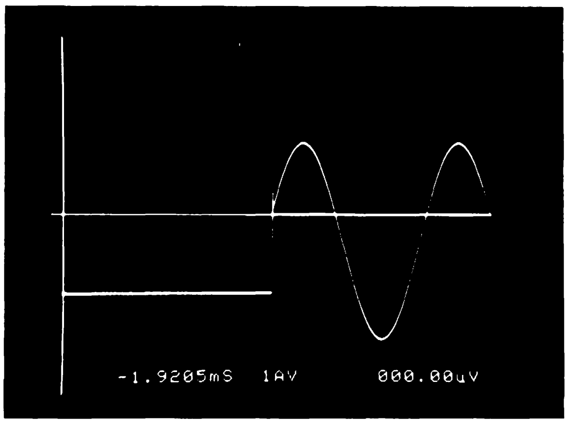


Figure 8-22

To use the VIEW mode:

#1. Take precautions to save any important data stored in the display memory.

#2. If any of the Plug-in's controls must be repositioned, place the Plug-in into the Hold mode, or press the LIVE button after the controls have been repositioned.

#3. AUTO/NORM switch: As required.

#4. VIEW switch: On

#5. LIVE button: Press.

EXAMPLE #8-7

Figure 8-22: Typical VIEW display with Positive Slope selected.

SLOPE SWITCH

➤NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch

Determines whether positive and/or negative going voltage transitions will qualify the signal as a trigger.

● (+) Slope

The signal voltage must be increasing.

● (-) Slope

The signal voltage must be decreasing.

● DUAL Slope

Either increasing or decreasing voltage values will qualify the signal.

EXAMPLE #8-8

Figure 8-23: (+) slope display. Signal qualifies as a valid trigger component at point (T_0).

Figure 8-24: (-) slope display. Signal qualifies as a valid trigger component at point (T_0).

Figure 8-25: DUAL slope display. Signal qualifies as a valid trigger at either point (T_1) or (T_2).

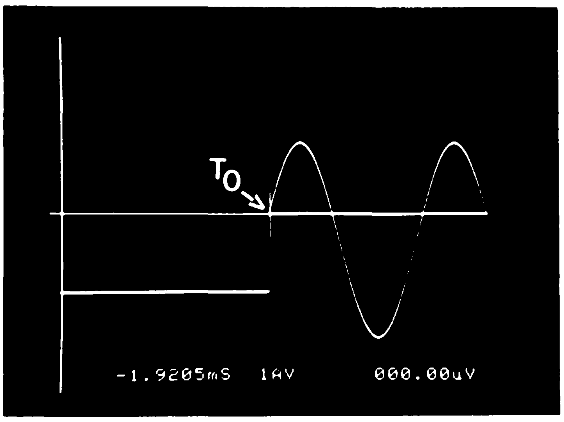


Figure 8-23

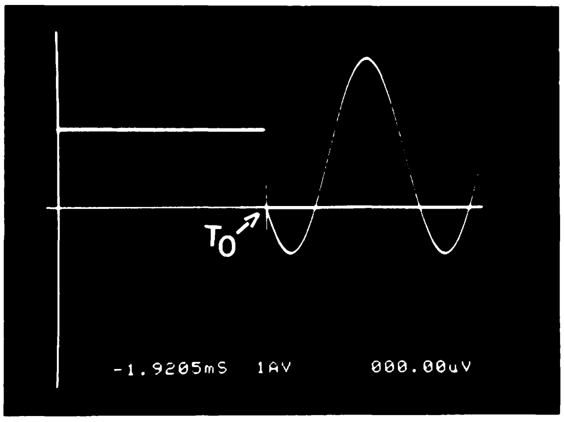


Figure 8-24

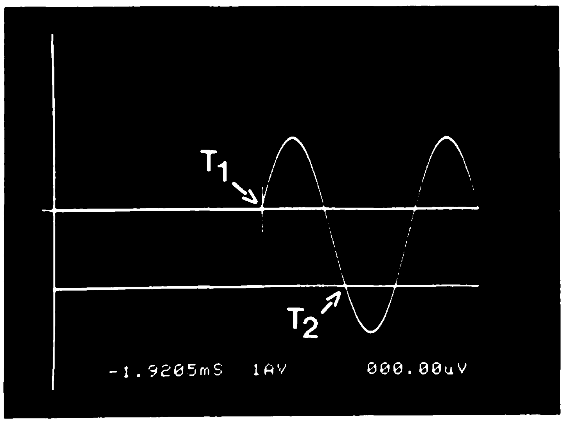


Figure 8-25

LEVEL CONTROL

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch

The LEVEL control adjusts the threshold levels which, when crossed by the signal, will qualify the signal as a valid trigger component.

Which of the two lines must be crossed by the signal is a function of the SLOPE switch.

- (+) - The signal must cross the upper threshold level.
- (-) - The signal must cross the lower threshold level.
- DUAL - The signal can cross either threshold level.

EXAMPLE #8-9

Figure 8-26: A (+) slope display. Signal qualifies as a valid trigger component at point (T_0).

Figure 8-27: A (-) slope display. Signal qualifies as a valid trigger component at point (T_0).

Figure 8-28: A DUAL slope display. Signal qualifies as a valid trigger at either point (T_1) or (T_2).

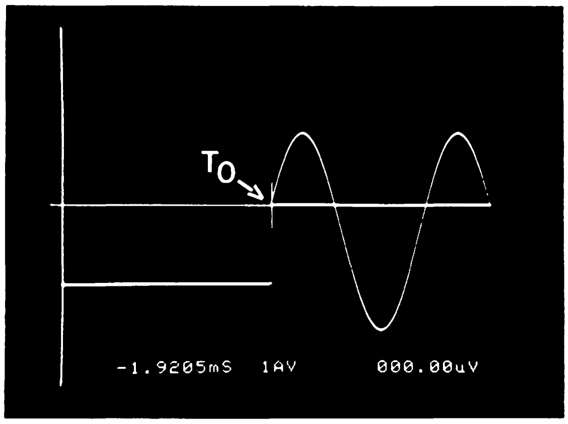


Figure 8-26

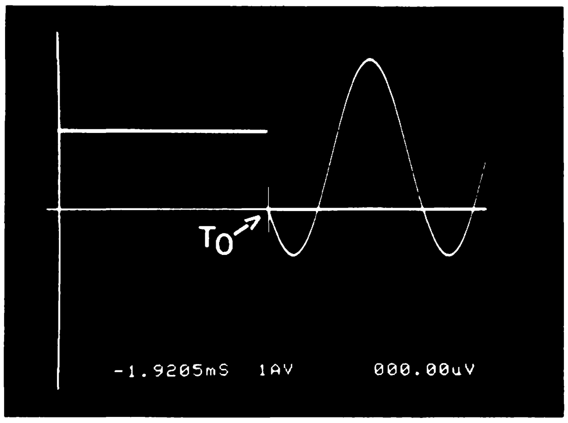


Figure 8-27

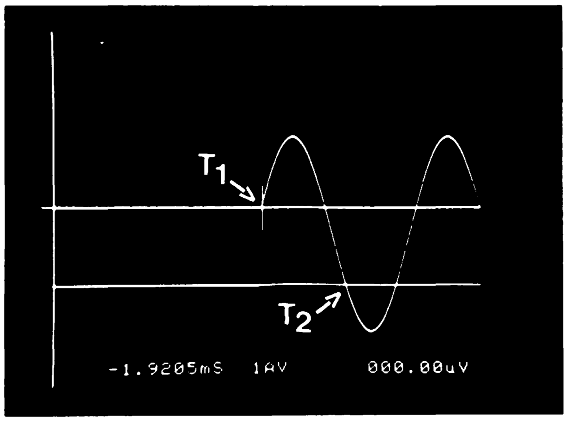


Figure 8-28

SENSITIVITY CONTROL

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch

Adjusts the distance (window) between the two threshold levels. This "window" must be crossed by the signal in order to qualify as a valid trigger component when either (+) or (-) slope triggering is selected.

The "window" voltage can be adjusted from a range of 400 millivolts to 18 volts when triggering via the EXT input BNC. And from 2% to 90% of the Volts Full Scale when triggering via the channel A or B amplifiers.

The voltage numerics will alternate between the voltage values of the upper and lower threshold levels when the vertical cursor is moved across the display screen with Autocenter turned on.

EXAMPLE #8-10

Figure 8-29: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.

Figure 8-30: The dashed lines on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger component.

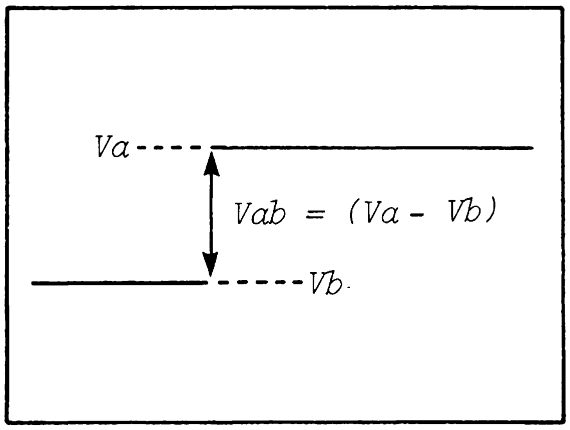


Figure 8-29

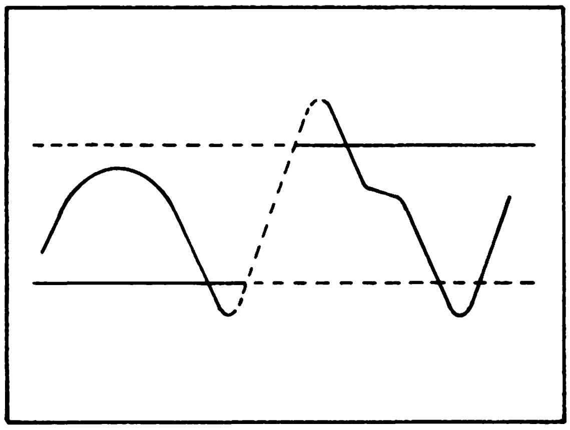


Figure 8-30

RECURRENT TRIGGERING

• (+) or (-) SLOPE TRIGGERING

After the first trigger has been initiated, the signal's slope must reverse, pass through the "window," reverse again, and then pass through the "window" once more in order to initiate another trigger.

EXAMPLE #8-11

Assume (+) Slope triggering has been selected and the VIEW switch is on.

Figure 8-31: The first positive slope (solid line) starts below the lower threshold level, passes through the "window," and initiates a trigger at point (T_1). The dashed lines represent the path that the signal must follow in order to initiate a second trigger at point (T_2).

Figure 8-32: Once again, the signal qualifies as a trigger at point (T_1). Since the second positive slope did not start below the lower threshold, a trigger will not occur at point (A). It will, however, occur at point (T_2) because the positive slope begins below the lower threshold.

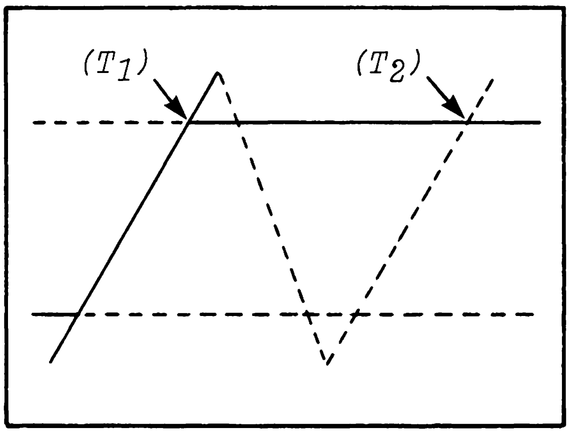


Figure 8-31

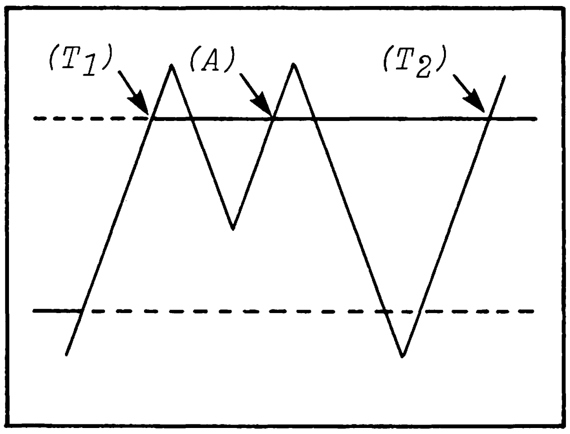


Figure 8-32

● DUAL SLOPE TRIGGERING

Recurrent triggers will be initiated each time the signal crosses either threshold level with the proper slope. The signal does not have to recross through the "window."

NOTE: The signal must experience a voltage change of 2% (minimum) of the selected Volts Full Scale to qualify as a valid trigger.

EXAMPLE #8-12

Assume "DUAL" slope triggering has been selected on the SLOPE switch and the VIEW switch is on.

Figure 8-33: Valid triggers will occur at points (T_1 thru T_4) because the signal crosses the threshold levels with the correct slopes.

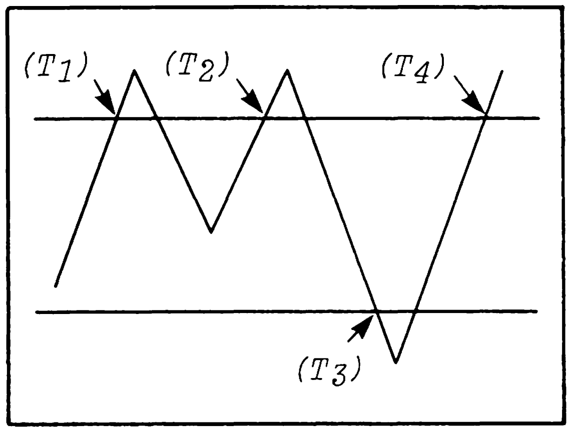


Figure 8-33

ADJUSTING THE TRIGGER

- (+) or (-) SLOPE TRIGGERING

#1. SLOPE: (+) or (-)

#2. AUTO/NORM: Auto

#3. COUPLING: As required.

#4. VIEW: On

#5. Trigger: Apply to EXT input BNC or to one of the channels.

#6. SOURCE: As required.

#7. DC/AC/GND: As required.

#8. LIVE: Press.

#9. POSITION: Adjust display for best placement.

#10. VOLTS FULL SCALE: As required.

#11. SENSITIVITY: Full counterclockwise. Then adjust clockwise until the "window" exceeds any "noise" spikes.

#12. LEVEL: Adjust until the upper threshold (+ slope) or lower threshold (- slope) intersects the desired trigger point.

#13. Fine tune the SENSITIVITY and LEVEL controls as required.

#14. After the SENSITIVITY and LEVEL controls have been properly positioned, place the AUTO/NORM switch to the "NORM" position. The Plug-in will continue to trigger.

NOTE: The TRIGGER light illuminates when a valid trigger is received and remains illuminated until the sweep is completed.

- DUAL SLOPE TRIGGERING

#1. SLOPE: Dual

#2. AUTO/NORM: Auto

#3. COUPLING: As required.

#4. VIEW: On

#5. Trigger: Apply to EXT input BNC or to one of the channels.

#6. SOURCE: As required.

#7. DC/AC/GND: As required.

#8. LIVE: Press.

#9. POSITION: Adjust display for best placement on screen.

#10. VOLTS FULL SCALE: As required.

#11. SENSITIVITY: Full counter-clockwise.

#12. LEVEL: Adjust until "window" is centered between the desired positive and negative trigger points.

#13. SENSITIVITY: Adjust until the upper and lower threshold levels intersect the desired positive and negative trigger points.

#14. Fine tune the LEVEL and SENSITIVITY controls as required.

#15. After the SENSITIVITY and LEVEL controls have been properly positioned, place the AUTO/NORM switch to the "NORM" position. The Plug-in will continue to trigger.

NOTE: The TRIGGER light illuminates when a valid trigger is received and remains illuminated until the sweep is completed.

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TRIGGER POSITION CONTROLS

The TRIG POSITION controls consist of a ZERO button (common to both channels), paddle "A" (channel A only), and paddle "B" (channel B only).

These controls select whether post-trigger (Normal), pre- and post-trigger (Cursor), or delayed trigger (Delayed) events will be displayed.

NOTE: These can be mixed or matched in multiple channel operation. Refer to *Special Procedures* tab, page 15-5.

● LIVE MODE (Coarse Adjust)
Pressing the paddle control causes the Trigger cursor to move 1/8 of full screen at the end of each sweep.

● LIVE MODE (High Speed Adjust)
Pressing, and holding, the LIVE button and paddle control causes a high speed movement of the Trigger cursor.

● SET-UP MODE (Fine Adjust)
Initiated by simultaneously pressing the HOLD LAST and HOLD NEXT buttons, illuminating all three STORAGE control LEDs. NOTE: ENSURE THAT THE HOLD LAST BUTTON IS RELEASED FIRST. The trigger's rate of movement increases the longer the paddle is pressed. Releasing and then repressing the paddle returns the advance to a slower rate of movement. The letter "S" suffix is added to the Plug-in/Channel numerics, (i.e., 1AS), when the Set-up mode is selected.

➤ IMPORTANT: OPERATING THE PADDLE CONTROLS, OR ZERO BUTTON, IN THE "SET-UP" MODE ALTERS THE (T_0) ORIGIN, CAUSING THE TIME NUMERICS TO BECOME ERRONEOUS. The "set-up" mode can be exited by pressing either the HOLD LAST or LIVE button. However, the time numerics will remain erroneous until a new sweep is acquired.

EXAMPLE #8-13

Figure 8-34: The types of triggers and related sweeps during which data is acquired for display.

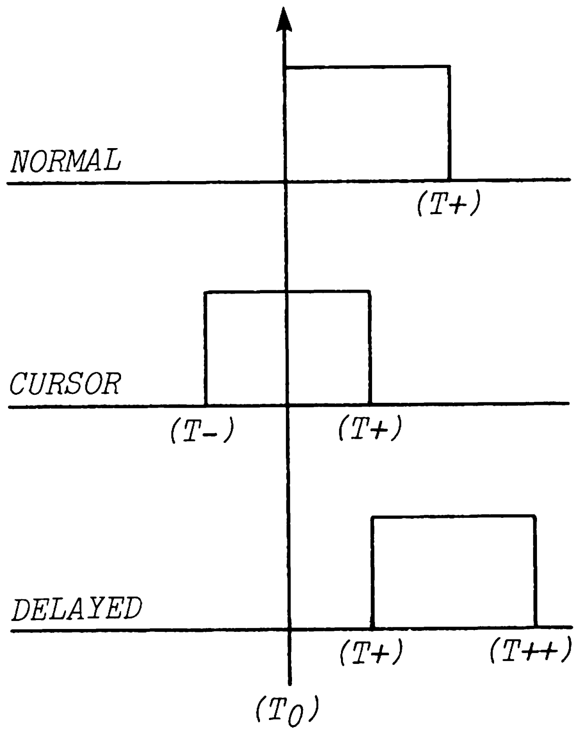

Figure 8-34

● NORMAL TRIGGER DISPLAY

The oscilloscope immediately resets to the Normal Trigger mode when the ZERO button is pressed and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed, since the "reset" command will not be recognized until the end of a sweep.

If the Plug-in is operating in the LIVE mode and -

#1. a long sweep is in progress, or

#2. no triggers are occurring, or

#3. a long delay has been selected,

then, to quickly reset the delay to zero, hold the ZERO button in and momentarily press the LIVE button.

The Plug-in's Trigger cursor is positioned at the extreme left-hand side of the screen when the oscilloscope is operating in the Normal Trigger mode. Only those events occurring after a valid trigger will be displayed on the screen.

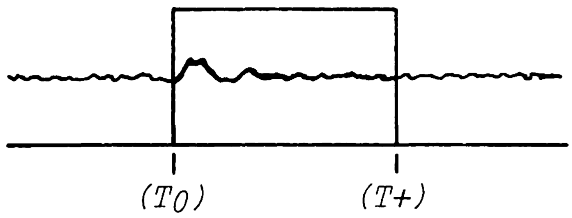

Figure 8-35

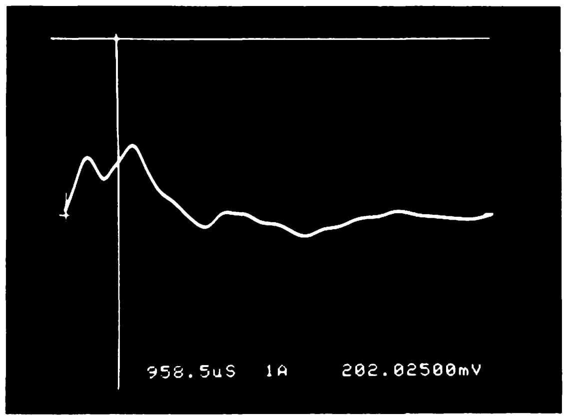

Figure 8-36

EXAMPLE #8-14

Figure 8-35: A typical input signal.

The boxed area represents one complete sweep starting at point (T_0), the trigger, and ending at point (T+).

Figure 8-36: The corresponding Normal trigger display of the signal captured during the sweep.

● CURSOR TRIGGER DISPLAY

The oscilloscope enters the Cursor Trigger mode when the TRIG POSITION paddle is pressed to the right and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed.

NOTE: If the Plug-in is in the LIVE mode and a long sweep is in progress, the Cursor Trigger command may not be acknowledged until the next sweep is initiated. (The TRIG POSITION paddle must be pressed towards the right as the new sweep is initiated.)

The Plug-in's Trigger cursor will reposition towards the right-hand side of the screen, stopping when the paddle is released. Pre-trigger events will be displayed to the left of the trigger cursor. Post-trigger events will be displayed to the right of it.

Essentially, data is continually being sampled and stored in the memory. When a valid trigger is received, the pre-trigger events are stored in the memory and the post-trigger events fill the remaining memory addresses.

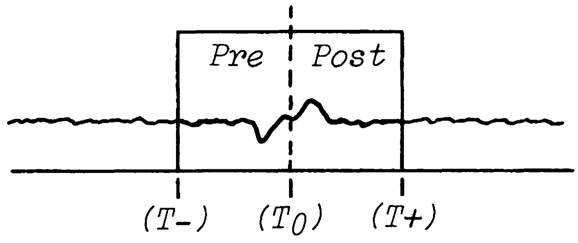

Figure 8-37

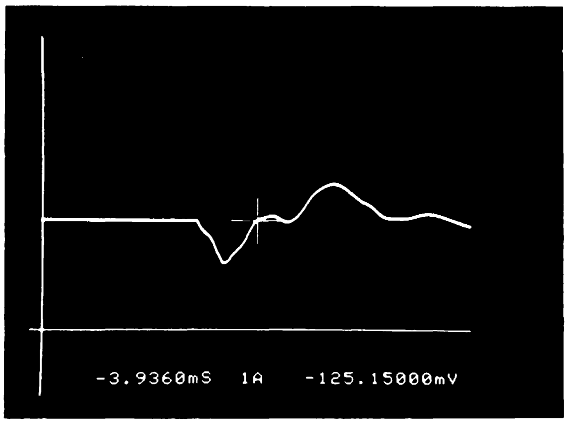

Figure 8-38

EXAMPLE #8-15

Figure 8-37: A typical input signal. The boxed area represents one complete sweep starting at point (T-) and ending at point (T+). Point (T_0), the trigger, "locks" the pre-trigger data in the memory's addresses. The remaining addresses will record the post-trigger data.

Figure 8-38: The corresponding display of the captured input signal.

- DELAYED TRIGGER DISPLAY

NOTE: Reposition the Mainframe's vertical cursor to the extreme left-hand side of the screen before activating the Delayed Trigger mode.

The oscilloscope enters the Delayed Trigger mode when the TRIG POSITION paddle is pressed to the left and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed.

NOTE: If the Plug-in is in the LIVE mode and a long sweep is in progress, the Delayed Trigger command may not be acknowledged until the next sweep is initiated. (The TRIG POSITION paddle must be pressed towards the left when the new sweep is initiated.)

The Plug-in's Trigger cursor (time zero) repositions to the left and continues to reposition off the left of screen. The time delay, indicated by the time numerics, reflects the time difference between the "positions" of the Trigger cursor and the vertical cursor.

Equation 8-6 computes the maximum time delay (T_{max}) that can be selected.

$$T_{max} \approx \frac{2^{24} \times (\text{TPP})}{(\text{Channels}) \times (\text{Memory})}$$

Equation 8-6

- (TPP): Time-per-point selection.
- (Channels): The number of channels turned on.
- (Memory): The position selected on the MEMORY switch. "ALL" = 1, "Halves" = 2, and "Quarters" = 4.

The Mainframe's vertical cursor can be repositioned after the delay has been set to inspect specific data point coordinates.

NOTE: Sometimes a very long delay may be inadvertently selected in the Delayed trigger mode of operation. To quickly clear the delay, hold the ZERO button in and momentarily press the LIVE pushbutton.

EXAMPLE #8-16

Figure 8-39: A typical input signal applied to an input BNC.

Point (T_0) indicates the point at which a valid trigger initiated the time delay.

The boxed area represents one complete sweep, starting at Point (T+) which represents the end of the time delay. Point (T++) represents the end of the sweep, during which time data was acquired for display.

Figure 8-40: The corresponding Delayed trigger display of the signal captured during the sweep.

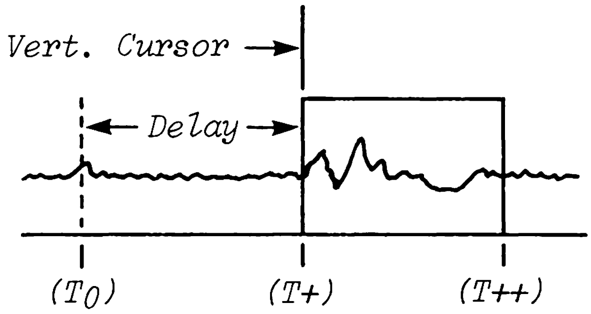

Figure 8-39

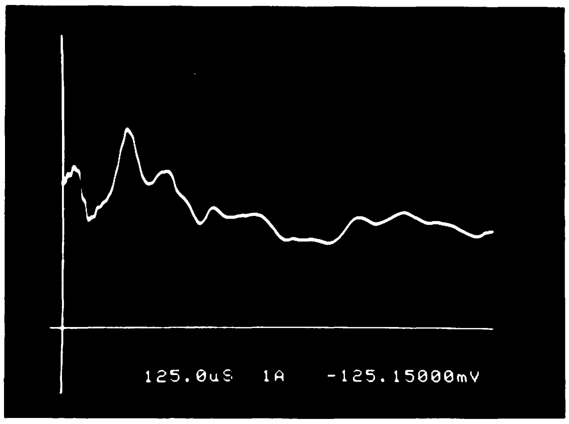

Figure 8-40

REMOTE CONTROL CONNECTOR

Events can occur so rapidly that the operator's reaction time is not fast enough to capture them.

This problem can be resolved by simulating certain commands with external sensors possessing the required reaction times.

Figure 8-41 identifies the function of each pin.

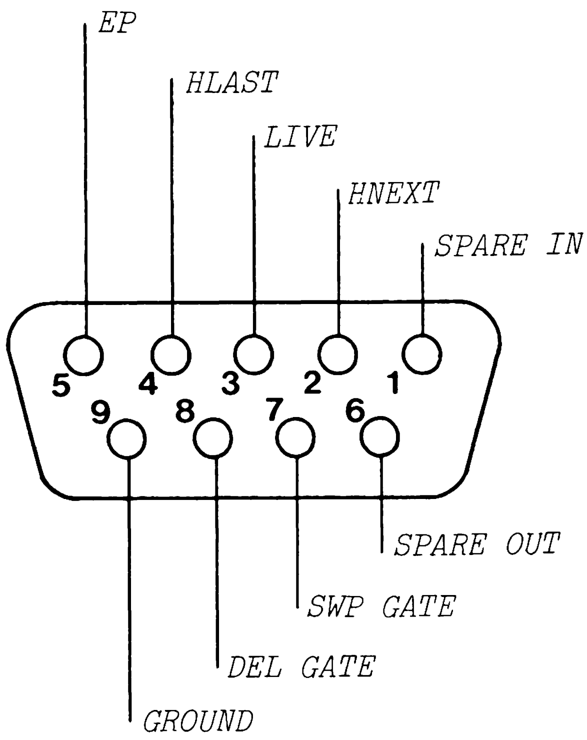

Figure 8-41

- **HOLD LAST, LIVE and HOLD NEXT**

The Storage Control buttons can be simulated by shorting the corresponding pins to ground through a low resistance contact or with an open collector TTL gate.

NOTE: Use the ground provided by Pin 9 on the Remote Control Connector.

- **EP**

The EP input is used to advance the memory to its next address when the TIME PER POINT switch is in either the EXT I or II positions.

The EP input should normally rest at less than 0.4 volts and then be raised to more than 3 volts DC each time the memory is to advance one address.
The "EP" input is TTL compatible.

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- DEL GATE

The Delayed Gate output activates when either channel receives a valid trigger.

The output normally rests at 0.4 volts and rises to +3 VDC immediately following the valid trigger. It will return to 0.4 volts as soon as the sweep has been completed.

Figure 8-42 illustrates the three types of triggers and corresponding sweeps and Delayed Gate outputs.

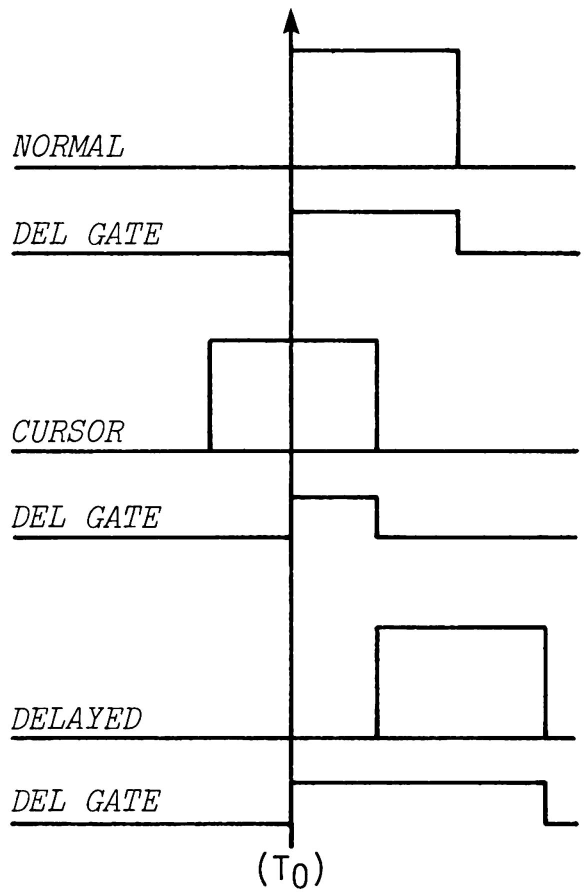


Figure 8-42

- SWP GATE

The Sweep Gate output is activated only during valid data point collection.

The output normally rests at 0.4 volts and rises to +3 VDC when a sweep is in progress.

- SPARE IN/SPARE OUT

Not currently being used.

PROBE POWER CONNECTOR

A ±12 VDC output voltage, with a maximum current of 100 ma, is available from the Probe Power connector.

The voltage polarities and ground are identified in Figure 8-43.

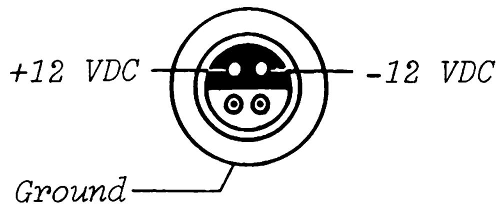


Figure 8-43

COMPENSATION POINT

Touching the test probe to the COMP point produces a square-wave on the screen.

►IMPORTANT: The Time Per Point must be 20 µSeconds or faster.

Compensate the test probe for the best response time (rise and fall times) on the square-wave display.

EXAMPLE #8-17

Figure 8-44 illustrates a square-wave displayed with expansion applied.

The top square-wave was produced from an uncompensated probe. The bottom square-wave was produced after the test probe was properly compensated.

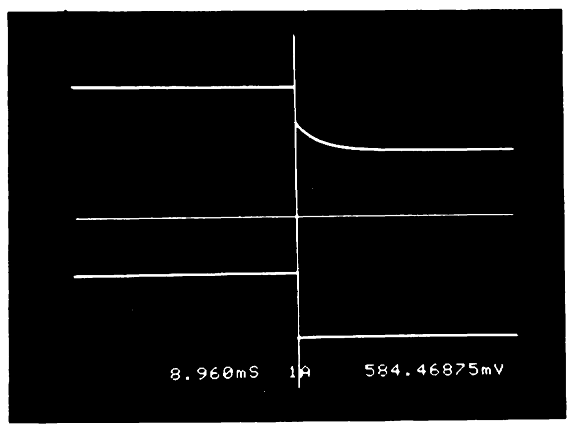
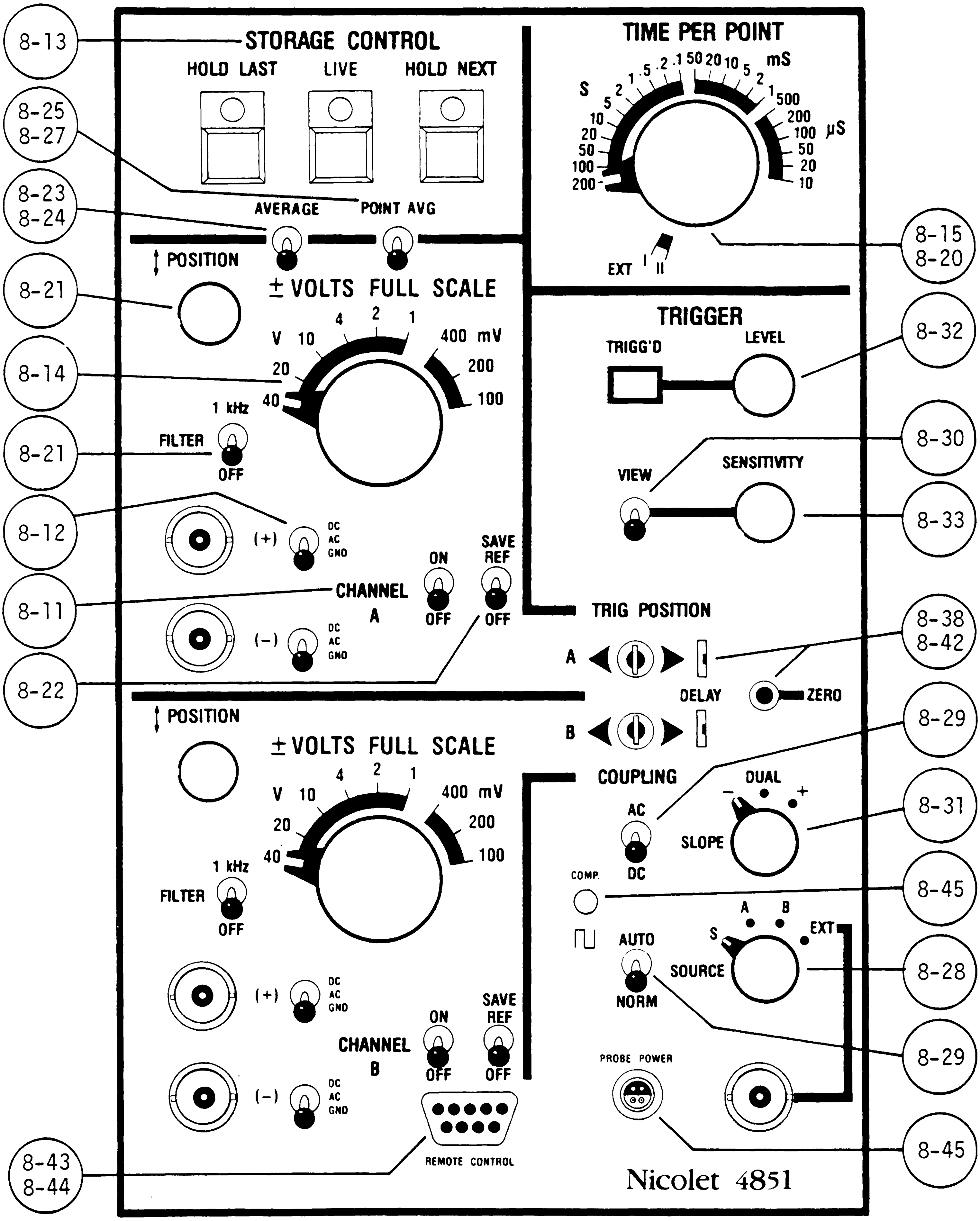


Figure 8-44

Model 4851 Plug-in



INTRODUCTION

The Model 4851, two channel Plug-in includes two high impedance, differential amplifiers; two 15-bit, 100 kHz digitizers; and a single 16K word memory.

Other features include -

- Single-ended or differential amplifiers.
- Positive, negative, or dual slope triggering.
- Normal, Pre- and Post-trigger, and Delayed trigger displays.
- A Trigger View mode to assist in the selection of the trigger's qualifying characteristics.
- Sweep Averaging, Point Averaging, and 1 kHz Filter to reduce the effects of "noise" on the signals.
- A Save Reference mode to compare "live" and saved signals.
- Remote control abilities.
- Test point compensation.
- A ±12 VDC probe power output.

►IMPORTANT: The term "Hold mode," in the following discussions, signifies that the Plug-in's HOLD LAST LED is illuminated only. The Live and Hold Next LEDS are turned off.

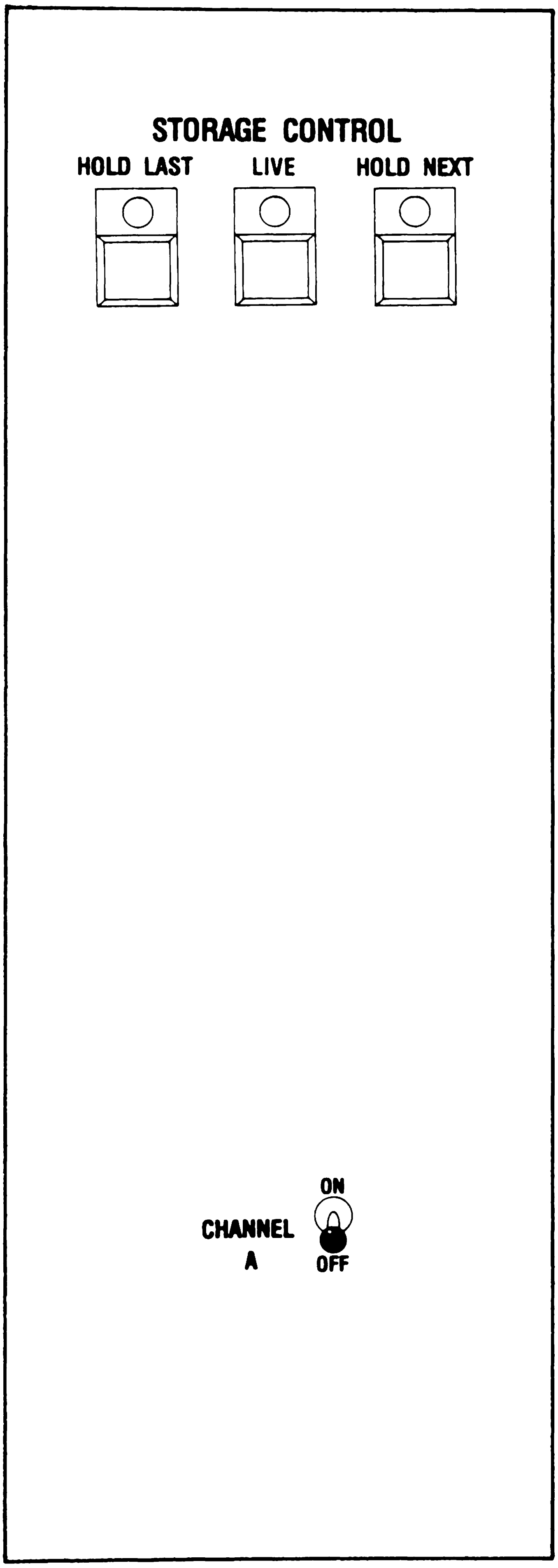
The Plug-in should be in the Hold mode whenever a Plug-in parameter is changed. Otherwise, the operator must either press the LIVE button to reset the Plug-in, or wait until after the next sweep is completed before the 4094 will acknowledge the parameter change(s).

The Plug-in is in the Hold mode when only the Hold Last LED is illuminated. If a sweep is not in progress, the Hold mode can be selected by pressing the HOLD LAST button. If, however, a sweep is currently in progress, the Hold mode can be selected by:

#1. HOLD LAST button: Press and hold.
#2. LIVE button: Press momentarily.
#3. HOLD LAST button: Release.

NOTE: The following descriptions are for single Plug-in operation only. Refer to the *Multiple Plug-ins* tab, after reading this section of the manual, for additional information.

4851



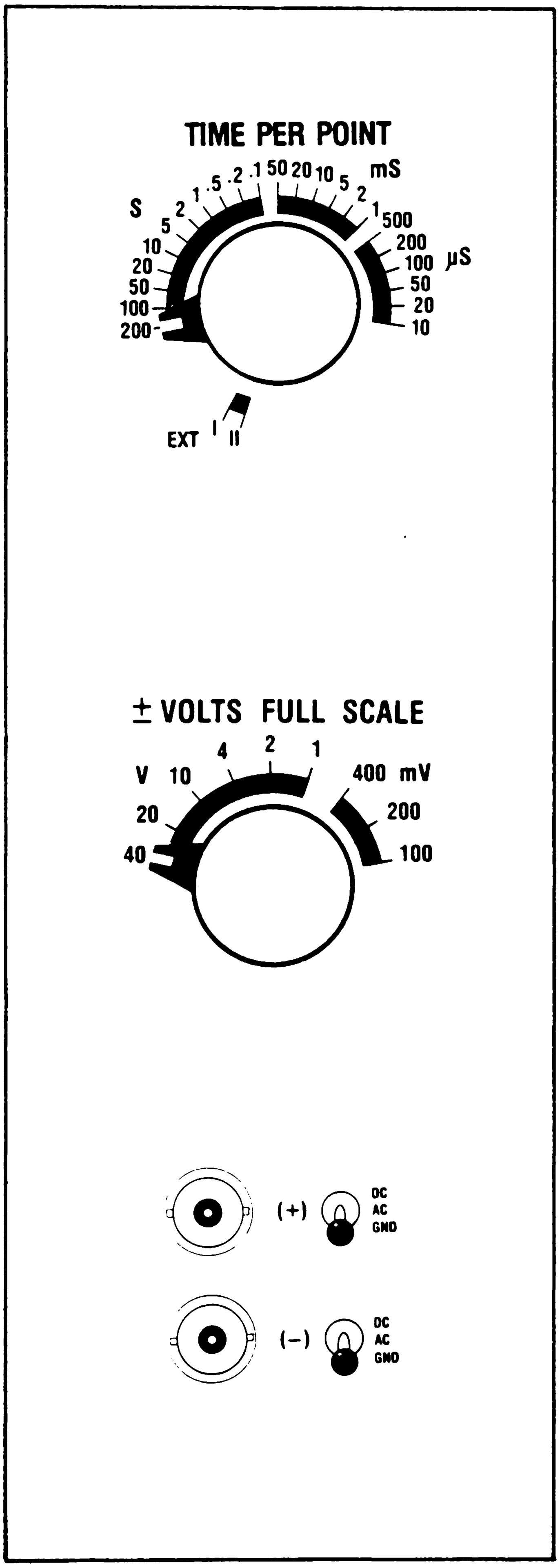
STORAGE CONTROL BUTTONS

The Storage Control buttons determine whether the displayed data groups will remain "live" or be stored in the display memory.

- LIVE - New signals are acquired and displayed on the screen each time a valid trigger is received.
- HOLD NEXT - The signal following the next valid trigger is stored in the display memory and displayed on the screen.
- HOLD LAST - The signal that followed the last valid trigger is stored in the display memory and displayed on the screen; including a signal already in progress at the moment the button is pressed.

CHANNEL SWITCH

The "ON" position allows the display memory to record data acquired by the associated channel and display it on the screen.



TIME PER POINT

Selects the time resolution of the signal to be acquired.

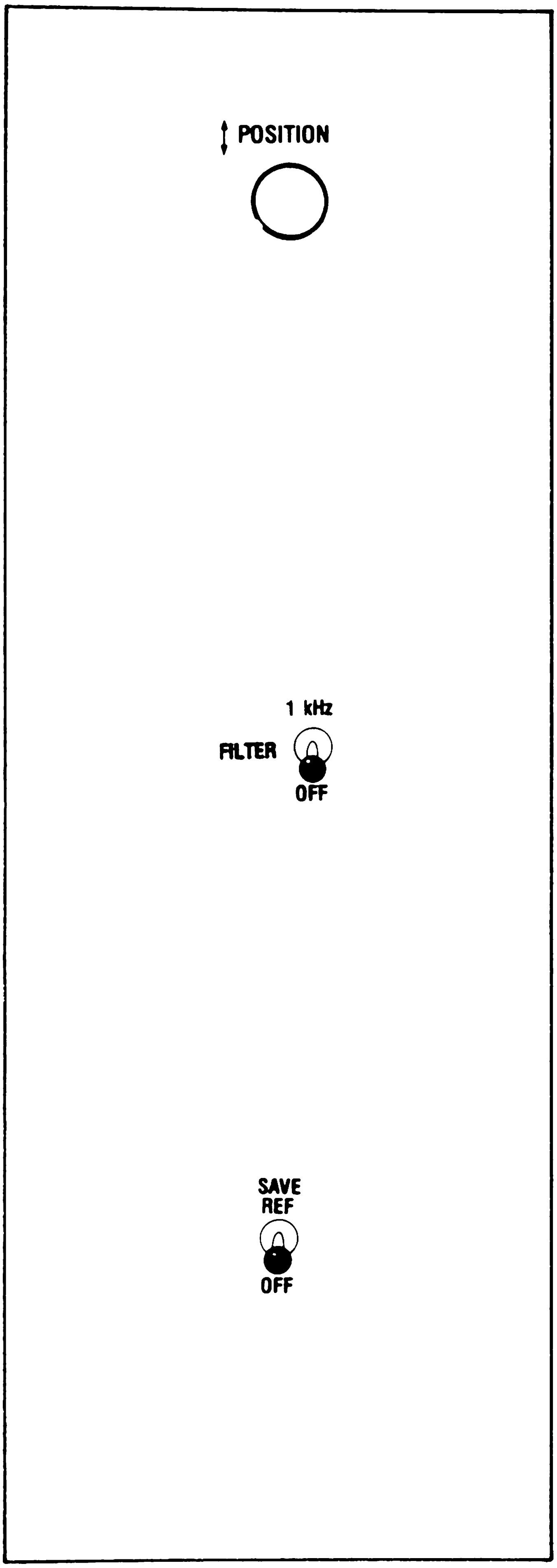
Sweep speeds are expressed as time-per-point rather than time-per-centimeter.

± VOLTS FULL SCALE SWITCH

Allows the oscilloscope to accept input signals ranging from ±100 millivolts to ±40 volts full scale.

DC/AC/GND SWITCH

- GND - Grounds the amplifier's input.
- DC - Allows both ac and dc signal components to enter the amplifier.
- AC - Blocks the dc component. Allows only the ac component to enter the amplifier.



POSITION CONTROL

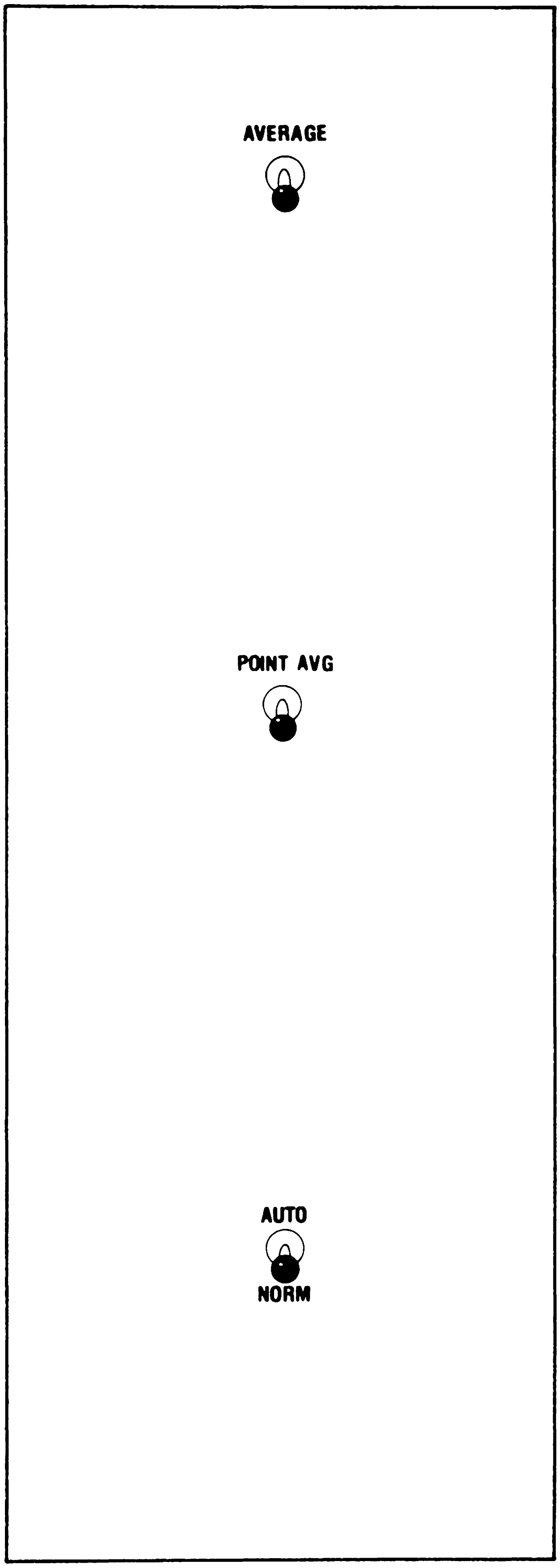
Vertically positions the displayed signal on the screen.

FILTER SWITCH

Filters high frequency "noise" components to ground. Used with low frequency input signals.

SAVE REFERENCE SWITCH

Allows the operator to compare "live" and saved signals in the Live mode.



AVERAGE SWITCH

Reduces "noise" on recurrent signals by averaging (from sweep to sweep) sampled voltages acquired equidistant with respect to each trigger, (T=0).

POINT AVERAGE SWITCH

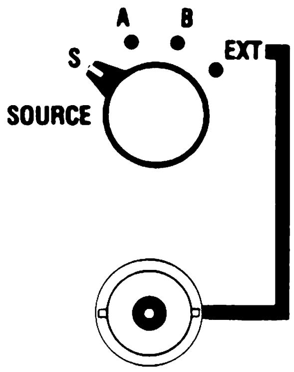
Reduces "noise" on single sweep input signals when the time-per-point is greater than *** µS by averaging the input signal at a constant sampling rate of *** µS/point between each displayed data point.

AUTO/NORM SWITCH

Determines whether the trigger will be generated internally in the absence of a valid trigger signal or by an external input signal.

- AUTO - Internally triggered.
- NORM - Externally triggered.

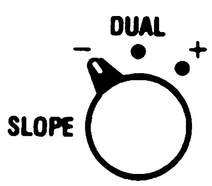
**Exact spec's to be verified.*



TRIGGER SOURCE SWITCH

Selects the source of the input trigger signal.

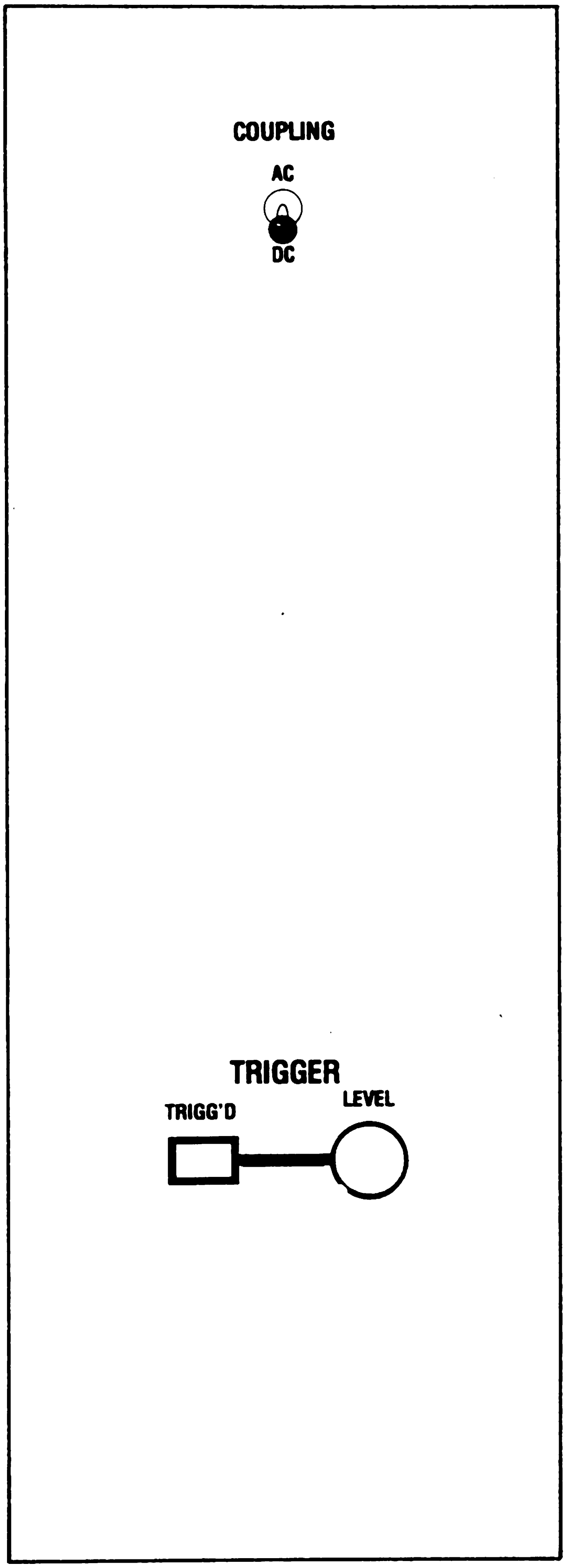
- (S) - "Slave," trigger comes from the "master" Plug-in when multiple Plug-ins are being triggered from a common source. The "master" Plug-in's switch must be in the (A), (B), or (EXT) positions. The "slave" Plug-in(s) must be in the (S) position.
- (A) - Trigger signal is derived from channel A.
- (B) - Trigger signal is derived from channel B.
- EXT - Trigger signal is derived from the EXT input BNC.



TRIGGER SLOPE SWITCH

Selects the signal's voltage transitions that will qualify it as a valid trigger.

- (+) - Positive-going only.
- (-) - Negative-going only.
- DUAL - Either positive- or negative-going voltage transitions.



TRIGGER COUPLING SWITCH

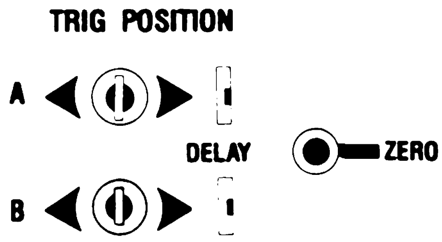
Determines whether or not the dc component of the input signal will be blocked.

- AC - Only the ac component of the signal is applied to the trigger circuit. The dc component is blocked.
- DC - All frequency components of the input signal are applied to the trigger circuit. Used when low frequency input signals are to be inspected or the dc component is of importance.

TRIGGER LEVEL CONTROL & TRIGG'D LED

Adjusts the voltage level that must be crossed by the triggering signal to qualify as a valid trigger.

The green LED indicator illuminates each time a valid trigger initiates a sweep.

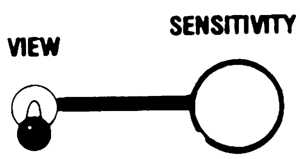


TRIGGER POSITION CONTROLS

Selects whether the screen will display post-trigger events (Normal Trigger), both pre- and post-trigger events (Cursor Trigger), or events that occurred following a specific time delay (Delayed Trigger).

- Normal Trigger - Press the Zero button.
- Cursor Trigger - Press the paddle switch to the right.
- Delayed Trigger - Press the paddle switch to the left.

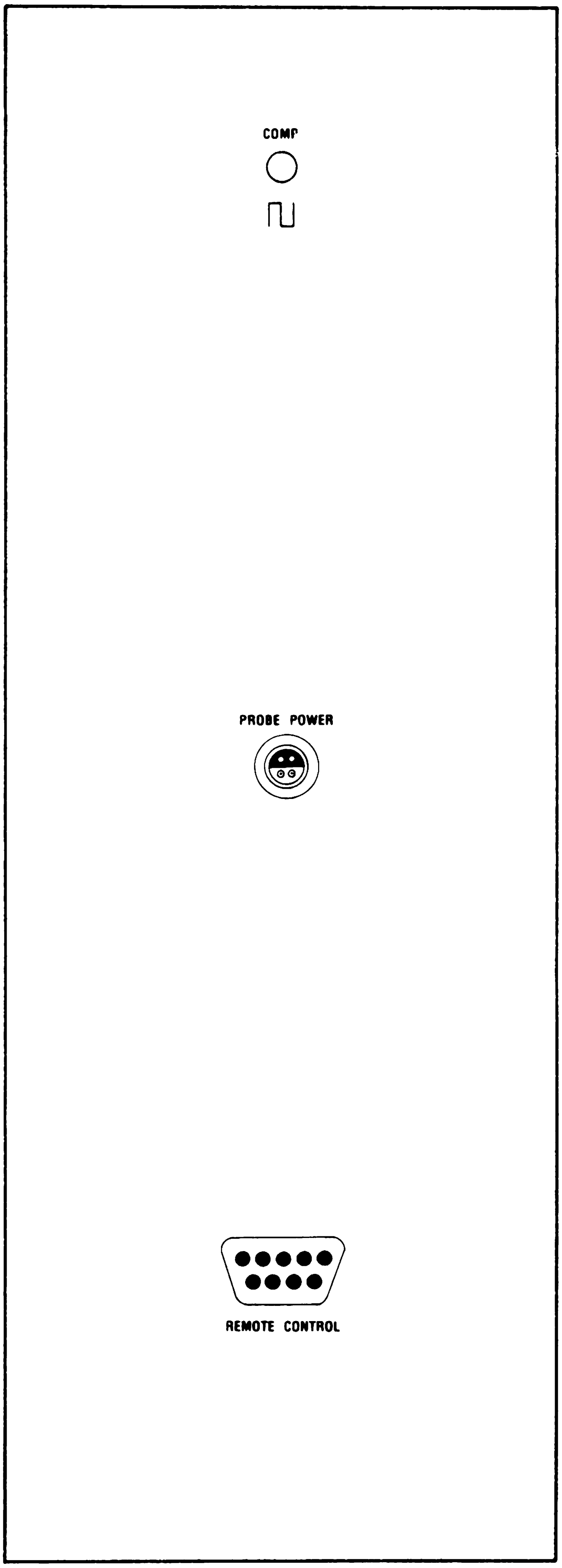
The adjacent LED indicator(s) illuminate when either Cursor or Delayed Trigger modes are selected.



TRIGGER SENSITIVITY & VIEW CONTROLS

The Trigger SENSITIVITY control adjusts the "window" (voltage span) that the signal must pass through before it will qualify as a valid trigger.

The VIEW switch, when turned on, introduces a "trigger adjust" display. This display assists the operator in the selection of specific characteristics that will qualify the signal as a valid trigger.



COMPENSATION POINT

Placing the test probe against the compensation point produces a square-wave display. This display assists the operator in the compensation of the test probe for the best response times.

PROBE POWER CONNECTOR

Provides a +12 and/or -12 VDC output.

REMOTE CONTROL CONNECTOR

Permits remote control of the Plug-in.

CHANNEL SWITCHES

The display memory will not store data unless the ON/OFF switch associated with the channel acquiring data is placed to the "ON" position.

For example, the CHANNEL A switch must be in the "ON" position if channel A is acquiring input signals.

If only one channel (typically channel A) is being used to acquire input signals, turn the unused channel off. This allows the entire display memory of 15,872 addresses to record data if the Mainframe's MEMORY switch is in the "ALL" position.

The number of addresses that will record each input signal depends upon the positions of the CHANNEL and MEMORY switches. Table 8-1 tabulates the number of addresses that will record each input signal.

NOTE: Table 8-1 is for single Plug-in operation only.

CHANNEL SWITCH		MEMORY SWITCH POSITION		
A	B	ALL	HALVES	QUARTERS
ON	OFF	15,872	7,936	3,968
OFF	ON	15,872	7,936	3,968
ON	ON	7,936	3,968	1,984

Table 8-1

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DC/AC/GND SWITCHES

This instrument uses high impedance, differential amplifiers. The high impedances (10^6 ohms) and low bias currents (10^{-10} amps) allow high impedance signal sources to be measured because of the light loading effect of the amplifiers.

The DC/AC/GND switches control the operation of the associated amplifiers' inputs.

> CAUTION - Always ensure that the input signals never exceed the maximum, allowable input voltage, with respect to ground, listed under tab *Specifications*.

- DC
  Allows both ac and dc components of the input signal to enter the amplifier.

- AC
  Blocks the dc component. Only the ac component of the signal enters the amplifier.

- GND
  Grounds the amplifier's input. Neither ac nor dc components will enter the amplifier.

NOTE: Always ground an unused amplifier input by placing the associated DC/AC/GND switch to the "GND" position. An ungrounded, unused input will introduce "noise."

Each of the amplifiers can be used as either Differential or Single-ended amplifiers.

- DIFFERENTIAL AMPLIFIERS

Placing the channel's DC/AC/GND switches to either the "DC" or "AC" position allows the amplifier to measure the difference between the voltages applied to the (+) and (-) input BNCs.

- SINGLE-END AMPLIFIERS

Placing one of the channel's DC/AC/GND switches to "GND" and the remaining switch to either "DC" or "AC" allows the oscilloscope to display the voltages applied to the active input.

STORAGE CONTROL BUTTONS

The Storage Control consists of three buttons: LIVE, HOLD NEXT and HOLD LAST.

These buttons determine whether or not data stored in the display memory will be replaced when a valid trigger is received.

- LIVE

Pressing the LIVE button erases the displayed data from the screen, readying it for the next display.

It also serves as a "master reset," enabling the Plug-in to determine whether or not any of the controls have been altered since the last signal acquisition.

➤ IMPORTANT: Changes made to the Plug-in's controls, while the LIVE LED is illuminated, will NOT be acknowledged until either the operator presses the LIVE button or the next valid trigger occurs.

- HOLD NEXT

The Live mode must be activated before the HOLD NEXT button is pressed.

The stored data is replaced when the next valid trigger is received. The Plug-in enters the Hold mode as soon as the sweep is completed.

- HOLD LAST

Pressing the HOLD LAST button allows a sweep currently in progress to be completed and then inhibits any further sweeps.

Data stored in the display memory is protected when only the Hold Last LED is illuminated, (Hold mode).

NOTE: If data stored in portions of the memory is to be saved, ensure that the Live LED is off before repositioning the Mainframe's MEMORY switch. Otherwise, data will be replaced if a valid trigger is received.

••Hold Mode

The Plug-in should be in the Hold mode (only the Hold Last LED is illuminated) whenever a Plug-in parameter is changed. See IMPORTANT note on Page 8-1.

- REMOTE CONTROL

Refer to Page 8-43, *Remote Control Connector* descriptions.

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±VOLTS FULL SCALE SWITCH

Allows signals ranging from ±100 millivolts to ±40 volts full scale to be measured when the X1 probe is used.

A maximum of ±400 volts full scale can be measured when the optional X10 probe is used.

The voltage numerics are directly related to the measured voltages when either the X1 or special X10 probe is used. Refer to tab *Accessories* for information on the special X10 probe.

The screen can display up to 32,768 voltage levels when the VERTICAL EXPANSION switch is turned off.

If the zero volts reference is vertically centered on the screen, the positive voltages will be displayed above the zero volts level by up to 16,383 levels. The negative voltages will be displayed below the zero volts level by up to 16,384 levels. Refer to Figure 8-1.

Table 8-2 tabulates the voltage increment of each level (volts per level) according to the position selected on the ±VOLTS FULL SCALE switch.

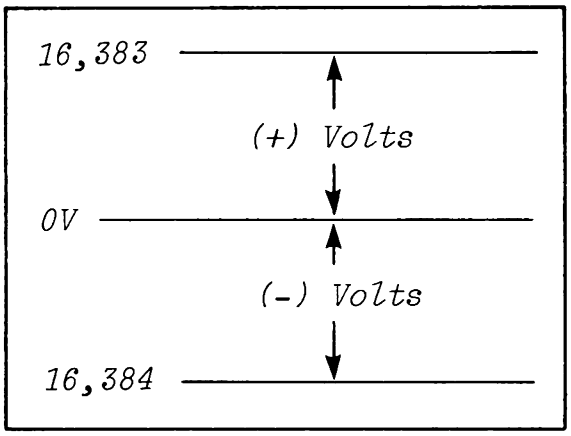

Figure 8-1

± V.F.S.	VOLTS PER LEVEL
100 mV	*6.25 uV*
200 mV	*12.50 uV*
400 mV	*25.00 uV*
1 V	*62.50 uV*
2 V	*125.00 uV*
4 V	*250.00 uV*
10 V	*625.00 uV*
20 V	*1.25 mV*
40 V	*2.50 mV*

Table 8-2

TIME PER POINT SWITCH

Determines the time resolution of the displayed signal. The faster the time-per-point when the signal is acquired, the higher the time resolution.

The Plug-in samples and digitizes the input signal's voltages once every 10 microseconds. This sampling rate is preset within the oscilloscope's circuitry. However, which of the sampled voltages will be selected for display is determined by the TIME PER POINT switch.

EXAMPLE #8-1

Figure 8-2: A typical input signal.

Figure 8-3: The 10 microsecond sampling rate superimposed over the signal.

Figure 8-4: The resulting digitized samples represented by dots.

Figure 8-5: Assume a time-per-point of 20 uSec. Every other digitized sample (larger dots) are selected for display.

Figure 8-6: Assume a time-per-point of 100 uSec's. Every tenth digitized sample (large dot) is selected for display.

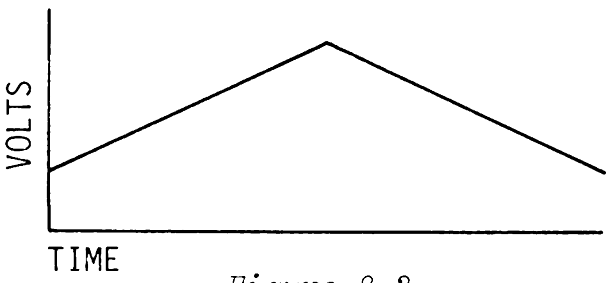

Figure 8-2

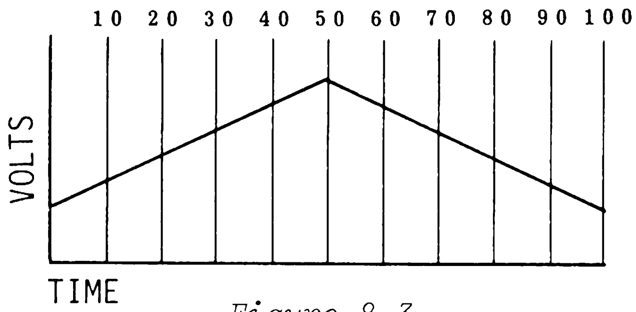

Figure 8-3

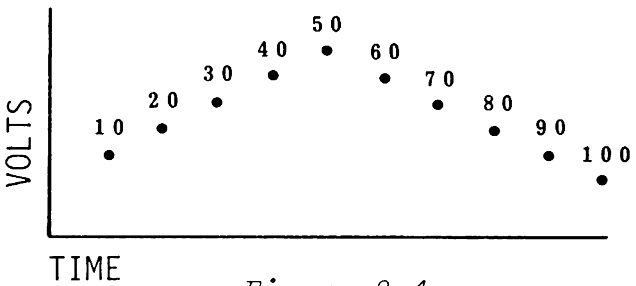

Figure 8-4

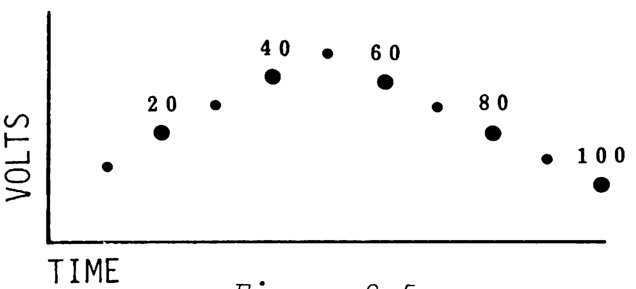

Figure 8-5

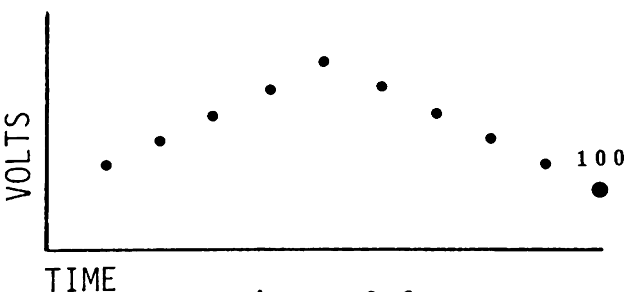

Figure 8-6

The number of allotted addresses (words) with which the display memory will record each input signal depends upon -

#1. The positions of the CHANNEL A and B "ON/OFF" switches; and

#2. The position selected on the Mainframe's MEMORY switch

Table 8-3 tabulates the approximate number of memory addresses that will record each input signal.

CHANNEL SWITCH		MEMORY SWITCH POSITION		
A	B	ALL	HALVES	QUARTERS
ON	OFF	*16K*	*8K*	*4K*
OFF	ON	*16K*	*8K*	*4K*
ON	ON	*8K*	*4K*	*2K*

Table 8-3

NOTE: Table 8-3 is for single Plug-in operation only.

SWEEP TIMES

Table 8-4 tabulates the approximate sweep times for single-channel measurements. For multiple channels, divide the listed times accordingly:

Two channels ------------------- (2)
Three or four channels --------- (4)

TIME PER POINT SWITCH	MEMORY SWITCH POSITIONS (Data Points Per Sweep)		
	ALL (15,872)	H1/H2 (7,936)	Q1/Q2/Q3/Q4 (3,968)
	Milliseconds Per Sweep		
10 μS	158.800	79.400	39.700
20	317.600	158.800	79.400
50	794.000	397.000	198.500
100	1588.000	794.000	397.000
200		1588.000	794.000
	Minutes Per Sweep		
1 mS	0.264	0.132	0.066
2	0.528	0.264	0.132
5	1.320	0.660	0.330
10	2.640	1.320	0.660
20	5.280	2.640	1.320
50	13.200	6.600	3.300
	Hours Per Sweep		
0.1 S	0.440	0.220	0.110
0.2	0.880	0.440	0.220
0.5	2.200	1.100	0.550
1	4.400	2.200	1.100
2	8.800	4.400	2.200
5	22.000	11.000	5.500
10	44.000	22.000	11.000
20	88.000	44.000	22.000
50	220.000	110.000	55.000
100	440.000	220.000	110.000
200	880.000	440.000	220.000

Table 8-4

● EXT I & II POSITIONS

The EXT I (fast) and EXT II (slow) time-per-point positions are used when -

#1. The desired time-per-point is not available on the TIME PER POINT switch; or

#2. The sampling rate is generated from a nonlinear time base.

The number of allotted addresses (words) that will record each input signal depends upon -

#1. The positions selected on the CHANNEL A and B "ON/OFF" switches; and

#2. The position selected on the Mainframe's MEMORY switch.

Table 8-5 tabulates the corresponding number of memory addresses that will record each input signal.

NOTE: Table 8-5 is for single Plug-in operation only.

The sampling of the input signal will begin *** nS to *** nS (and end *** nS to *** nS) after the "EP" command is applied to the Remote Control Connector.

CHANNEL SWITCH		MEMORY SWITCH POSITION		
A	B	ALL	HALVES	QUARTERS
ON	OFF	*15,872*	*7,936*	*3,968*
OFF	ON	*15,872*	*7,936*	*3,968*
ON	ON	*7,936*	*3,968*	*1,984*

Table 8-5

IN EXT I (fast) mode, a delay will occur between the time of the first sample and the time at which a display will appear. This delay occurs because the samples are stored by the Plug-in's buffer memory before being "dumped" into the display memory.

This time delay can be approximated by multiplying the allotted addresses (from Table 8-5) by the average time period between each sample. See Equation 8-1.

Time Delay = (addresses) x (period)

Equation 8-1

In EXT II (slow) mode, each sample will be displayed as soon as it is acquired, allowing real-time monitoring of slow signals.

** Exact spec's to be verified.*

● EXT I Position

The EXT I position is used when the sampling rate is between *** µS and ** µS (or *** µS and *** µS if averaging is applied). The EXT I mode requires two external commands to acquire samples:

#1. A valid trigger command; and

#2. A TTL input signal (EP command) applied to the Remote Control Connector.

The trigger command initiates the sampling sequence and first data point acquisition, and the "EP" commands determine the sampling rate. Samples are acquired with *** nS of the leading, positive edge of the "EP" commands. The buffer memory stores all of the data points before "dumping" them into the display memory.

NOTE: The Point Average mode is not operable in the EXT I mode.

EXAMPLE #8-2

Figure 8-7: Typical input signal.

Figure 8-8: "EP" commands superimposed over the input signal.

Figure 8-9: A valid trigger occurring at that point in time.

Figure 8-7

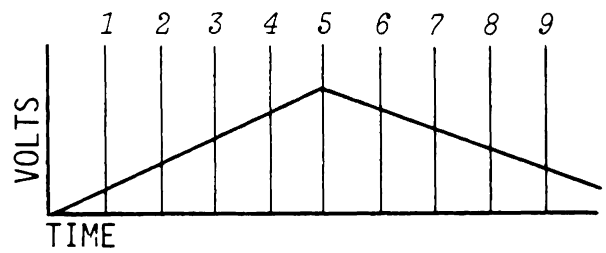

Figure 8-8

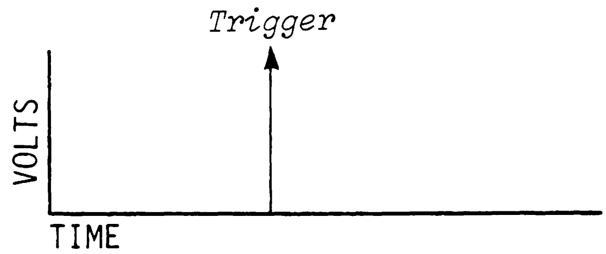

Figure 8-9

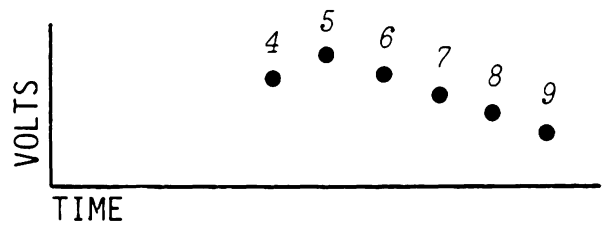

Figure 8-9A

Figure 8-9A: The corresponding digitized samples, represented by the dots, that will be stored in the display memory.

* *Exact spec's to be verified.*

● EXT II POSITION

The EXT II position is used when the sampling rate is equal to, or slower than ** µS (or *** µS if averaging is applied). The EXT II mode requires two external commands to acquire samples:

#1. A valid trigger command; and

#2. A TTL input signal (EP command) applied to the Remote Control Connector.

The trigger command initiates the sampling sequence and the first data point acquisition, and the "EP" commands determine the sampling rate. Each data point will immediately appear on the display screen as each one is acquired.

NOTE: The Point Average mode is not operable in the EXT II mode.

EXAMPLE #8-3

Figure 8-10: Typical input signal.

Figure 8-11: "EP" commands superimposed over the input signal.

Figure 8-12: A valid trigger occurring at that point in time.

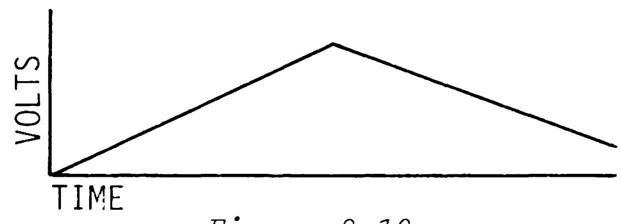

Figure 8-10

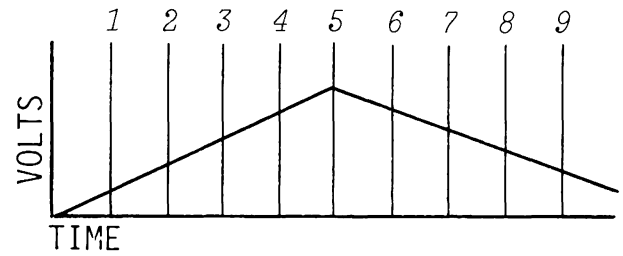

Figure 8-11

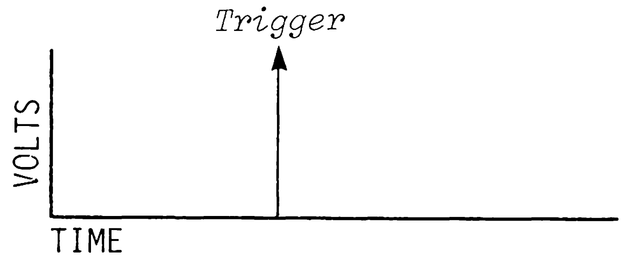

Figure 8-12

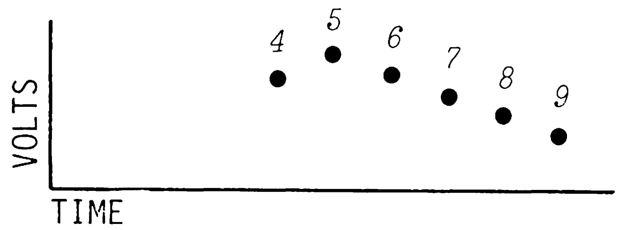

Figure 8-13

Figure 8-13: The corresponding digitized samples, represented by the dots, that will be stored in the display memory.

** Exact spec's to be verified.*

FILTER SWITCH

Rejects high frequency "noise" components on the input signal.

This feature can be used in any acquisition mode, including Average and Point Average.

NOTE: 1 kHz = -*db/point.

POSITION CONTROL

Vertically repositions a "live" display on the screen.

NOTE: The POSITION control does not introduce a dc offset to the signal. Rather, it varies the location of the zero volts reference on the screen by up to 60% of the selected Volts Full Scale.

For example, if the selected Volts Full Scale equals ±1V, the display can be varied from (+1.6 V to -0.4 V) down to (-1.6 V to +0.4 V) by using the POSITION control.

The voltage numerics will remain unchanged when the POSITION control is used.

* *Exact spec's to be verified.*

SAVE REFERENCE SWITCH

➤ IMPORTANT: The Trigger View mode overrides the Save Reference mode. See IMPORTANT note on Page 8-30.

Allows "live" and stored signals to be compared when the Plug-in is operating in the Live mode. This enables the operator to observe the effects of altering the characteristics of the input signal.

Turning the SAVE REFERENCE switch on causes alternate, displayed data point coordintes to become "frozen" in the display memory's addresses. The remaining addresses continue to record changes in the input signal and display these changes superimposed over the "frozen" data points. The reference of the "frozen" display is protected in the Live mode.

In addition, the Plug-in/Channel numerics will also display a letter "R" suffix indicating which data points have been saved ("frozen").

The display returns to normal operation when the switch is turned off.

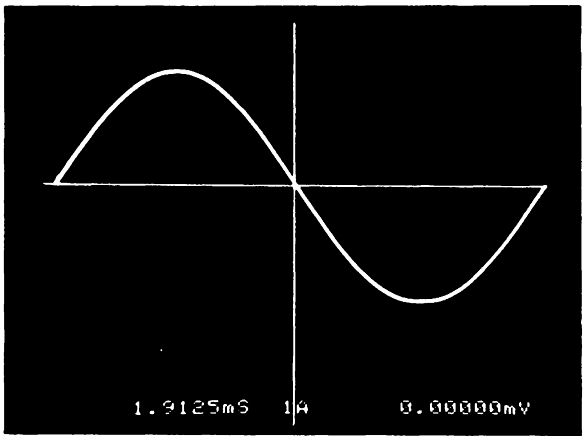

Figure 8-14

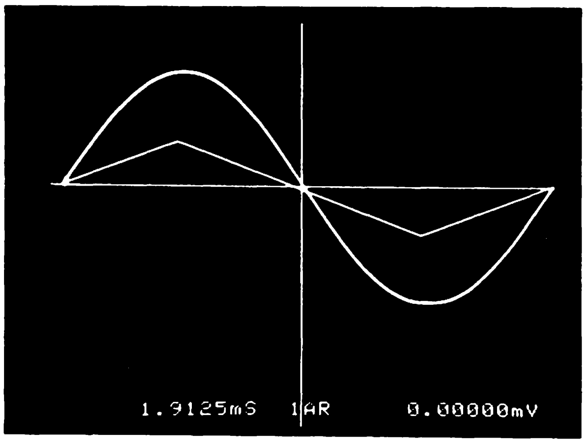

Figure 8-15

EXAMPLE #8-4

Figure 8-14: Typical signal acquired with SAVE REFERENCE turned off.

Figure 8-15: Resulting display of the altered signal superposed over the original signal when the SAVE REFERENCE switch was turned on.

AVERAGE SWITCH

Reduces the effects of "noise" on recurrent input signals by "sweep" averaging successive sweeps.

To function properly, the input signal must be time-locked to an associated trigger signal.

The sampling rate is determined by the selected Time-Per-Point.

Sample voltages acquired during the first sweep are stored in the memory. Then, samples acquired during the second sweep are averaged with those acquired during the first sweep. Each "newer" average, computed from Equation 8-2, updates the memory.

This process of averaging "new" samples with the "old" averages stored in the memory repeats for each sweep.

$$SV_{ave} = \text{Old} \times \frac{(K-1)}{K} + \frac{\text{New}}{K}$$

Equation 8-2

- (Old): The average voltage value currently stored in the memory's address.
- (New): The newest sampled voltage acquired during the current sweep.
- (K): The values tabulated in Table 8-6, corresponding to the sweep in progress.

SWEEP	1	2	3-5	6-10	11-21
K	*1*	*2*	*4*	*8*	*16*

Table 8-6

The term "K" is computed from Equation 8-3. The result is rounded off to the nearest, lower power of two, (2^n).

$$K = \text{Sweep} + \frac{\text{Sweep}}{2}$$

Equation 8-3

NOTE: This type of averaging is called virtual averaging and is similar to "true" or normalized averaging. However, unlike normalized averaging, virtual averaging "weights" each sweep differently because of the use of binary number "K" instead of "N" (Number of Sweeps). If the variations in voltages, from sweep to sweep, are due entirely to "noise" and not because of signal changes, the result is identical.

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EXAMPLE #8-5

Figure 8-16: First sweep sampled at 1V1, 1V2, ... $1V_x$.

Figure 8-17: Second sweep sampled at 2V1, 2V2, ... $2V_x$.

Figure 8-18: Third sweep sampled at 3V1, 3V2, ... $3V_x$.

If -

1V1 = 8V, 2V1 = 10V, and 3V1 = 8V, the average value of the first data point displayed (AV_1, AV_2, AV_3) during each of the three sweeps equals:

$$AV_1 = 0V \times \frac{(1-1)}{1} + \frac{8V}{1} = 8V$$

$$AV_2 = 8V \times \frac{(2-1)}{2} + \frac{10V}{2} = 9V$$

$$AV_3 = 9V \times \frac{(4-1)}{4} + \frac{8V}{4} = 8.75V$$

Figure 8-19: The upper display illustrates a "noisy" signal acquired without the Average mode.

The lower display illustrates, after several sweeps, the same "noisy" signal captured with the Average mode.

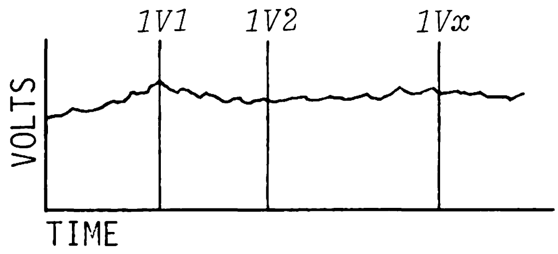

Figure 8-16

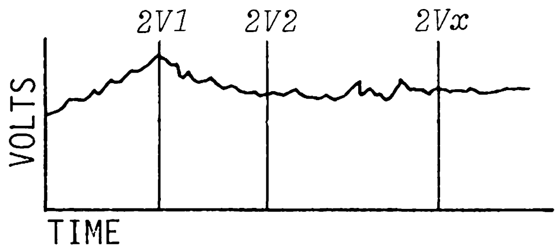

Figure 8-17

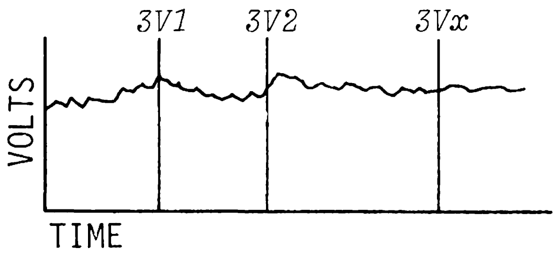

Figure 8-18

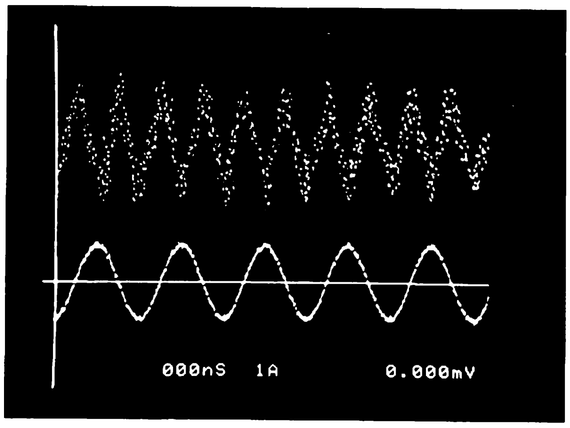

Figure 8-19

POINT AVERAGE SWITCH

Reduces the effects of "noise" on an input signal acquired when the time-per-point is slower than *** micro-seconds.

The oscilloscope acquires data at a constant rate of *** microseconds per sample. As each sample is acquired, it is averaged with the preceding samples within the same sampling period (time-per-point setting).

For example, an average is computed from the values of the first and second samples which, in turn, is averaged with the value of the third sample, etc.

When the last sample within the string has been averaged, the final averaged value is stored in one of the memory's addresses and displayed by a single data point coordinate.

This process repeats until each one of the memory's allotted addresses has recorded an average value.

The point average values are computed by Equation 8-4.

$$PV_{ave} = \text{Old} \times \frac{(K-1)}{K} + \frac{\text{New}}{K}$$

Equation 8-4

- (Old): The average voltage value currently stored in the memory's address.
- (New): The newest sampled voltage acquired within the string.
- (K): The values tabulated in Table 8-7, corresponding to the sample being acquired.

SAMPLE	1	2	3-5	6-10	11-21
K	*1*	*2*	*4*	*8*	*16*

Table 8-7

The term "K" is computed from Equation 8-5. The result is rounded off to the nearest, lower power of two, (2^n).

$$K = \text{Sample} + \frac{\text{Sample}}{2}$$

Equation 8-5

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*Exact spec's to be verified.

EXAMPLE #8-6

Assume that a string of three samples will be point averaged for each data point coordinate.

Figure 8-20: The first string sampled at 1V1, 1V2, and 1V3 for the first data point to be displayed in the sweep. (Sample 2V1 starts the second string of samples for the second data point.)

If-
1V1 = 6V, 1V2 = 8V, and 1V3 = 4V, the average voltage value of the first data point to be displayed in the sweep will equal 6.25 volts.

Where -

$$PV_1 = 0V \times \frac{(1-1)}{1} + \frac{6V}{1} = 6V$$

$$PV_2 = 6V \times \frac{(2-1)}{2} + \frac{8V}{2} = 7V$$

$$PV_3 = 7V \times \frac{(4-1)}{4} + \frac{4V}{4} = 6.25V$$

Figure 8-21: The upper display illustrates a "noisy" signal acquired without the Point Average mode.

The lower display illustrates, after one sweep, the same "noisy" signal captured with the Point Average mode.

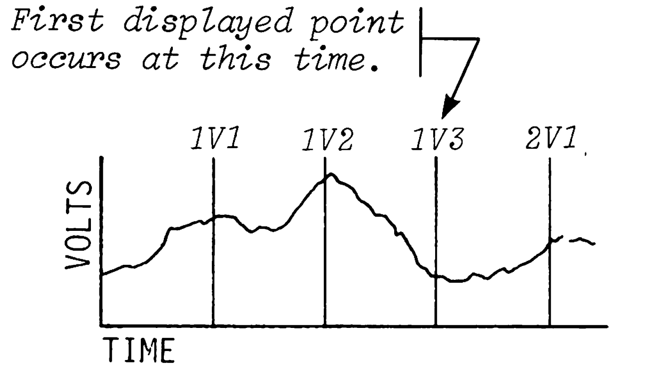

Figure 8-20

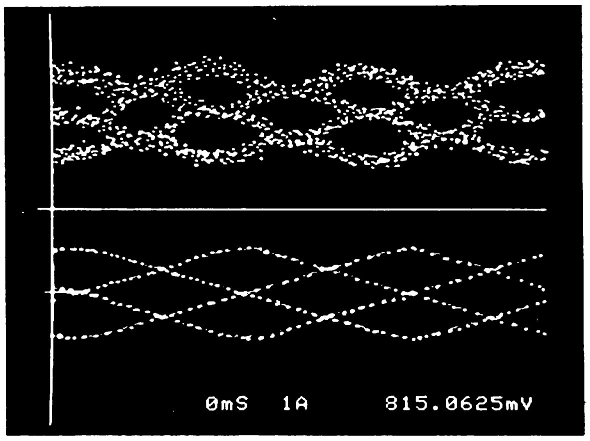

Figure 8-21

- COMBINING AVERAGE & POINT AVERAGE

The "sweep" Average and Point Average modes of operation can be combined if the time-per-point is slower than *** microseconds. The effectiveness of averaging very "noisy," repetitive signals is enhanced when both of these modes are combined.

Essentially, Point Averaged values acquired during the first sweep are recorded in the memory's addresses. Then, as each "new" Point Averaged value is acquired in the second sweep, it is "sweep" Averaged with the corresponding value stored in the memory. The resulting average values continually replace the "older" values stored in the memory.

This process of "sweep" Averaging the "older" values stored in the memory with the "newer" Point Averaged values acquired during the current sweep repeats with every sweep, providing additional improvements in the signal to noise ratio.

The FILTER switch can also be used in conjunction with the Average and/or Point Average modes of operation.

Exact spec's to be verified.

SOURCE SWITCH

Selects whether the triggers will be derived from either the channel A or channel B amplifiers, or through the EXT input BNC.

● EXT
Selected when the trigger is applied to the EXT input BNC, enabling a common trigger to simultaneously initiate sweeps on both channels.

The amplitude of the signal must be *** volts minimum to qualify as a valid trigger.

● A or B

Selected to allow amplification of the signal before it enters the trigger detection circuits. The signal must be at least **% of the selected Volts Full Scale to qualify as a valid trigger.

NOTE: A valid trigger applied to channel A will also initiate a sweep on channel B if the CHANNEL B "ON/OFF" switch is turned on. The opposite is true when a trigger is applied to CHANNEL B.

● S
Selected when multiple Plug-ins will be triggered by a common signal.

The trigger must be applied to the "Master" Plug-in and the position selected on that Plug-in's SOURCE switch (A, B, or EXT) must correspond accordingly.

The remaining Plug-in(s) are referred to as the Slave Plug-ins. The SOURCE switch(es) must be placed to the "S" position.

A trigger applied to the Master Plug-in will also trigger a sweep at the Slave Plug-ins.

** Exact spec's to be verified.*

AUTO/NORM SWITCH

Determines whether the trigger will be generated internally in the absence of a valid trigger signal or solely by an external source.

- AUTO

Automatically triggers in the absence of a valid trigger.

- NORM

The trigger is externally generated. The next valid trigger to occur, after the preceding sweep has been completed, will initiate a new sweep.

COUPLING SWITCH

Determines whether or not a dc component on the triggering signal being applied to the EXT input BNC will be attenuated.

- AC

Signals are capacitively coupled to the trigger detection circuit. DC components of approximately 2 hertz, or less, are attenuated while the ac component is allowed to pass.

- DC

Both ac and dc components of the signal are coupled to the trigger detection circuitry.

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VIEW SWITCH

➤IMPORTANT: Displayed data will be erased from the display memory when the VIEW switch is turned on. Precautions must be taken if the displayed data is to be saved. (Such as recording the data on a diskette or placing the MEMORY switch to an empty, or unimportant, "halves" or "quarters" position.) In addition, the View mode will override the Save Reference mode and the functions of the TRIG POSITION controls.

Two horizontal lines appear and the Plug-in's Trigger cursor moves to screen center when VIEW is selected and the Plug-in is operating in the Live mode with sweeps occurring. A letter "V" suffix will be added to the Plug-in/Channel numerics, (e.g., 1AV). If external triggering is selected, the Plug-in number will be followed by an "EV" suffix, (e.g., 1EV).

The configuration and position of the two lines indicate the slope (page 8-31), minimum amplitude (page 8-32), and minimum voltage change (page 8-33) that the signal must experience to qualify as a valid trigger. All three characteristics must be met by the signal before a sweep will be initiated.

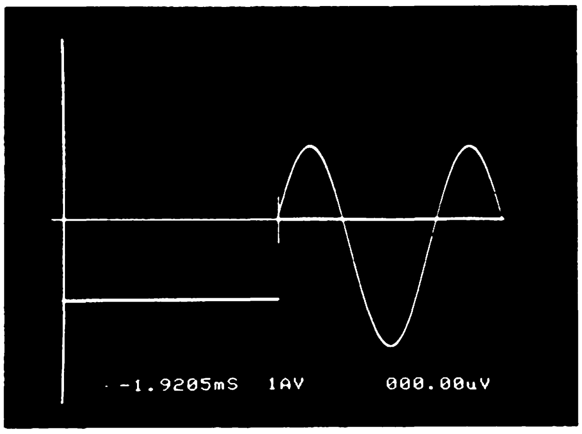

Figure 8-22

To use the VIEW mode:

#1. Take precautions to save any important data stored in the display memory.

#2. If any of the Plug-in's controls must be repositioned, place the Plug-in into the Hold mode, or press the LIVE button after the controls have been repositioned.

#3. AUTO/NORM switch: As required.

#4. VIEW switch: On

#5. LIVE button: Press.

EXAMPLE #8-7

Figure 8-22: Typical VIEW display with Positive Slope selected.

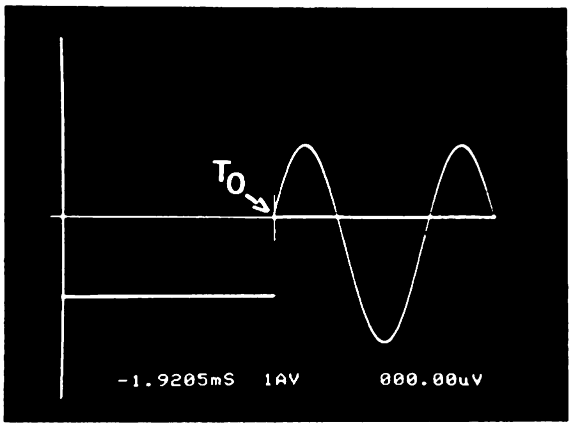

Figure 8-23

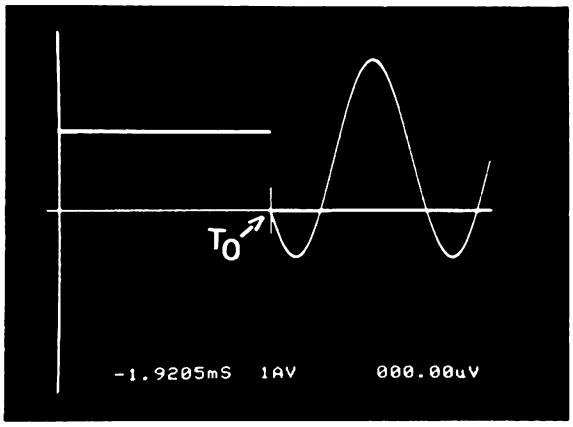

Figure 8-24

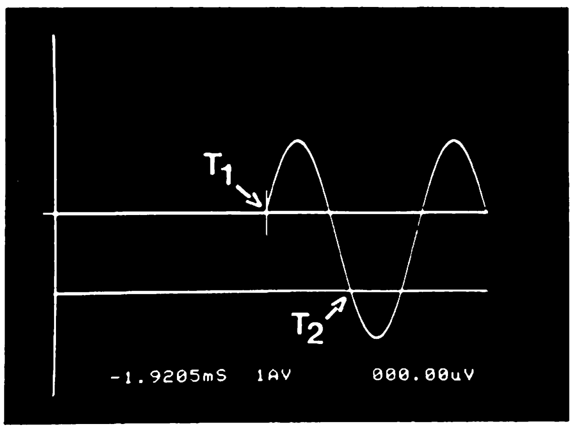

Figure 8-25

SLOPE SWITCH

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch.

Determines whether positive and/or negative going voltage transitions will qualify the signal as a trigger.

- (+) Slope

The signal voltage must be increasing.

- (-) Slope

The signal voltage must be decreasing.

- DUAL Slope

Either increasing or decreasing voltage values will qualify the signal.

EXAMPLE #8-8

Figure 8-23: (+) slope display. Signal qualifies as a valid trigger component at point (T_0).

Figure 8-24: (-) slope display. Signal qualifies as a valid trigger component at point (T_0).

Figure 8-25: DUAL slope display. Signal qualifies as a valid trigger at either point (T_1) or (T_2).

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LEVEL CONTROL

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch.

The LEVEL control adjusts the threshold levels which, when crossed by the signal, will qualify the signal as a valid trigger component.

Which of the two lines must be crossed by the signal is a function of the SLOPE switch.

- (+) - The signal must cross the upper threshold level.
- (-) - The signal must cross the lower threshold level.
- DUAL - The signal can cross either threshold level.

EXAMPLE #8-9

Figure 8-26: A (+) slope display. Signal qualifies as a valid trigger component at point (T_0).

Figure 8-27: A (-) slope display. Signal qualifies as a valid trigger component at point (T_0).

Figure 8-28: A DUAL slope display. Signal qualifies as a valid trigger at either point (T_1) or (T_2).

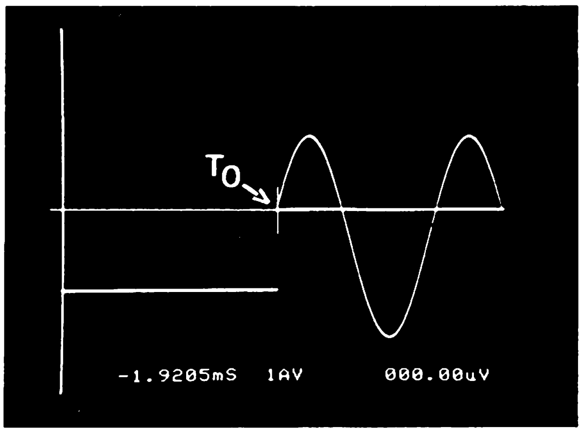

Figure 8-26

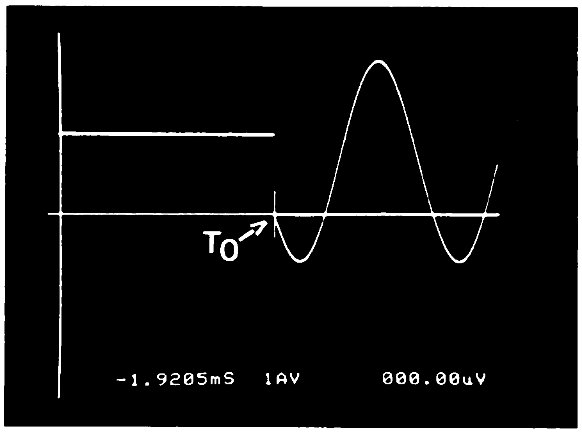

Figure 8-27

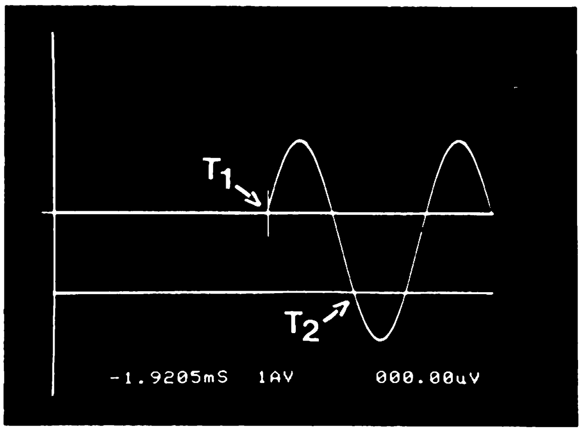

Figure 8-28

SENSITIVITY CONTROL

➤NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch.

Adjusts the distance (window) between the two threshold levels. This "window" must be crossed by the signal in order to qualify as a valid trigger component when either (+) or (-) slope triggering is selected.

The "window" voltage can be adjusted from a range of *** millivolts to ** volts when triggering via the EXT input BNC. And from *% to **% of the Volts Full Scale when triggering via the channel A or B amplifiers.

The voltage numerics will alternate between the voltage values of the upper and lower threshold levels when the vertical cursor is moved across the display screen with Autocenter turned on.

EXAMPLE #8-10

Figure 8-29: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.

Figure 8-30: The dashed lines on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger component.

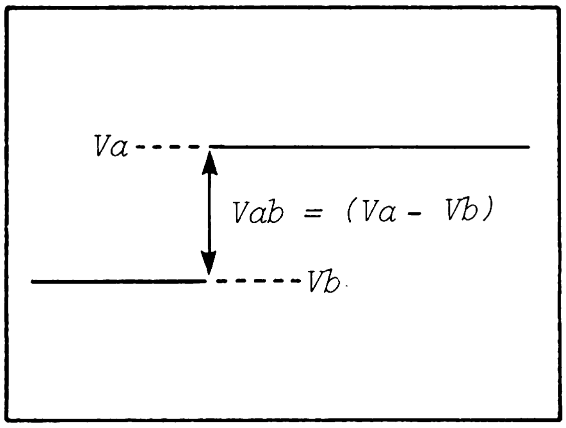

Figure 8-29

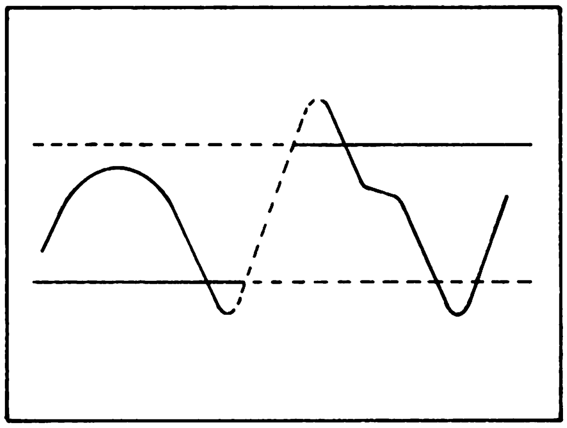

Figure 8-30

*Exact spec's to be verified.

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RECURRENT TRIGGERING

● (+) or (-) SLOPE TRIGGERING

After the first trigger has been initiated, the signal's slope must reverse, pass through the "window," reverse again, and then pass through the "window" once more in order to initiate another trigger.

EXAMPLE #8-11

Assume (+) Slope triggering has been selected and the VIEW switch is on.

Figure 8-31: The first positive slope (solid line) starts below the lower threshold level, passes through the "window," and initiates a trigger at point (T_1). The dashed lines represent the path that the signal must follow in order to initiate a second trigger at point (T_2).

Figure 8-32: Once again, the signal qualifies as a trigger at point (T_1). Since the second positive slope did not start below the lower threshold, a trigger will not occur at point (A). It will, however, occur at point (T_2) because the positive slope begins below the lower threshold.

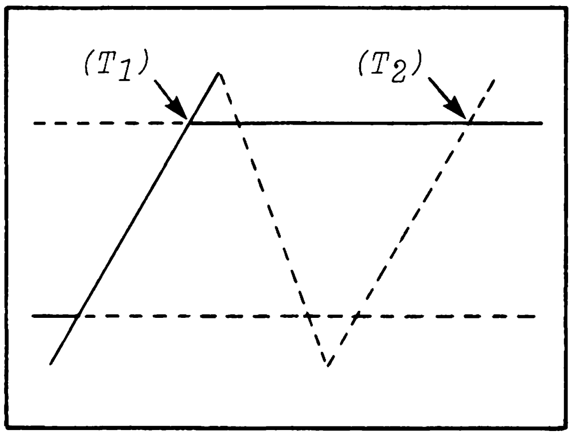

Figure 8-31

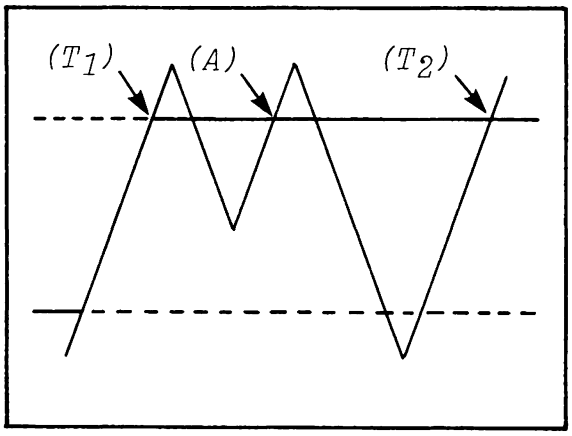

Figure 8-32

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● DUAL SLOPE TRIGGERING

Recurrent triggers will be initiated each time the signal crosses either threshold level with the proper slope. The signal does not have to recross through the "window."

NOTE: The signal must experience a voltage change of *% (minimum) of the selected Volts Full Scale to qualify as a valid trigger.

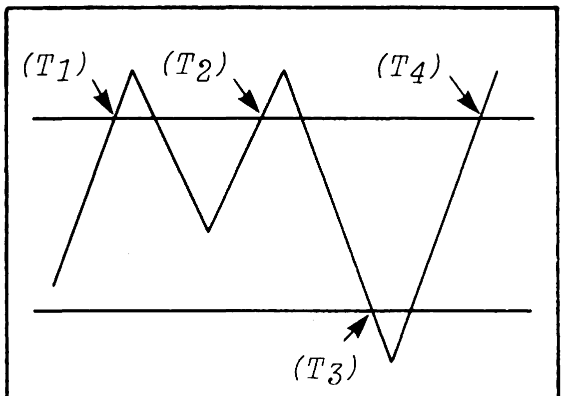

Figure 8-33

EXAMPLE #8-12

Assume "DUAL" slope triggering has been selected on the SLOPE switch and the VIEW switch is on.

Figure 8-33: Valid triggers will occur at points (T_1 thru T_4) because the signal crosses the threshold levels with the correct slopes.

** Exact spec's to be verified.*

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ADJUSTING THE TRIGGER

● (+) or (-) SLOPE TRIGGERING

#1. SLOPE: (+) or (-)

#2. AUTO/NORM: Auto

#3. COUPLING: As required.

#4. VIEW: On

#5. Trigger: Apply to EXT input BNC or to one of the channels.

#6. SOURCE: As required.

#7. DC/AC/GND: As required.

#8. LIVE: Press.

#9. POSITION: Adjust display for best placement.

#10. VOLTS FULL SCALE: As required.

#11. SENSITIVITY: Full counterclockwise. Then adjust clockwise until the "window" exceeds any "noise" spikes.

#12. LEVEL: Adjust until the upper threshold (+ slope) or lower threshold (- slope) intersects the desired trigger point.

#13. Fine tune the SENSITIVITY and LEVEL controls as required.

#14. After the SENSITIVITY and LEVEL controls have been properly positioned, place the AUTO/NORM switch to the "NORM" position. The Plug-in will continue to trigger.

NOTE: The TRIGGER light illuminates when a valid trigger is received and remains illuminated until the sweep is completed.

- DUAL SLOPE TRIGGERING

#1. SLOPE: Dual

#2. AUTO/NORM: Auto

#3. COUPLING: As required.

#4. VIEW: On

#5. Trigger: Apply to EXT input BNC or to one of the channels.

#6. SOURCE: As required.

#7. DC/AC/GND: As required.

#8. LIVE: Press.

#9. POSITION: Adjust display for best placement on screen.

#10. VOLTS FULL SCALE: As required.

#11. SENSITIVITY: Full counter-clockwise.

#12. LEVEL: Adjust until "window" is centered between the desired positive and negative trigger points.

#13. SENSITIVITY: Adjust until the upper and lower threshold levels intersect the desired positive and negative trigger points.

#14. Fine tune the LEVEL and SENSITIVITY controls as required.

#15. After the SENSITIVITY and LEVEL controls have been properly positioned, place the AUTO/NORM switch to the "NORM" position. The Plug-in will continue to trigger.

NOTE: The TRIGGER light illuminates when a valid trigger is received and remains illuminated until the sweep is completed.

TRIGGER POSITION CONTROLS

The TRIG POSITION controls consist of a ZERO button (common to both channels), paddle "A" (channel A only), and paddle "B" (channel B only).

These controls select whether post-trigger (Normal), pre- and post-trigger (Cursor), or delayed trigger (Delayed) events will be displayed.

NOTE: These can be mixed or matched in multiple channel operation. Refer to *Special Procedures* tab, page 15-5.

● LIVE MODE (Coarse Adjust)
Pressing the paddle control causes the Trigger cursor to move 1/8 of full screen at the end of each sweep.

● LIVE MODE (High Speed Adjust)
Pressing, and holding, the LIVE button and paddle control causes a high speed movement of the Trigger cursor.

● SET-UP MODE (Fine Adjust)
Initiated by simultaneously pressing the HOLD LAST and HOLD NEXT buttons, illuminating all three STORAGE control LEDs. NOTE: ENSURE THAT THE HOLD LAST BUTTON IS RELEASED FIRST. The trigger's rate of movement increases the longer the paddle is pressed. Releasing and then repressing the paddle returns the advance to a slower rate of movement. The letter "S" suffix is added to the Plug-in/Channel numerics, (i.e., 1AS), when the Set-up mode is selected.

➤ IMPORTANT: OPERATING THE PADDLE CONTROLS, OR ZERO BUTTON, IN THE "SET-UP" MODE ALTERS THE (T_0) ORIGIN, CAUSING THE TIME NUMERICS TO BECOME ERRONEOUS. The "set-up" mode can be exited by pressing either the HOLD LAST or LIVE button. However, the time numerics will remain erroneous until a new sweep is acquired.

EXAMPLE #8-13
Figure 8-34: The types of triggers and related sweeps during which data is acquired for display.

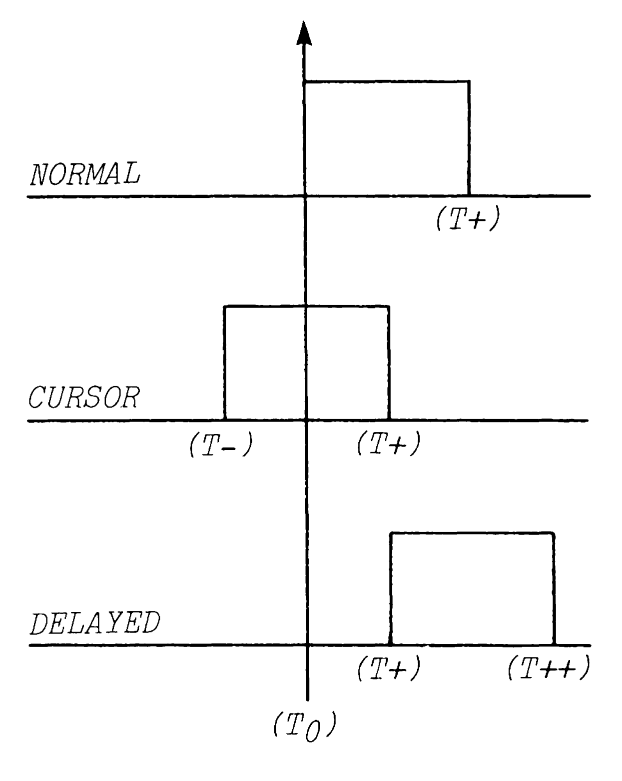

Figure 8-34

● NORMAL TRIGGER DISPLAY

The oscilloscope immediately resets to the Normal Trigger mode when the ZERO button is pressed and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed, since the "reset" command will not be recognized until the end of the sweep.

If the Plug-in is operating in the LIVE mode and -

#1. a long sweep is in progress, or

#2. no triggers are occurring, or

#3. a long delay has been selected,

then, to quickly reset the delay to zero, hold the ZERO button in and momentarily press the LIVE button.

The Plug-in's Trigger cursor is positioned at the extreme left-hand side of the screen when the oscilloscope is operating in the Normal Trigger mode. Only those events occurring after a valid trigger will be displayed on the screen.

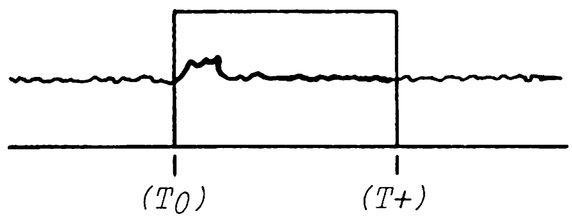

Figure 8-35

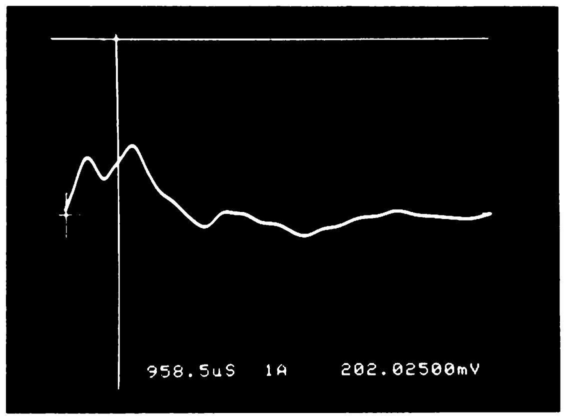

Figure 8-36

EXAMPLE #8-14

Figure 8-35: A typical input signal.

The boxed area represents one complete sweep starting at point (T_0), the trigger, and ending at point (T+).

Figure 8-36: The corresponding Normal Trigger display of the signal captured during the sweep.

● CURSOR TRIGGER DISPLAY

The oscilloscope enters the Cursor Trigger mode when the TRIG POSITION paddle is pressed to the right and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed.

NOTE: If the Plug-in is in the LIVE mode and a long sweep is in progress, the Cursor Trigger command may not be acknowledged until the next sweep is initiated. (The TRIG POSITION paddle must be pressed towards the right as the new sweep is initiated.)

The Plug-in's Trigger cursor will reposition towards the right-hand side of the screen, stopping when the paddle is released. Pre-trigger events will be displayed to the left of the trigger cursor. Post-trigger events will be displayed to the right of it.

Essentially, data is continually being sampled and stored in the memory. When a valid trigger is received, the pre-trigger events are stored in the memory and the post-trigger events fill the remaining memory addresses.

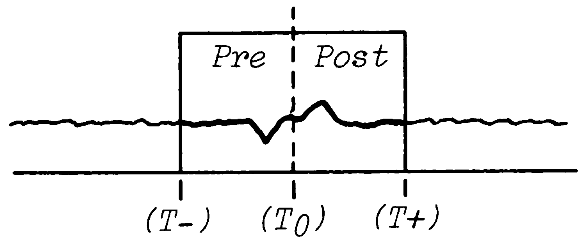

Figure 8-37

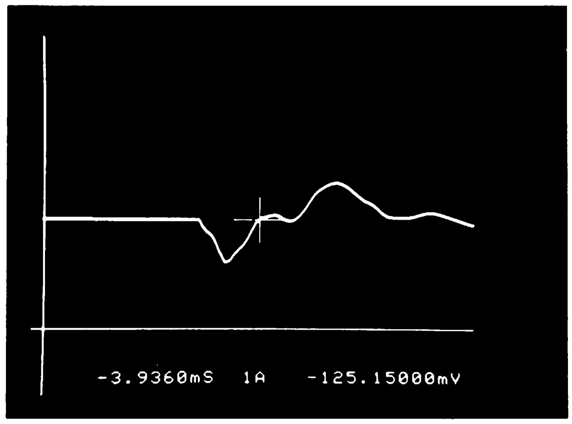

Figure 8-38

EXAMPLE #8-15

Figure 8-37: A typical input signal. The boxed area represents one complete sweep starting at point (T-) and ending at point (T+). Point (T_0), the trigger, "locks" the pre-trigger data in the memory's addresses. The remaining addresses will record the post-trigger data.

Figure 8-38: The corresponding display of the captured input signal.

- DELAYED TRIGGER DISPLAY

NOTE: Reposition the Mainframe's vertical cursor to the extreme left-hand side of the screen before activating the Delayed Trigger mode.

The oscilloscope enters the Delayed Trigger mode when the TRIG POSITION paddle is pressed to the left and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed.

NOTE: If the Plug-in is in the LIVE mode and a long sweep is in progress, the Delayed Trigger command may not be acknowledged until the next sweep is initiated. (The TRIG POSITION paddle must be pressed towards the left when the new sweep is initiated.)

The Plug-in's Trigger cursor (time zero) repositions to the left and continues to reposition off the left of screen. The time delay, indicated by the time numerics, reflects the time difference between the "positions" of the Trigger cursor and vertical cursor.

Equation 8-6 computes the maximum time delay (T_{max}) that can be selected.

$$\boxed{T_{max} \approx \frac{2^{24} \times (\text{TPP})}{(\text{Channels}) \times (\text{Memory})}}$$

Equation 8-6

- (TPP): Time-per-point selection.
- (Channels): The number of channels turned on.
- (Memory): The position selected on the MEMORY switch: "ALL" = 1, "Halves" = 2, and "Quarters" = 4.

The Mainframe's vertical cursor can be repositioned after the delay has been set to inspect specific data point coordinates.

NOTE: Sometimes a very long delay may be inadvertently selected in the Delayed Trigger mode of operation. To quickly clear the delay, hold the ZERO button in and momentarily press the LIVE button.

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EXAMPLE #8-16

Figure 8-39: A typical input signal applied to an input BNC.

Point (T_0) indicates the point at which a valid trigger initiated the time delay.

The boxed area represents one complete sweep, starting at Point (T+) which represents the end of the time delay. Point (T++) represents the end of the sweep, during which time data was acquired for display.

Figure 8-40: The corresponding Delayed trigger display of the signal captured during the sweep.

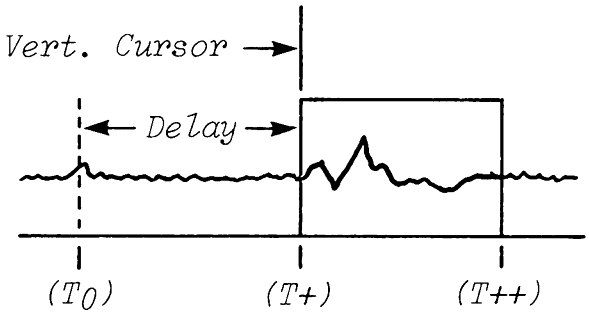

Figure 8-39

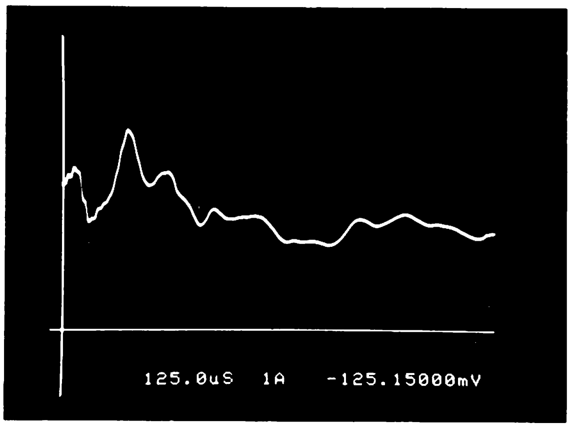

Figure 8-40

REMOTE CONTROL CONNECTOR

Events can occur so rapidly that the operator's reaction time is not fast enough to capture them.

This problem can be resolved by simulating certain commands with external sensors possessing the required reaction times.

Figure 8-41 identifies the function of each pin.

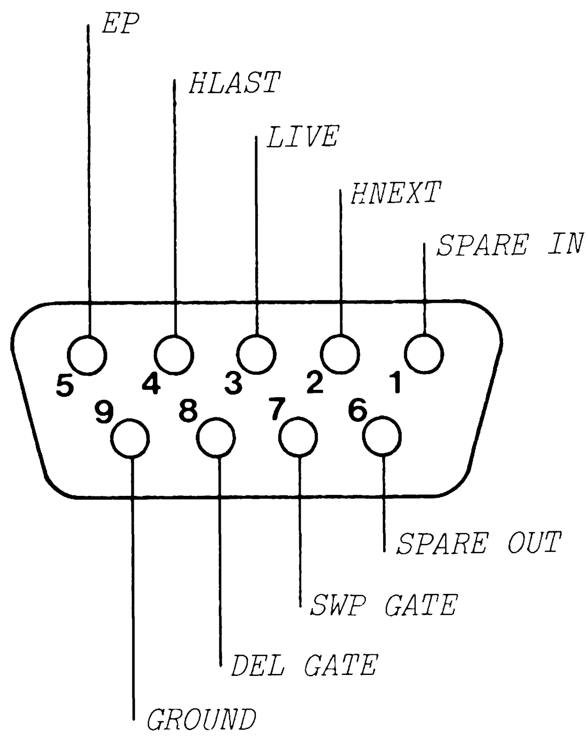

Figure 8-41

● HOLD LAST, LIVE and HOLD NEXT

The Storage Control buttons can be simulated by shorting the corresponding pins to ground through a low resistance contact or with an open collector TTL gate.

NOTE: Use the ground provided by Pin 9 on the Remote Control Connector.

● EP

The EP input is used to advance the memory to its next address when the TIME PER POINT switch is in either the EXT I or II positions.

The EP input should normally rest at less than 0.4 volts and then be raised to more than 3 volts DC each time the memory is to advance one address.
The "EP" input is TTL compatible.

● DEL GATE

The Delayed Gate output activates when either channel receives a valid trigger.

The output normally rests at 0.4 volts and rises to +3 VDC immediately following the valid trigger. It will return to 0.4 volts as soon as the sweep has been completed.

Figure 8-42 illustrates the three types of triggers and corresponding sweeps and Delayed Gate outputs.

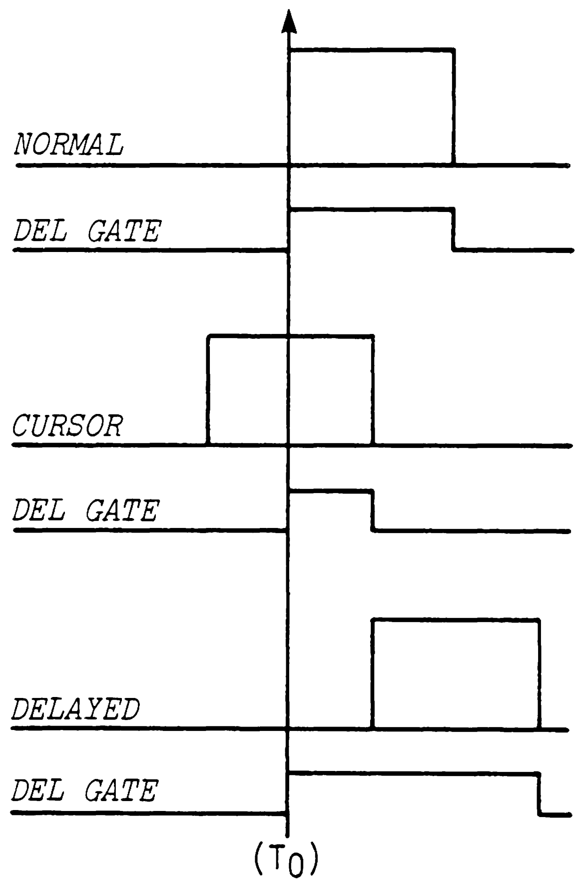

Figure 8-42

● SWP GATE

The Sweep Gate output is activated only during valid data point collection.

The output normally rests at 0.4 volts and rises to +3 VDC when a sweep is in progress.

● SPARE IN/SPARE OUT

Not currently being used.

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PROBE POWER CONNECTOR

A ±12 VDC output voltage, with a maximum current of *** ma, is available from the Probe Power connector.

The voltage polarities and ground are identified in Figure 8-43.

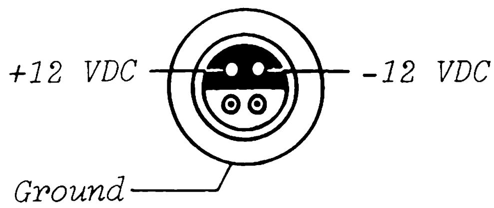


Figure 8-43

COMPENSATION POINT

Touching the test probe to the COMP point produces a square-wave on the screen.

► IMPORTANT: The Time Per Point must be 20 μSeconds or faster.

Compensate the test probe for the best response time (rise and fall times) on the square-wave display.

EXAMPLE #8-17

Figure 8-44 illustrates a square-wave displayed with expansion applied.

The top square-wave was produced from an uncompensated probe. The bottom square-wave was produced after the test probe was properly compensated.

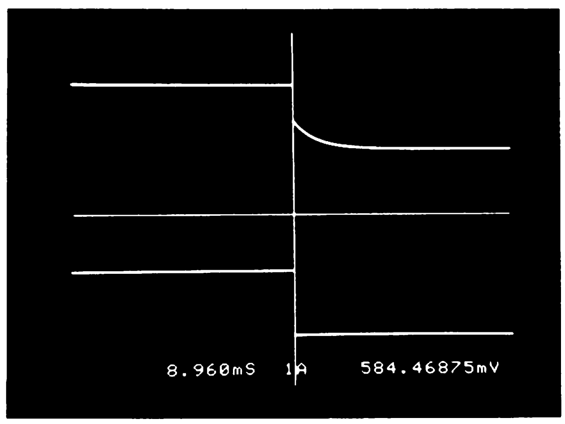
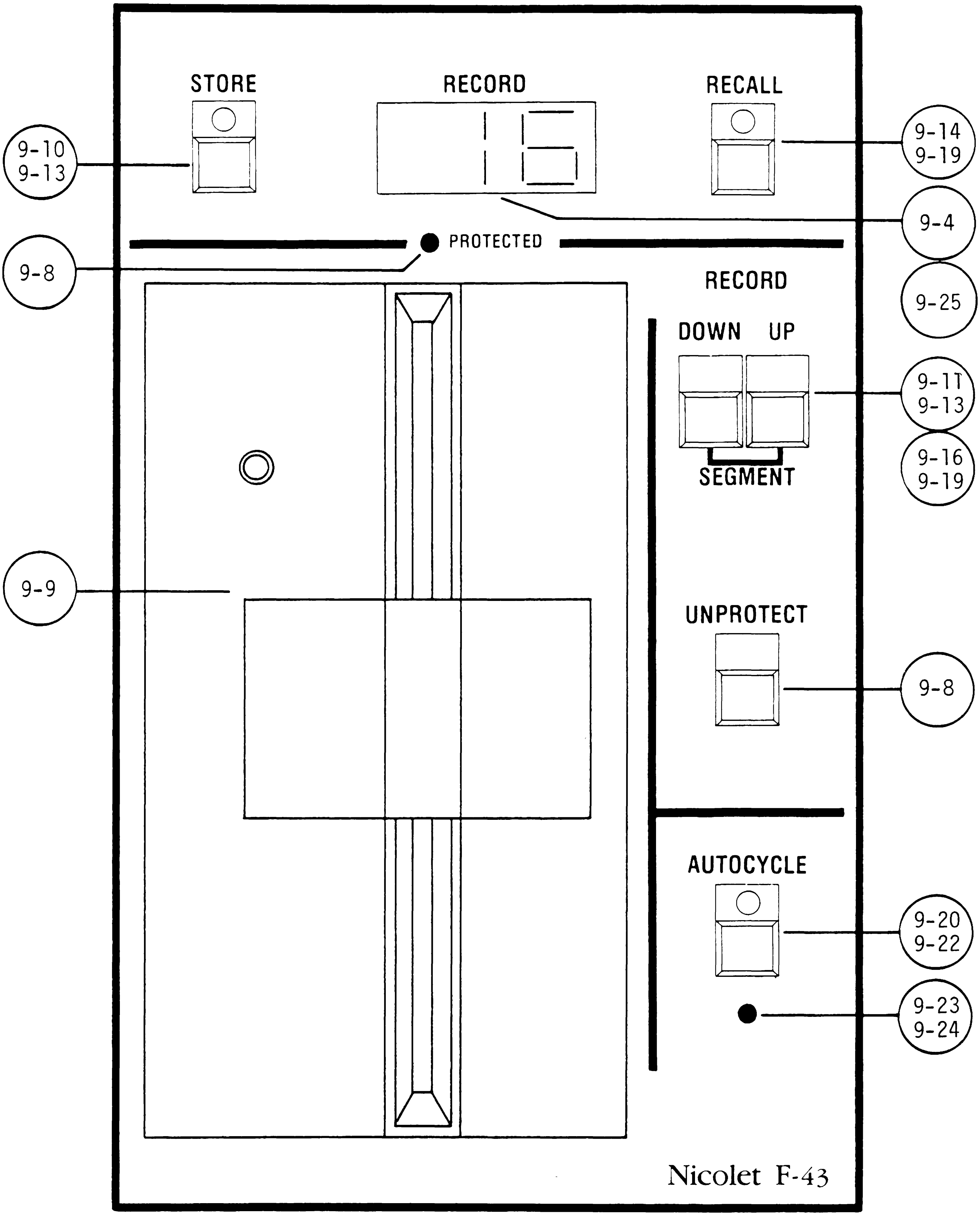


Figure 8-44

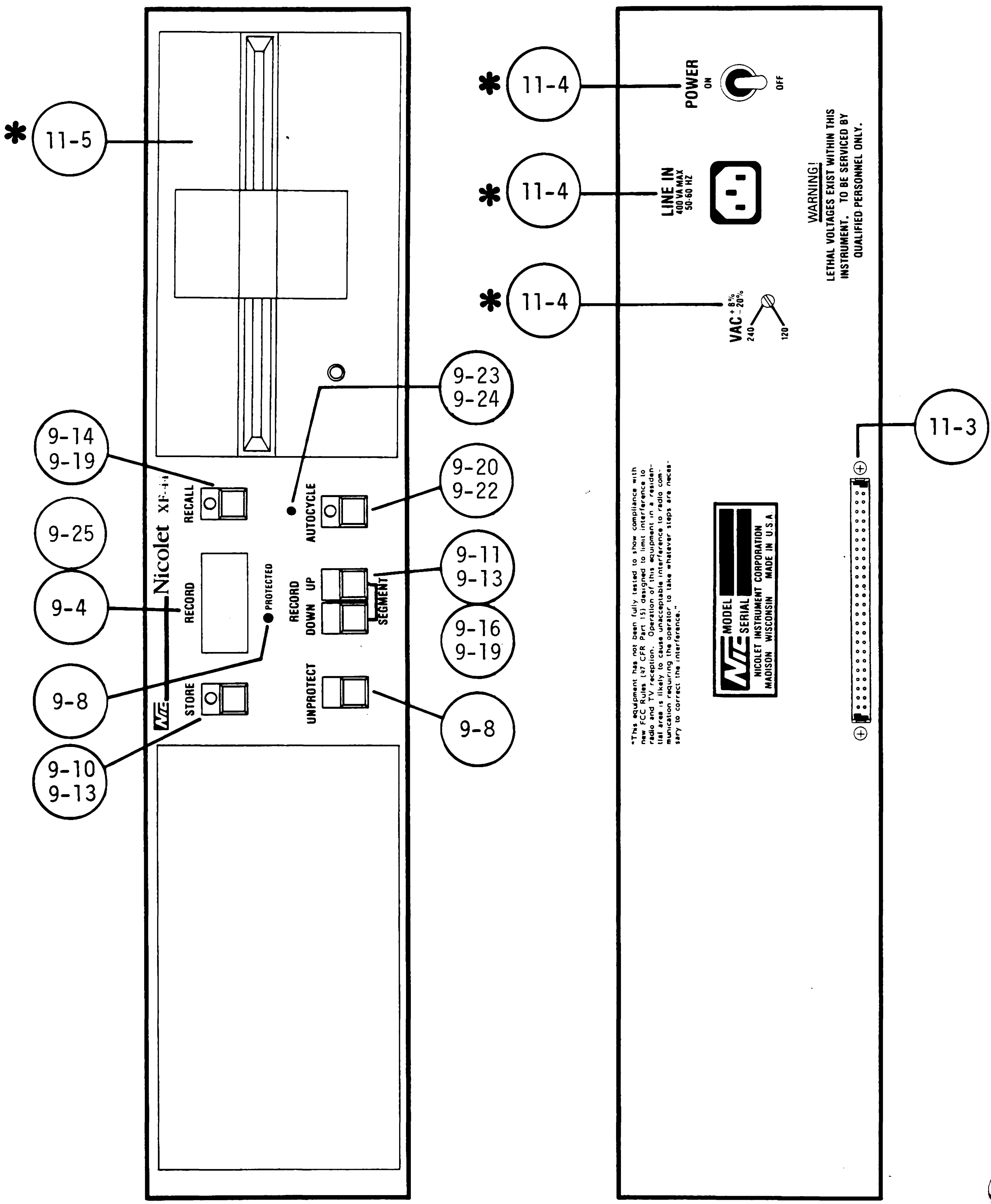
Exact spec's to be verified.

Disk Recorder—F-43



NOTE: The operation of the Model XF-44/1 is identical to that of the Model F-43. See reverse side of this tab for the XF-44/1 configuration.

Disk Recorder—XF-44/1



* REFER TO "DUAL DISK RECORDERS" TAB

INTRODUCTION

The Disk Recorder transfers data onto the floppy diskette for storage. The stored data can be recalled at a later time for inspection on the screen.

The diskette is divided into twenty individual records. Each record is capable of storing either a single (16K), two (8K), or four (4K) data groups.

DATA STORE METHODS

The operator can record data by any of the following procedures.

- Normal Store Routine

Data groups are sequentially stored on identical segments of each record until all twenty records have stored a data group.

- Segmented Store Mode

Data groups are stored on each segment of the record before incrementing to the next record.

- Autocycle Routine

Data groups are automatically stored at the end of a sweep. The oscilloscope will be rearmed into the Live/ Hold Next modes upon completion of storage.

DATA RECALL METHODS

The operator can recall data by either of the following methods.

- Normal Recall Routine

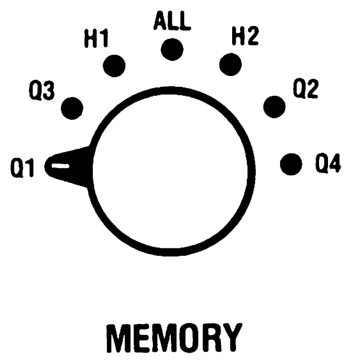
Used to recall either all or part of the data stored in a single record. This method also allows data stored in different records (but not in identical segments) to be recalled and displayed for comparison.

- Segmented Recall Mode

Used to recall data stored on different tracks (but in identical segments) and display them on the screen for comparison.

FORMAT ROUTINE

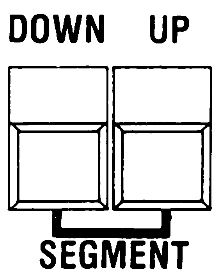
Divides floppy diskettes, purchased from different suppliers, into the twenty individual records required by the Series 4094 oscilloscope to store data.



MEMORY SWITCH (Mainframe Front Panel)

Determines whether the selected diskette record will remain intact (ALL) or divide into either "halves" (H1 or H2) or "quarters" (Q1, Q2, Q3, or Q4).

The MEMORY switch is located on the Mainframe's front panel.



DOWN PUSHBUTTON

Decrements the displayed record and/or segment by a factor of (1).

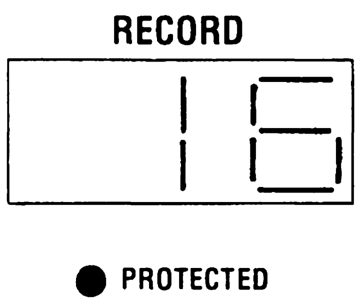
UP PUSHBUTTON

Increments the displayed record and/or segment by a factor of (1).

SEGMENT PUSHBUTTONS

Each segment of the selected record stores a data group before the diskette increments to the next record. Enables data groups stored on identical segments, but in different records, to be "mixed" during the Recall routine.

The Segmented mode is activated by simultaneously pressing the UP and DOWN pushbuttons.



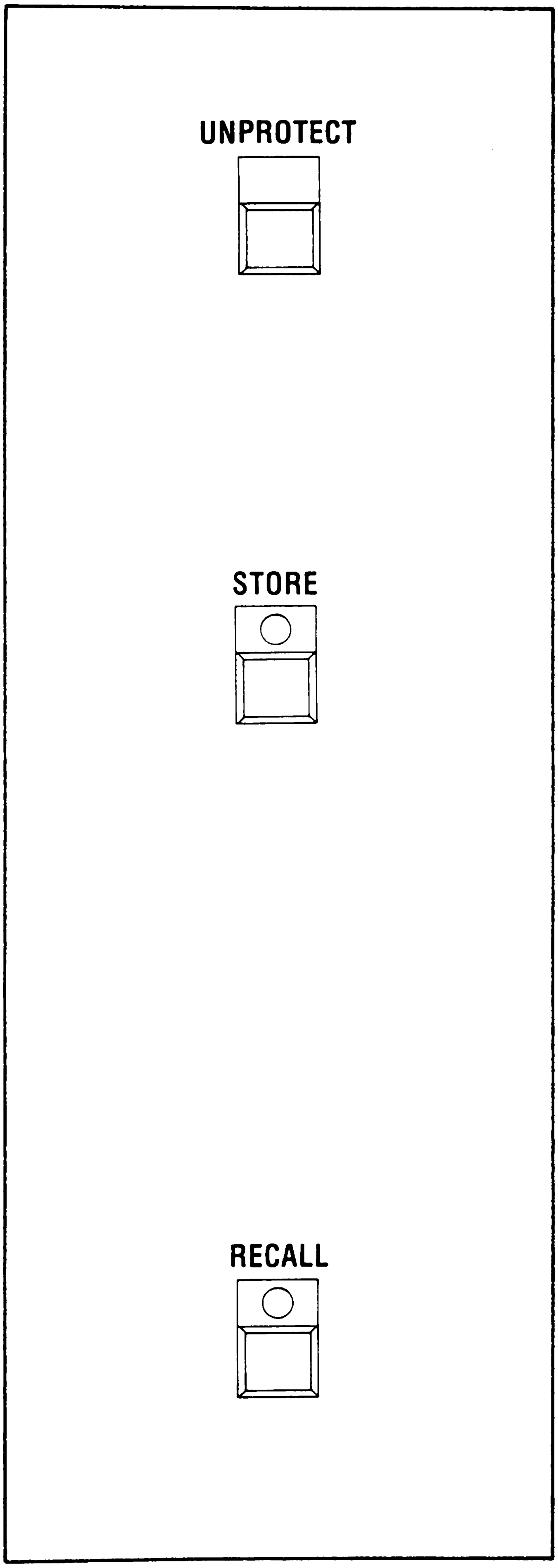
NUMERICAL DISPLAY

The following information will be displayed on the numerical display.

- RECORD NUMBER - For a Series 4094 diskette, numbers 01 thru 20. For Series 2090 diskette, numbers 1 thru 8 (leading zero is suppressed).
- SEGMENT - Either H1, H2, F1, F2, F3, or F4 alternates with the selected record number when operating in the Segmented Store/Recall modes or in the Autocycle routine.
- FORMAT MODE - The word "For" appears, formatting an entire diskette.
- ERROR FLAGS - The letter "E" alternates with an error code number.

PROTECTED LED

Alerts the operator, when LED is illuminated, that the record/segment selected to store data is already holding data.



UNPROTECT PUSHBUTTON

Allows previously stored data to be replaced by overriding the automatic protection feature.

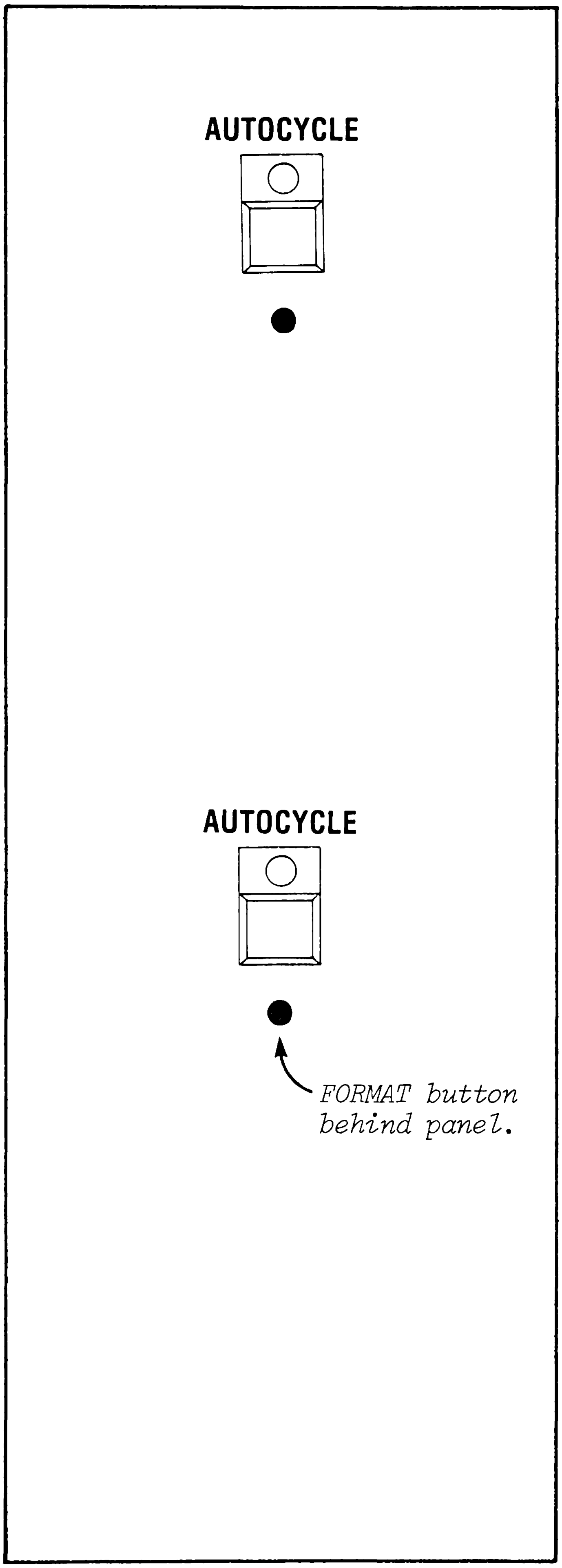
STORE PUSHBUTTON

Transfers data from the display memory to the diskette for storage. The LED indicator illuminates during the transfer of data.

It is also used to activate the Format routine after the FORMAT push-button is pressed.

RECALL PUSHBUTTON

Transfers data from the diskette to the display memory for viewing. The LED indicator illuminates during the transfer of data.



AUTOCYCLE PUSHBUTTON

Data automatically transfers from the display memory to the diskette each time the Plug-in's Live/Hold Next LEDs turn off and the Hold Last LED turns on. The Plug-in returns to the Live/Hold Next modes after the data has transferred.

Repressing the AUTOCYCLE pushbutton exits the Autocycle routine and turns off the LED indicator.

FORMAT PUSHBUTTON

Divides a new, unformatted diskette into twenty individual records. The STORE pushbutton must also be pressed to activate the Format routine.

The FORMAT pushbutton is mounted behind the Disk Recorder's front panel. It is operated by inserting a small diameter instrument into the access hole located below/above the AUTOCYCLE button.

Pressing the FORMAT pushbutton a second time aborts the Format routine.

THE DISKETTE

The Series 4094 diskette stores data for recall at a later time and is divided into twenty individual records. Each record can store up to (16K) data points of digitized data and can be left intact or divided into subgroups referred to as "segments."

➤ IMPORTANT: A Series 2090 diskette can not be formatted, nor can it store data on an F-43/XF-44 disk recorder. It can, however, be used to recall 2090 oscilloscope into the 4094 memory.

The position selected on the MEMORY switch (Mainframe panel) determines whether or not a record will be divided:

- ALL
  Each record remains intact, storing a single (16K) data group; twenty data groups per diskette.
- H1 or H2
  Each record divides into "halves." Two (8K) data groups can be stored on a record; forty data groups per diskette.
- Q1, Q2, Q3, or Q4
  Each record divides into "quarters." Four (4K) data groups can be stored on a record; eight data groups per diskette.

EXAMPLE #9-1

Figure 9-1 illustrates the three record configurations (intact, halves, and quarters) that can be selected by the MEMORY switch.

NOTE: The "quarter" segments are prefixed by the letter (F) on the numerical display instead of the (Q) designations on the MEMORY switch.

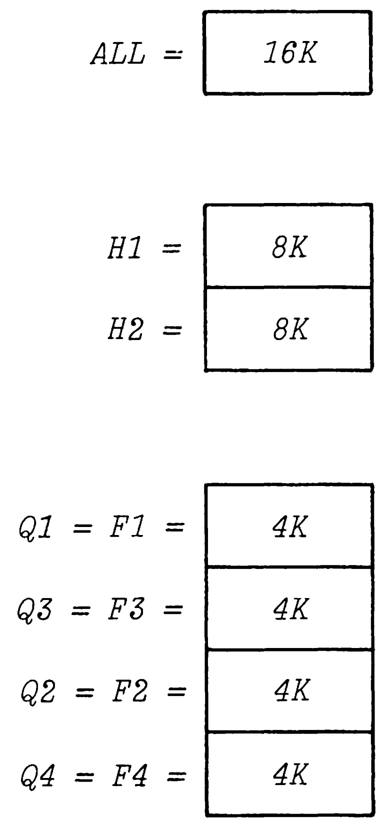


Figure 9-1

● DATA PROTECTION

➤IMPORTANT: The data protection features are NOT designed to protect data if the diskette is subjected to magnetic fields, or any other conditions that may adversely affect the diskette and/or recorded data.

● Automatic Protection

Protect marks are automatically registered for each data group stored on the diskette and are identified by an illuminated PROTECTED LED. The operator can quickly determine whether or not the entire record is protected by switching the MEMORY switch and observing the PROTECTED LED.

The word "Pro" will appear on the numerical display if the STORE button is pressed while the PROTECTED LED is illuminated. To clear the numerical display, press the UP/DOWN button.

A protected Record/Segment can be unprotected by pressing the UNPROTECT button. An entire diskette can be quickly unprotected by selecting Record 01 and then pressing and holding in the UNPROTECT button. The diskette will not "ring-around" from Record #20 to Record #01.

● Tab Protection

Affixing a protect tab over the rectangular notch (Figure 9-2) allows data to be recalled, but not replaced. The PROTECTED LED remains illuminated when a tab protected diskette is inserted into the disk recorder.

The protect tab must be removed before attempting to perform an Unprotect/Store/Autocycle/Format/Copy routine. Otherwise, the word "Pro" will appear on the numerical display. To clear the word "Pro" from the numerical display, press the UP/DOWN button.

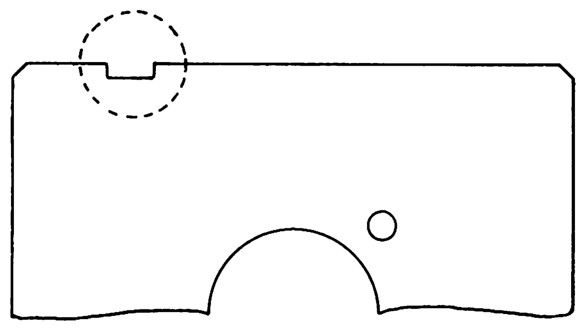


Figure 9-2

● LOADING THE DISKETTE

The disk drive automatically energizes when the diskette is inserted into the disk recorder.

The numerical display will illuminate only if the diskette has been formatted and it is either a Series 2090 or 4094 diskette.

► IMPORTANT: The drive's door must be closed within 3 seconds after the diskette has been inserted into the disk recorder. Otherwise, the recorder will not acknowledge the presence of the diskette.

To insert the diskette:

#1. Open the small door at the front of the disk recorder. (Door should already be open - see CAUTION note on this page.)

#2. Position the diskette as shown in Figure 9-3.

#3. Slide the diskette into the disk recorder.

#4. Close the door within 3 seconds after inserting the diskette.

The diskette is removed by opening the door and pulling the diskette out.

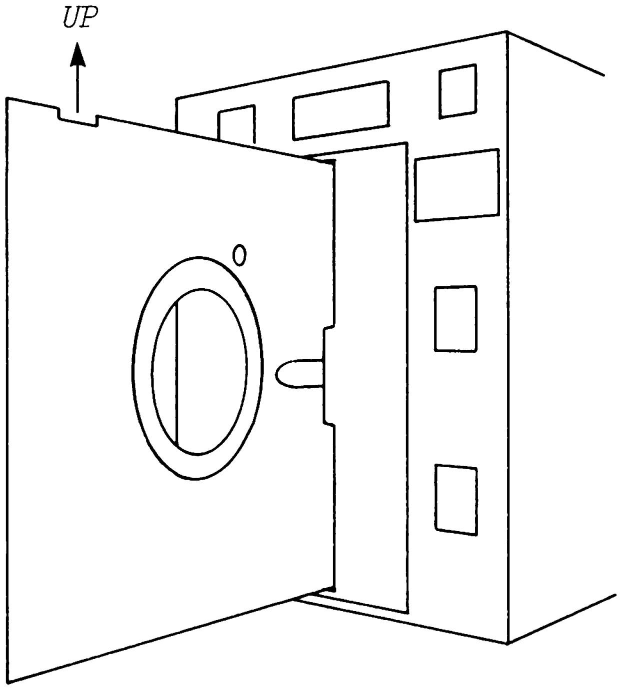


Figure 9-3

WARNING: To guard against physical damage to the disk heads and/or diskette, ALWAYS open the drive's door when:

a. Power is off, or
b. Applying/removing power, or
c. Drive is not being used, or
d. Transporting the instrument.

STORE ROUTINE

Data transfers from the display memory to the diskette each time the STORE button is pressed. The Plug-in should be in the Hold mode for proper operation.

The disk recorder automatically increments to the next record each time the STORE button is pressed and the data group has been stored. The "beeper" announces each time the diskette "rings-around" from Record #20 to Record #01.

The UNPROTECT button must be pressed, before initiating a Store routine, if a protected data group is to be replaced. A protected data group is identified by an illuminated PROTECTED LED and can be bypassed by pressing the UP/DOWN button.

● SELECTING A RECORD TO STORE DATA

A specific record can be selected to store the data group by pressing the UP/DOWN button and observing the numerical display.

● SELECTING A SEGMENT TO STORE DATA

The position selected on the MEMORY switch determines which Segment of the record will store the data group.

- ALL
  Stores one (16K) data group on the entire record.
- H1 or H2
  Stores one (8K) data group on the segment selected.
- Q1, Q2, Q3, or Q4
  Stores one (4K) data group on the segment selected.

● NORMAL STORE ROUTINE PROCEDURE

#1. MEMORY switch: Select segment.

#2. UP/DOWN button: Select record number on numerical display.
   a. If PROTECTED LED illuminates, either bypass the record or press the UNPROTECT button.

#3. STORE button: Press.
   a. STORE LED illuminates during transfer of data.
   b. Recorder increments diskette to next record after the data group has been stored.

EXAMPLE #9-2

Assume that the MEMORY switch is in the "H1" position; a protected data group is stored on Record #20 - Segment H1; and the first of two (8K) data groups is to be stored on Record #19.

Figure 9-4 illustrates the sequence of storing the data groups, one at a time. Record #20 was manually by-passed with the UP button.

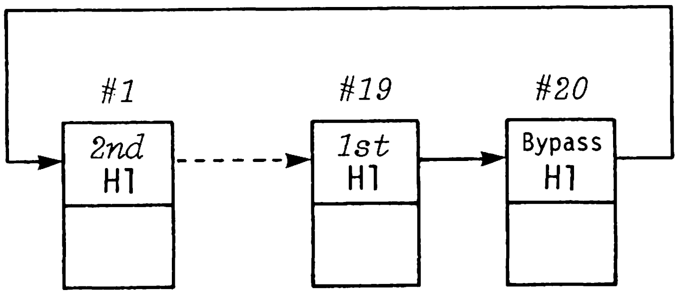


Figure 9-4

SEGMENTED STORE MODE

Allows the recorder to sequentially access consecutive segments of an entire Record before incrementing the diskette to the next Record.

● ACTIVATING THE SEGMENTED MODE

Activated by simultaneously pressing the UP/DOWN buttons.

● DEACTIVATING THE SEGMENTED MODE

Deactivated by simultaneously pressing the UP/DOWN buttons a second time.

● SELECTING A RECORD TO STORE DATA

The Record Number displayed on the numerical display while holding in both the UP and DOWN buttons will be the Record at which Segmented mode is entered. Pressing the UP (or DOWN) button causes the numerical display to increment (decrement) in segments, (F# or H#).

The Segmented mode must be exited if a specific Record Number is to be selected, or verified. A specific Record can be selected by exiting the Segmented mode and pressing the UP/DOWN button while observing the numerical display.

● SELECTING A SEGMENT SIZE

Each Record can be divided into either "halves" or "quarters." Which of these two sizes will be selected is determined by the position of the MEMORY switch at the time that the Segmented mode is activated.

- ALL
  Not allowed. Already provided for by the Normal Store routine.

- H1 or H2
  Each record divides into "halves," storing two (8K) data groups; forty data groups per diskette. The Record Number will be replaced by either an H1 or H2 designation on the numerical display.

- Q1, Q2, Q3, or Q4
  Each record divides into "quarters," storing four (4K) data groups; eighty data groups per diskette. The Record Number will be replaced by either an F1, F2, F3, or F4 designation on the numerical display.

The operator can bypass a Segment designation displayed on the numerical display by pressing either the UP or DOWN button.

● Equal Segment Sizes

Only equally sized segments can be selected to store data while operating in the Segmented mode. (e.g., If the MEMORY switch was in the H1/H2 position when the Segmented mode was activated, then data can only be stored on one half of the record.)

The recorder will automatically exit the Segmented mode if the operator reselects a larger/smaller segment size on the MEMORY switch and attempts to store data. The word "Err" will appear on the numerical display while the STORE button is pressed and then be replaced by a Record Number when the button is released.

● Mixing Segment Sizes

A data group can be recorded on a larger/smaller segment than was initially selected by exiting the Segmented mode, selecting the new segment size on the MEMORY switch, and then reactivating the Segmented mode. This is accomplished by:

#1. UP/DOWN buttons: Press both.

#2. MEMORY switch: Select new size.

#3. UP/DOWN buttons: Press both.

● SEGMENTED STORE PROCEDURE

#1. UP/DOWN button: Increment/ decrement numerical display until desired Record Number is displayed.

#2. MEMORY switch: Select whether the record will be divided into "halves" (H1 or H2), or into "quarters" (Q1, Q2, Q3, or Q4).

#3. UP/DOWN buttons: Press both simultaneously and observe the numerical display to verify the selected Record Number.

#4. UP/DOWN buttons: Select which Segment of the record (displayed on the numerical display) will store the first data group.

   a. If the PROTECTED LED illuminates, either bypass the Record/Segment or press the UNPROTECT button.

#5. STORE button: Momentarily press.

   a. STORE LED illuminates during transfer of data.

   b. Disk Recorder increments to next Segment/Record.

EXAMPLE #9-3

Assume that the MEMORY switch was in the H1 position when the Segmented mode as activated. Also assume that a protected data group is stored on Record #19 - Segment H2, and the first of five consecutive (8K) data groups is to be stored on Record #19 - Segment H1.

Figure 9-5 illustrates the sequence of storing each data group, one at a time. Record #19 - Segment H2 was manually bypassed by pressing the UP button.

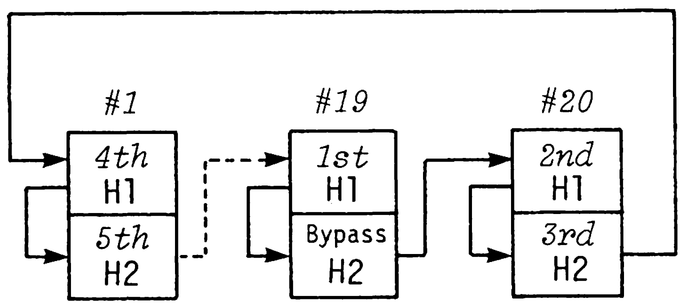


Figure 9-5

RECALL ROUTINE

Data transfers from the diskette to the display memory each time the RECALL button is pressed.

NOTE: The Plug-in must be in the Hold mode when recalling data from the diskette. Otherwise, the word "Err" will appear on the numerical display when the RECALL button is pressed.

The data is recalled from the diskette according to the position selected on the MEMORY switch. The disk recorder automatically increments the diskette to the next record each time the RECALL button is pressed.

A record can be bypassed by pressing either the UP or DOWN button. The operator can scan through the diskette by pressing and holding in the RECALL button.

A "beeper" announces each time the diskette "rings-around" from Record #20 to #01.

● SELECTING A SEGMENT TO RECALL DATA

The position selected on the MEMORY switch will allow the data stored within that segment to be recalled when the RECALL button is pressed.

- ALL
  Recalls one (16K), two (8K), or four (4K) data groups.
- H1 or H2
  Recalls one (8K), or two (4K) data groups.
- Q1, Q2, Q3, or Q4
  Recalls one (4K) data group from the selected segment.

EXAMPLE #9-4

Assume four (4K) data groups are stored on a single record.

Four (4K) data groups can be recalled by selecting the "ALL" position.
ALL = (F1, F2, F3 and F4).

Two (4K) data groups can be recalled by selecting a "halves" position.
H1 = (F1 & F3). H2 = (F2 & F4).

One (4K) data group will be recalled according to the segment selected on the MEMORY switch.
Q1 = F1. Q2 = F2. Q3 = F3. Q4 = F4.

● SELECTING A RECORD TO RECALL DATA

A specific record can be selected to recall either all of the data stored on it, or only a segment of the data. The record number will be displayed on the numerical display and can be incremented/decremented by using the UP/DOWN buttons.

The operator can elect to scan the entire diskette for a specific display by pressing and holding in the RECALL button.

The operator can also elect to recall data stored on different records, but NOT on identical segments (e.g., all on Segment H1) and display them superimposed on the screen for comparison. This is accomplished by recalling and storing each data group, one at a time, in a different display memory subsection and then placing the MEMORY switch to the "ALL" position.

EXAMPLE #9-5

Assume that four (16K) data groups stored on Records #1, #3, #7, and #9 are to be compared on the screen.

The following sequence illustrates the proper procedure of transferring one fourth of each data group and storing each one in a different display memory subsection.

#1.	*Numerical Display:*	*Select "01"*
#2.	*MEMORY switch:*	*Q1*
#3.	*RECALL button:*	*Press.*
#4.	*Numerical Display:*	*Select "03"*
#5.	*MEMORY switch:*	*Q3*
#6.	*RECALL button:*	*Press.*
#7.	*Numerical Display:*	*Select "07"*
#8.	*MEMORY switch:*	*Q2*
#9.	*RECALL button:*	*Press.*
#10.	*Numerical Display:*	*Select "09"*
#11.	*MEMORY switch:*	*Q4*
#12.	*RECALL button:*	*Press.*
#13.	*MEMORY switch:*	*ALL*

The operator can now view all four (4K) data groups superimposed on the screen, but at a lower (4K) resolution per waveform.

SEGMENTED RECALL MODE

The Segmented Recall mode allows the operator to "mix" data groups which are stored on different Records, but on identical Segments, (e.g., all stored on Segment H1).

- ACTIVATING THE SEGMENTED MODE

Activated by simultaneously pressing the UP/DOWN buttons.

- DEACTIVATING THE SEGMENTED MODE

Deactivated by simultaneously pressing the UP/DOWN buttons.

- SELECTING A RECORD TO RECALL DATA

The Record Number displayed on the numerical display while holding in both the UP and DOWN buttons will be the Record at which Segmented mode is entered. Pressing the UP (or DOWN) button causes the numerical display to increment (decrement) in segments, (F# or H#).

The Segmented mode must be exited if a specific Record Number is to be selected, or verified. A specific Record can be selected by exiting the Segmented mode and pressing the UP/DOWN button while observing the numerical display.

- SELECTING A SEGMENT SIZE

Data can be recalled from either a half or a quarter of the record. Which of these two segment sizes will be selected is determined by the position of the MEMORY switch at the time that the Segmented mode is activated.

- ALL
  Not allowed. Already provided for by the Normal Store routine.
- H1 or H2
  Each record divides into "halves," recalling one (8K), or two (4K) data groups. The Record Number will be replaced by either an H1 or an H2 designation on the numerical display.
- Q1, Q2, Q3, or Q4
  Each record divides into "quarters," recalling one (4K) data group. The Record Number will be replaced by either an F1, F2, F3, or F4 designation on the numerical display.

The operator can bypass a Segment designation displayed on the numerical display by pressing either the UP or DOWN button.

• Selecting a Different Segment Size

The operator can reselect a larger/smaller segment size to recall its data by exiting the Segmented mode; selecting the new segment size on the MEMORY switch; and then reactivating the Segmented mode. This is accomplished by:

#1. UP/DOWN buttons: Press both simultaneously to exit the Segmented mode.

#2. MEMORY switch: Select the new segment size.

#3. UP/DOWN buttons: Press both simultaneously to reenter the Segmented mode.

If the above procedure is not used, the recorder will automatically exit the Segmented mode when the RECALL button is pressed. The word "Err" will appear on the numerical display while the RECALL button is pressed and then be replaced by a Record Number when the button is released.

EXAMPLE #9-6

Assume that the MEMORY switch was in the "H1" position when the Segmented mode was activated.

The recorder will only be allowed to recall data from either Segment H1 or H2, depending upon which segment designation is being displayed on the numerical display. The recalled data can consist of either a single (8K), or up to two (4K) data groups.

If the operator wanted to recall only a single (4K) data group rather than the (8K) data group that would be recalled due to the "H1" position selected on the MEMORY switch, it will be necessary to perform the three step procedure listed at the left.

● SEGMENTED RECALL PROCEDURE

#1. MEMORY switch: Select the position which corresponds to the desired Segment size and the Display Memory Subsection in which the first, recalled data group is to be stored.

#2. UP/DOWN buttons: Increment/decrement the numerical display until the desired Record Number appears.

#3. UP/DOWN buttons: Press both simultaneously to enter the Segmented mode.

#4. UP/DOWN buttons: Increment/decrement the numerical display until the desired Segment designation appears.

#5. RECALL button: Press.

#6. UP/DOWN buttons: Press both simultaneously to exit the Segmented mode.

#7. MEMORY switch: Select the position which corresponds to the desired Segment size (typically the same size as selected in Step #1) and the Display Memory Subsection in which the next, recalled data group is to be stored.

#8. Repeat Steps #2 thru #8 until all of the desired data groups have been recalled and stored in the Display Memory's Subsections.

#9. UP/DOWN buttons: Press both simultaneously to exit the Segmented mode.

#10. MEMORY switch: ALL

a. The recalled data groups will be displayed superimposed on the display screen.

EXAMPLE #9-7

Assume four (4K) data groups (one each stored on Segment F1 of Records #1, #3, #7 and #9) are to be recalled and superimposed on the display screen.

#1. MEMORY switch: Q1

#2. UP/DOWN buttons: Increment/decrement numerical display until Record Number (01) appears.

#3. UP/DOWN buttons: Press both.

#4. Numerical Display: Increment/decrement display until (01/F1) appears.*

#5. RECALL button: Press.

#6. MEMORY switch: Q3

#7. Numerical Display: Increment display until (03/F1) appears.*

#8. RECALL button: Press.

#9. MEMORY switch: Q2

#10. Numerical Display: Increment display until (07/F1) appears.*

#11. RECALL button: Press.

#12. MEMORY switch: Q4

#13. Numerical Display: Increment display until (09/F1) appears.*

#14. RECALL button: Press.

#15. MEMORY switch: ALL

#16. UP/DOWN buttons: Press both simultaneously to exit the Segmented mode.

(*) The Record Number can be verified by exiting the Segmented mode. If incorrect, increment/decrement the numerical display until the correct Record Number appears and then reactivate the Segmented mode.

AUTOCYCLE ROUTINE

Data is automatically acquired by the Plug-in and then transferred from the display memory to the diskette at the end of each sweep.

The Plug-in alternates between the Live/Hold Next (data acquisition) mode and the Hold (data transfer) mode until Record #20 has stored (16K) words of data.

NOTE: The diskette does not "ring-around" from Record #20 to Record #01 in the Autocycle routine.

● SELECTING THE FIRST RECORD

Any one of the twenty records can be selected to store the first data group by pressing either the UP or DOWN button and observing the numerical display.

The recorder will store (16K) words of data on each record, starting with the record selected to store the first data group and ending with Record #20.

NOTE: The protect tab (if affixed) must be removed from the diskette. The operator must unprotect all of the records selected to store data in the Autocycle routine, otherwise the word "Pro" will appear on the numerical display when the AUTOCYCLE button is pressed.

#1. Numerical Display: Display the Record Number which is to store the first data group.

#2. MEMORY switch: ALL

#3. UNPROTECT button: Press and hold in until each record, through Record #20, is unprotected.

#4. Repeat Step #1.

● SELECTING THE SEGMENT SIZES

Whether each record will store one, two, or four data groups is determined by the position of the MEMORY switch at the time that the Autocycle routine is activated.

- ALL
  Each record remains intact, storing a single (16K) data group.
- H1 or H2
  Each record divides into "halves," storing two (8K) data groups.
- Q1, Q2, Q3, or Q4
  Each record divides into "quarters," storing four (4K) data groups.

The Autocycle routine must be exited to reselect a larger/smaller segment.

● ACTIVATING THE AUTOCYCLE ROUTINE

Activated by pressing the AUTOCYCLE button.

➤ IMPORTANT: Previously acquired data must be stored on the diskette before activating the Autocycle routine. Otherwise, it will be replaced by the first Autocycle sweep.

● DEACTIVATING THE AUTOCYCLE ROUTINE

The Record Number selected to store the first data group will reappear on the numerical display when the Autocycle routine is exited. The Autocycle routine will deactivate when -

#1. Record #20 has stored (16K) words of data, or

#2. Any of the Disk Recorder's buttons are pressed and held until the AUTOCYCLE LED turns off.

The operator can identify on which Record/Segment the Autocycle routine was aborted by -

#1. MEMORY switch: ALL

#2. UP button: Increment numerical display until first unprotected record number appears.

#3. DOWN button: Decrement the numerical display by one record.

#4. MEMORY switch: Switch between each position and observe the PROTECTED LED.

  a. If the LED remains illuminated for each position, the next record is the one on which the Autocycle routine was aborted. Increment the numerical display by one record.

EXAMPLE #9-8

Assume Record #05 was selected to store the first data group; the operator unprotected Records #05 through #20; and the MEMORY switch was in the "ALL" position when the AUTOCYCLE button was pressed.

#1. Plug-in enters Live/Hold Next mode.

#2. Valid trigger occurs, initiating a sweep.

#3. Plug-in enters Hold mode at the end of the sweep.

- *a. Data transfers to the Record Number appearing on the numerical display, (Record #05 for the first data group).*
- *b. Numerical display increments to next Record Number.*

#4. Steps #1 through #3 repeat until Record #20 stores a data group.

- *a. Recorder exits Autocycle.*
- *b. Record #05 reappears on the numerical display.*

Figure 9-6: Storing successive data groups according to the position selected on the MEMORY switch.

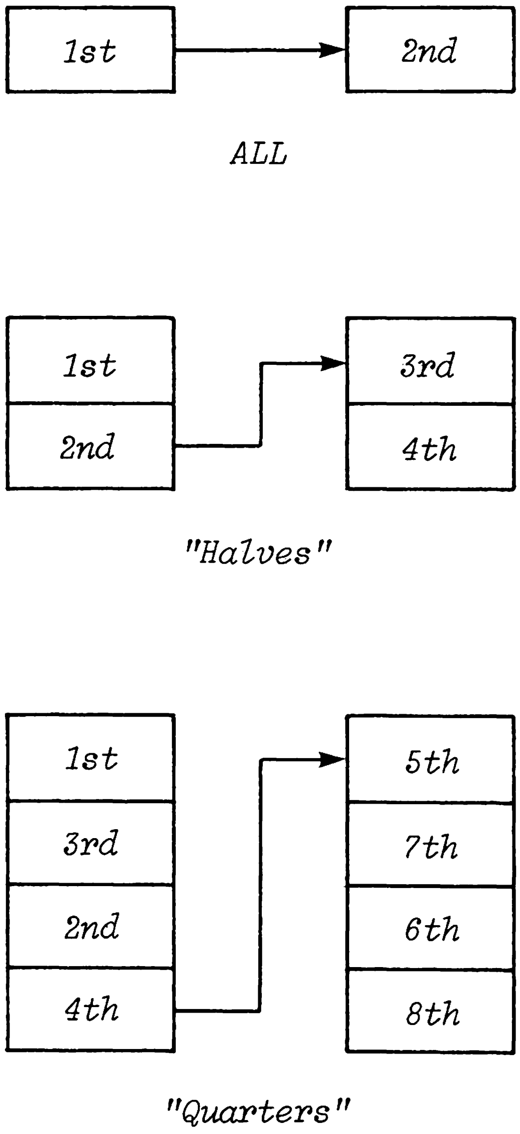


Figure 9-6

FORMAT ROUTINE

➤IMPORTANT: Only 80 track, 96 TPI, double sided diskettes can be formatted on the F-43 Disk Recorder. The diskettes shipped with the Series 4094 oscilloscopes have been pre-formatted at the factory. A series 2090 diskette can not be formatted.

● ENTERING THE FORMAT ROUTINE

The Format routine divides the diskette into the required twenty records and takes approximately three minutes for completion.

The Format routine is armed by pressing the FORMAT button (accessed via the hole adjacent to the AUTOCYCLE button) with a small diameter instrument. The word "For" will appear on the numerical display when the routine has been successfully armed.

The actual formatting process will not start until the STORE button is pressed.

NOTE: The STORE button must be pressed within 45 seconds after arming the Format routine. Otherwise, the routine will be automatically unarmed if the time period is allowed to elapse.

● EXITING THE FORMAT ROUTINE

The recorder automatically exits the Format routine after the diskette has been formatted. The STORE LED will turn off and the word "For" will be replaced with a Record Number.

The Format routine can be manually unarmed (BEFORE the STORE button is pressed) by pressing any button, (including the FORMAT, but not the STORE button) on the Disk Recorder.

● TAB PROTECTED DISKETTES

The tab must be removed. Otherwise, the word "Pro" will appear on the numerical display when the operator attempts to arm the Format routine.

NOTE: A misaligned disk drive and/or head may cause erroneous Store/Recall routines which may resemble a faulty disk recorder. Therefore, it is recommended that a factory formatted diskette be kept unaltered to help verify the proper operation of the disk recorder.

Return the diskette to the place of purchase if the recorder has been verified operational and the diskette in question can not be formatted after a second attempt.

● FORMATTING DISKETTES

#1. Insert the diskette into the Disk Recorder.
   a. Disk drive energizes.

#2. Insert a small diameter instrument into the hole adjacent to the AUTOCYCLE button.
   a. The word "For" appears on the numerical display.

   NOTE: If the word "Pro" appears, remove the tab from the diskette and repeat Steps #1 and #2.

#3. Press the STORE button within 45 seconds after performing Step #2.
   a. The STORE LED illuminates and the Disk Recorder begins the formatting process.
   b. Upon completion, the STORE LED turns off and the word "For" is replaced on the numerical display by a Record number.

ERROR CODES

The following is a tabulation of Error Codes which will appear on the numerical display in the event of an erroneous operation.

An Error Code can be cleared by momentarily pressing either the UP or DOWN button.

ERROR WORDS

- Pro - Attempting to -
  - #1. Store/Format/Copy/Unprotect/Autocycle on a tab protected diskette, or
  - #2. Attempting to Store or Autocycle on a protected record.
- Err - Attempting to -
  - #1. Recall data while the Plug-in is in the Live mode, or
  - #2. Store/recall data (while in the Segmented mode) from a larger/smaller Segment than was initially selected, or
  - #3. Unprotect either a 2090 or a Program diskette.

ERROR NUMBERS

- E3 - CRC data error. (e.g., Check sum error.) Try again.
- E4 - CRC data ID error. (e.g., Check sum error.) Try again.
- E5 - Either a bad diskette (try again) or the diskette being used is not a 4094 diskette.
- E6 - Either a bad diskette (try again), or the diskette being used is not a 4094 diskette, or no diskette is present in the disk recorder.
- E7 - Either a broken drive and/or broken drive cable.
- E8 - Diskette being used is not 4094 formatted.
- E9 - Disk Program not understood. Try again.
- E10 - Disk Program not understood. Try again.
- E11 - Disk Program not understood. Try again.

INTRODUCTION

The Model 4094 oscilloscope can be operated with two Plug-ins, providing up to four channel operation.

The second Plug-in will be located in the F-43 Disk Recorder bay.

The 4562 and 4851 Plug-ins can be mixed or matched in any combination. The operation of the Plug-ins remain identical to that as previously described under the *Plug-ins* tab.

However, since the Mainframe is sharing its capabilities with up to four channels, the following descriptions should be read to properly apply the dual Plug-in mode of operation.

NOTE: The term "Hold mode" will be used to indicate that the Plug-in(s) have exited the Live mode; only the Hold Last LED is illuminated.

MEMORY ADDRESS ALLOCATION

The number of activated channels and the position of the MEMORY switch determines the number of allotted addresses that will record the captured input signals. See Table 10-1.

NUMBER OF CHANNELS	MEMORY SWITCH		
	ALL	H1/H2	Q1 - Q4
1	*15,872*	*7,936*	*3,968*
2	*7,936*	*3,968*	*1,984*
3	*5,290*	*2,645*	*1,322*
4	*3,968*	*1,984*	*922*

Table 10-1

SWEEP TIMES

The sweep times will decrease when multiple channels are activated.

Refer to *Plug-ins* tab, Page 8-17, Table 8-4 (for the appropriate Plug-in) and divide the listed sweep times accordingly:

Two channels ------------------- (2)

Three or four channels --------- (4)

MULTIPLE PLUG-INS

MASTER TRIGGERING

A valid trigger applied to the Master Plug-in also triggers a sweep at the Slave Plug-ins.

The trigger must be applied to the "Master" Plug-in and the position selected on the "Master" Plug-in's SOURCE switch (A, B, or EXT) must correspond accordingly.

The remaining Plug-in(s) are referred to as the "Slave" Plug-ins. The SOURCE switch(es) must be placed to the "S" position(s).

MIXING TRIGGER DISPLAYS

The operator can select any combination of Normal, Cursor, and Delayed trigger displays. Each channel operates independently.

THE BUS ARBITRATION JUMPER

If the 4094 is to be operated without a third bay plug-in, the Bus Arbitration Jumper, (Figure 10-1) must be installed in the third bay Bus Aribitration Cable connector, (Figure 10-2).

CAUTION: The jumper must be inserted into the Bus Arbitration Cable connector with the small notch positioned towards the front of the oscilloscope, (Figure 10-3). Refer to the 4094 Service Manual for detailed instructions.

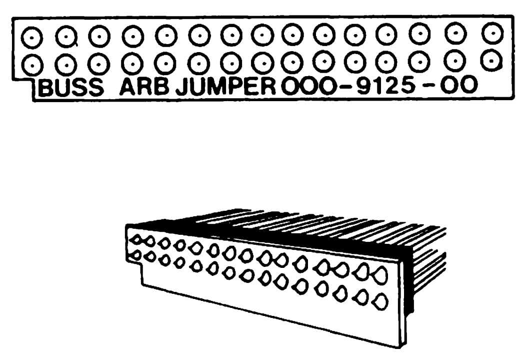


Figure 10-1

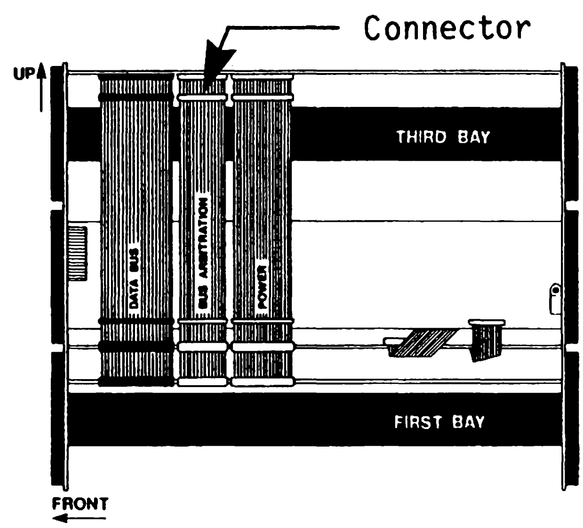


Figure 10-2

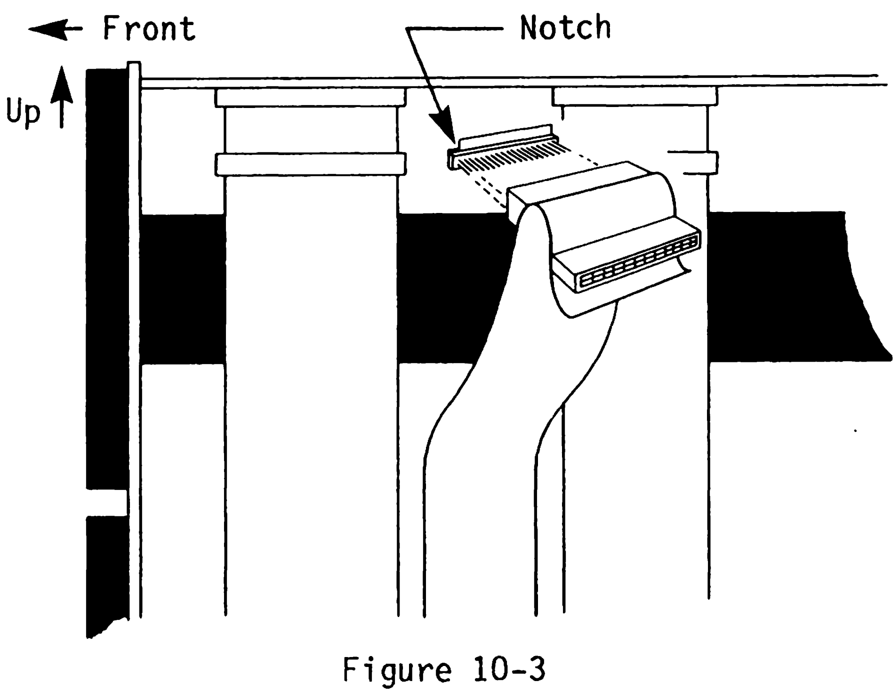


Figure 10-3

MASTER/SLAVE OPTION

Nicolet 4094 plug-ins can be linked with the Master/Slave option to form a data acquisition system with up to 16 channels. Triggers received by the master plug-in are sent out to all slave plug-ins via the master/slave cable harness. The master/slave option also provides interconnection of the LIVE, HOLD LAST, HOLD NEXT plug-in controls.

The 4094 master/slave option requires internal plug-in modifications as well as a specialized cable harness. Only 4 channel 4094's can be adapted to use master/slave triggering due to hardware limitations.

- SPECIFICATIONS

TRIGGER DELAY: 210 nS

Trigger Delay is the time from trigger detection to the first sample, (same for masters and slaves).

TRIGGER DELAY UNCERTAINTY: 20 nS

Trigger Delay Uncertainty is for Zero or Post-Trigger Delays.

SLAVE TRIGGER SIGNAL DELAY:

a. From external cable to next slave plug-in in the same Mainframe: 50 nS

b. From internal plug-in connection to external cable: 8 nS

Slave Trigger Signal Delay is the trigger time delay imposed by each slave plug-in.

● CABLING

Master/slave cables are attached to the REMOTE CONTROL connectors located on the front panel of each plug-in. The sections of cable with coaxial conductors are used between 4094 Mainframes while non-coaxial conductors connect plug-ins within one 4094 mainframe, (Figure 10-1).

➤ IMPORTANT: Take care to push the connectors in all the way and secure with screws. Intermittent operation can be caused by loose connectors.

● PLUG-INS

All 4094 plug-ins must be factory modified to provide the master/slave ability. Left side plug-ins and right side plug-ins are NOT interchangeable if master/slave is to work correctly. Switching left and right plug-ins will not damage the plug-ins as long as master/slave cabling is not attached. Left and right plug-ins are labeled on the the internal metal shielding.

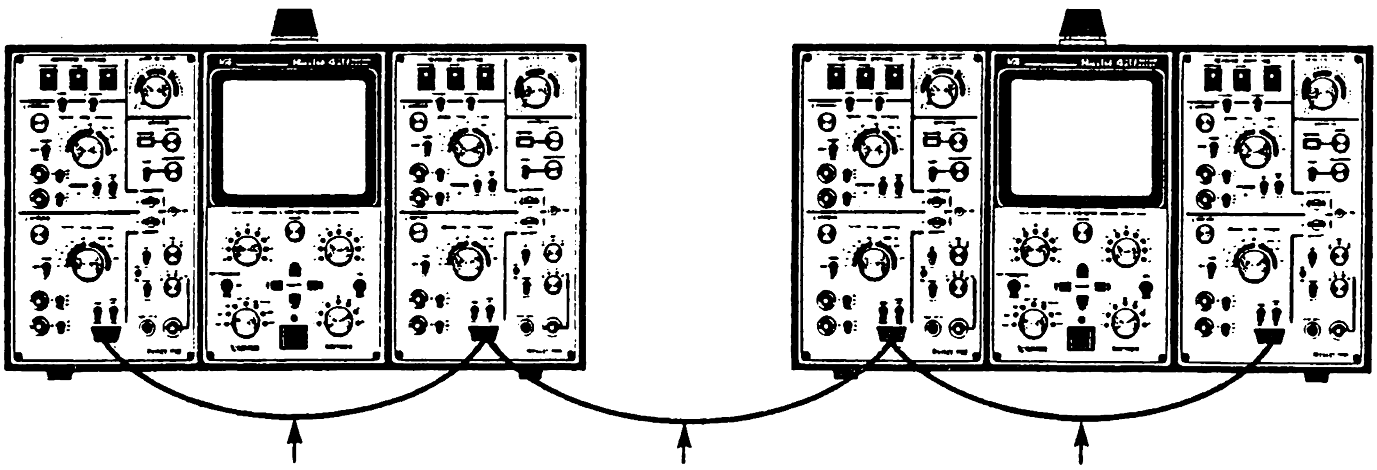
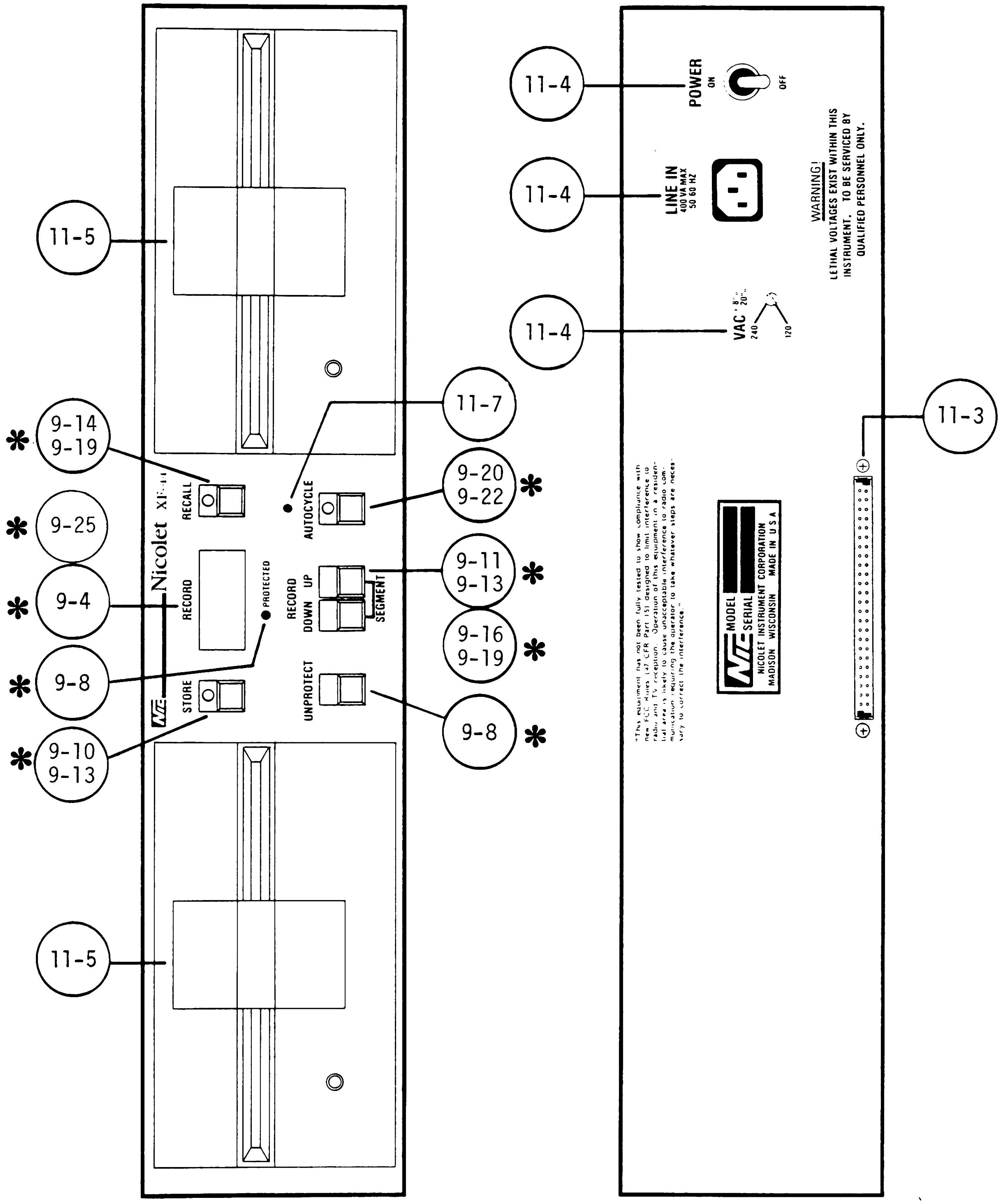


Figure #1

Disk Recorder—XF-44/2



* REFER TO "DISK RECORDER" TAB

XF-44/2

INTRODUCTION

The optional NICOLET XF-44/2 Dual Disk Recorder is typically used to record signals acquired by the Model 4094 Digital oscilloscope. However, an important, additional feature of the XF-44/2 is its ability to easily copy data from one diskette onto another.

The basic operation of this accessory is essentially identical to that of the F-43 and XF-44/1 Disk Recorders described under tab *Disk Recorders*. However, due to several operational exceptions and added features, the following descriptions should be read.

NOTE: The left-hand drive will be referred to as *DRIVE 0*. And the right-hand drive will be *DRIVE 1*.

NOTE: The term "Hold mode" will be used to indicate that the Plug-in has exited the Live mode, only the Hold Last LED is illuminated.

> WARNING: To guard against physical damage to the disk heads and/or diskette, ALWAYS open the drive's door when:
>
> a. Power is off, or
>
> b. Applying/removing power, or
>
> c. Drive is not being used, or
>
> d. Transporting the instrument.

RIBBON CABLE CONNECTOR

Use the ribbon cable furnished with the XF-44 Disk Recorder and interface the two instruments as shown in Figure 11-1.

NOTE: The ribbon cable connectors are keyed on the 4094 and XF-44 as illustrated in Figure 11-1.

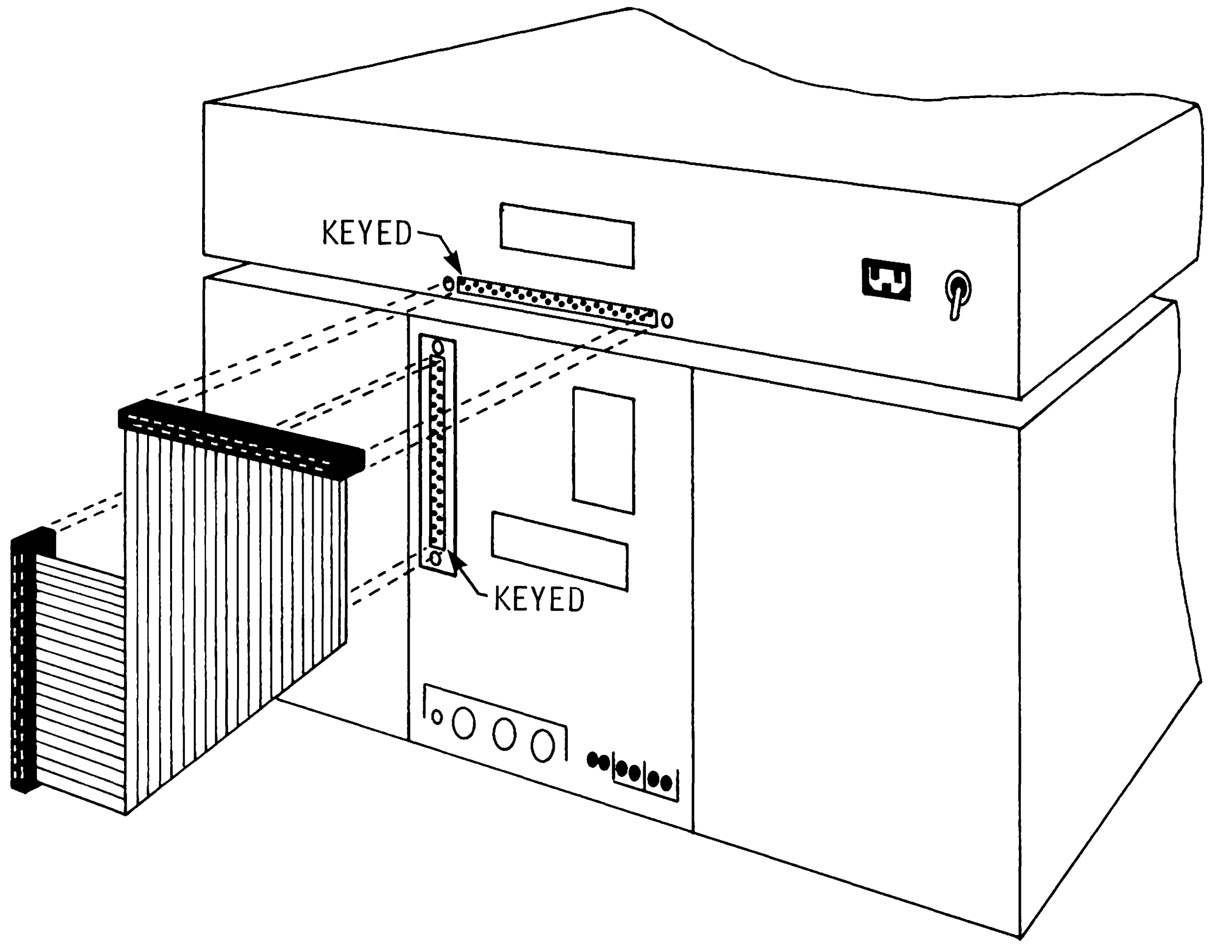


Figure 11-1

POWER REQUIREMENTS

A POWER selector is located on the rear panel of the XF-44.

The position of the XF-44's POWER selector must correspond to that which is selected on the 4094's selector.

> WARNING: Always ensure that the position of the XF-44's POWER selector corresponds to that of the 4094's POWER selector before applying power to either unit.

For additional information on the POWER selectors, refer to *POWER REQUIREMENTS*, located under the tab labeled *Receiving & Pwr Req's*.

The low voltage logic commands between the XF-44 and 4094 are interconnected via the ribbon cable leading between the two instruments.

The ribbon cable also provides power to a relay inside of the XF-44. This relay applies line power to the Disk Drives as soon as the 4094 is turned on. The XF-44's POWER switch must be in the "ON" position.

POWER SWITCH

The POWER: ON/OFF switch mounted on the back of the XF-44 has been provided as a servicing aid. It should always be left in the "ON" position during normal operation.

Placing the POWER switch to the "OFF" position is designed to remove line power from the disk drives. The low voltage logic power will remain via the ribbon cable.

> WARNING: Lethal voltages exist within the XF-44. It should be serviced only by qualified personnel. Remove all power from this instrument before servicing. Reapply power only after all safety measures have been observed.

IMPORTANT: If power is to be removed from the XF-44 during "normal" operation, it should be removed by turning the 4094 off. This procedure is designed to remove line power from the disk drives and logic power from the circuitry during normal operations. Removing power by any other means may cause the disk heads to drift, causing erroneous operations.

LOADING THE DISKETTE(S)

The disk drive(s) automatically energize when the diskette(s) are inserted. Position the diskettes as shown in Figure 11-2.

A Record Number appears on the numerical display if the diskettes have been formatted and are either Series 2090 or 4094 diskettes.

➤ IMPORTANT: The drive's door must be closed within 3 seconds after the diskette has been inserted. Otherwise, the Disk Recorder will not recognize the presence of the diskette.

Table 11-1 tabulates the Record Numbers which will be displayed, corresponding to the type of diskette and into which disk drive it is inserted.

NOTE: When loading two diskettes into an XF-44/2, load one at a time and observe the numerical display for a confirming Record Number before inserting the second one. If a Record Number does not appear, the diskette must be formatted.

TYPE OF DISKETTE	DISK DRIVES	
	DRIVE 0	DRIVE 1
2090	*1 - 8*	*1_1 - 1_8*
4094	*01 - 20*	*101 - 120*

Table 11-1

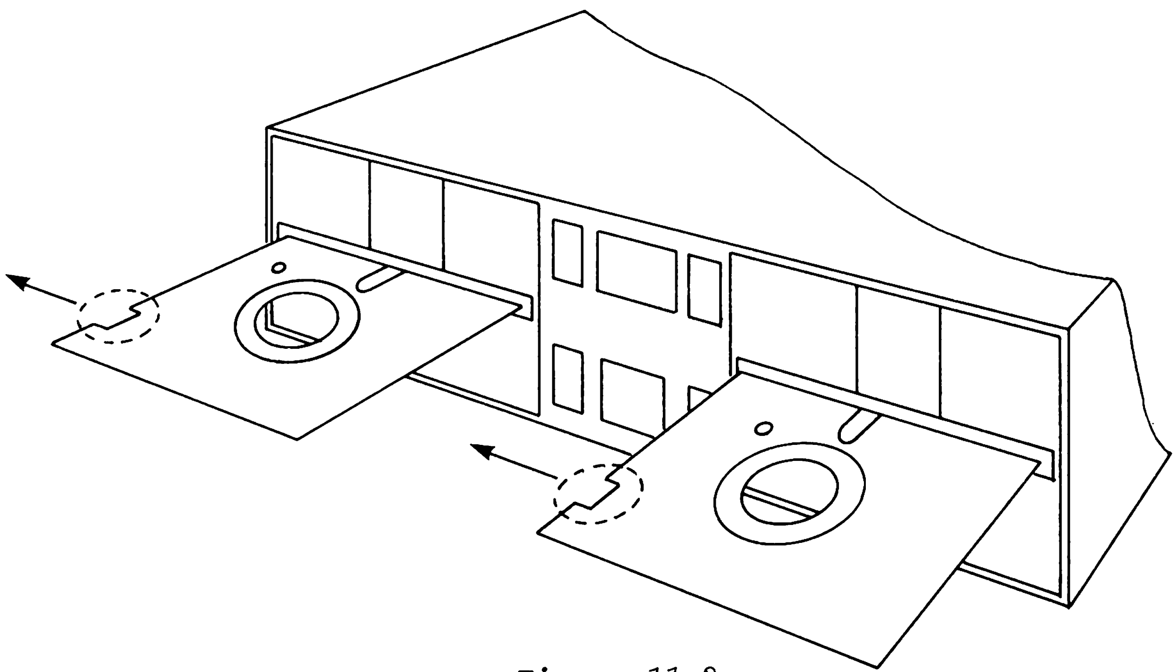


Figure 11-2

NUMERICS DISPLAY

The numerics display will display the the Record Numbers in the following manner, according to which drive the diskette is placed and the type of diskette being used.

- 2090 Diskette
  - Drive 0: Records 1 thru 8
  - Drive 1: Records 1_1 thru 1_8
- 4094 Diskette
  - Drive 0: Records 01 thru 20
  - Drive 1: Records 101 thru 120
- Program Diskette
  - Drive 0: P01 thru P99, max.
  - Drive 1: P01 thru P99, max.

RECORDING SIGNALS

If the oscilloscope is operating with two or more Plug-ins, each Plug-in must be in the Hold mode before data will transfer from the Mainframe's display memory to the XF-44 for storage on the diskette(s).

AUTOCYCLING THE DISKETTES

The XF-44 can operate as either a single or dual disk drive when in the Autocycle routine.

- SINGLE DRIVE: The diskette must be placed in *DRIVE 0*. The Record Number selected to store the first data group, up through Record #20, must be unprotected or the word "Pro" will appear on the numerical display when the AUTOCYCLE button is pressed.
- DUAL DRIVES: Either drive can be selected to record data first. The recorder does <u>not</u> step between the two drives when one diskette becomes filled with data. The operator must manually select which drive will record data.

  The Record Number selected to store the first data group, up through Record #20, must be unprotected. Otherwise, the word "Pro" will appear on the numerical display when the AUTOCYCLE button is pressed.

FORMAT ROUTINE

The Format routine divides a diskette into the required twenty records. It takes approximately three minutes to complete the Format routine.

► IMPORTANT: Only 80 track, 96 TPI, double sided diskettes can be formatted on the XF-44/2 Disk Recorder.

Diskettes shipped with the Series 4094 oscilloscopes have already been formatted at the factory.

► IMPORTANT: Either disk drive can be used to format a diskette. However, ensure that the unused disk drive does not contain a diskette to guard against the possibility of formatting the wrong diskette.

The Format routine is armed by pressing the FORMAT pushbutton (accessed via the hole adjacent to the AUTOCYCLE pushbutton) with a small diameter instrument. The word "For" will appear on the numerical display. Pressing the STORE pushbutton will then initiate the Format routine.

NOTE: The Recorder automatically unarms the Format routine if the STORE button is not pressed within 45 seconds after the FORMAT routine has been armed.

The word "Pro" will appear on the numerical display if the operator attempts to Format a tab protected diskette. The tab must be removed in order to Format the diskette.

Pressing the FORMAT pushbutton a second time exits the Format routine.

A misaligned disk drive and/or head may cause erroneous Store/Recall routines which may resemble a faulty disk recorder.

It is recommended that a factory formatted diskette be kept unaltered to help verify the proper operation of the disk recorder.

Return the diskette to the place of purchase if the disk drive and head have been verified operational and the diskette in question can not be formatted after a second attempt.

COPYING DISKETTES

Data stored on one diskette can be duplicated on another when the XF-44/2 is used in conjunction with the *DISKETTE COPY* program selected on the Disk Programs diskette.

The entire diskette must be copied; individual records can not be selected for duplication.

To copy a diskette -

#1. Insert the Program Diskette into either of the two drives.
   a. A letter "P" and program "number" appears on the numerical display.

#2. UP/DOWN buttons: Press until "P01" (Catalog Number) appears on the numerical display.

#3. RECALL button: Press.
   a. The phrase PROGRAM "CATALOG" appears on the status line at the top of the display screen.

#4. FUNCTION switch: PRGM

#5. EXECUTE button: Press.
   a. The Catalog Program becomes resident in the Program Memory.

#6. CURSOR Up/Down button: Press until the desired Program and Program Number appears on the status line. The Program Number will also appear on the numerical display.

#7. EXECUTE button: Press.
   a. The Catalog Program exits the Program Memory.

#8. RECALL button: Press.
   a. The selected Program becomes resident in the Program Memory.

#9. Remove the Program Diskette.

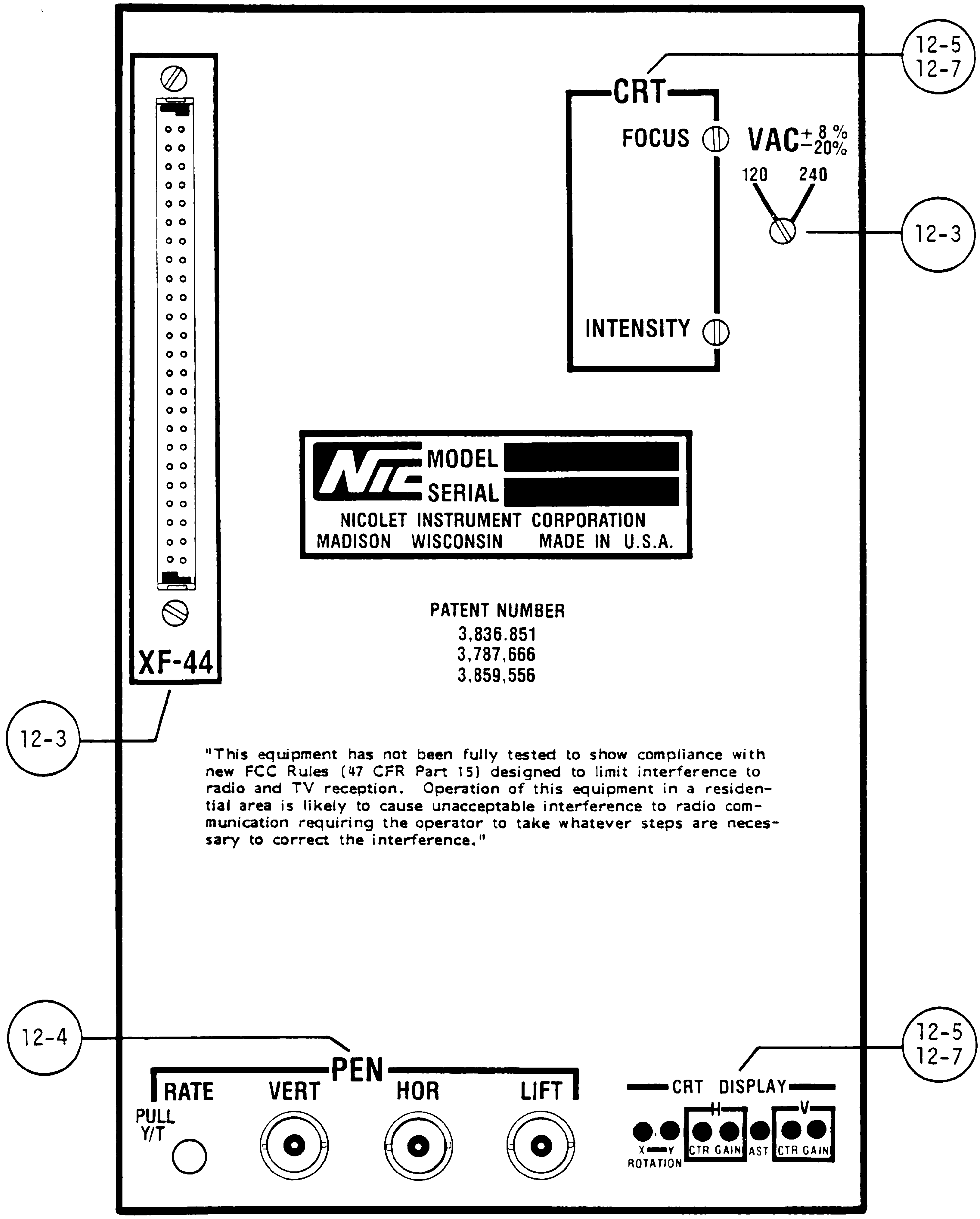
#10. Insert the master diskette into *DRIVE 0*.

#11. Insert the duplicating diskette into *DRIVE 1*.

#12. EXECUTE button: Press.
   a. The data stored on the master diskette is duplicated on the blank diskette.

➤ IMPORTANT: The *DISKETTE COPY* program will remain resident in the Program Memory until either the power is removed from the 4094 or the Program is replaced by a different program.

Back Panel



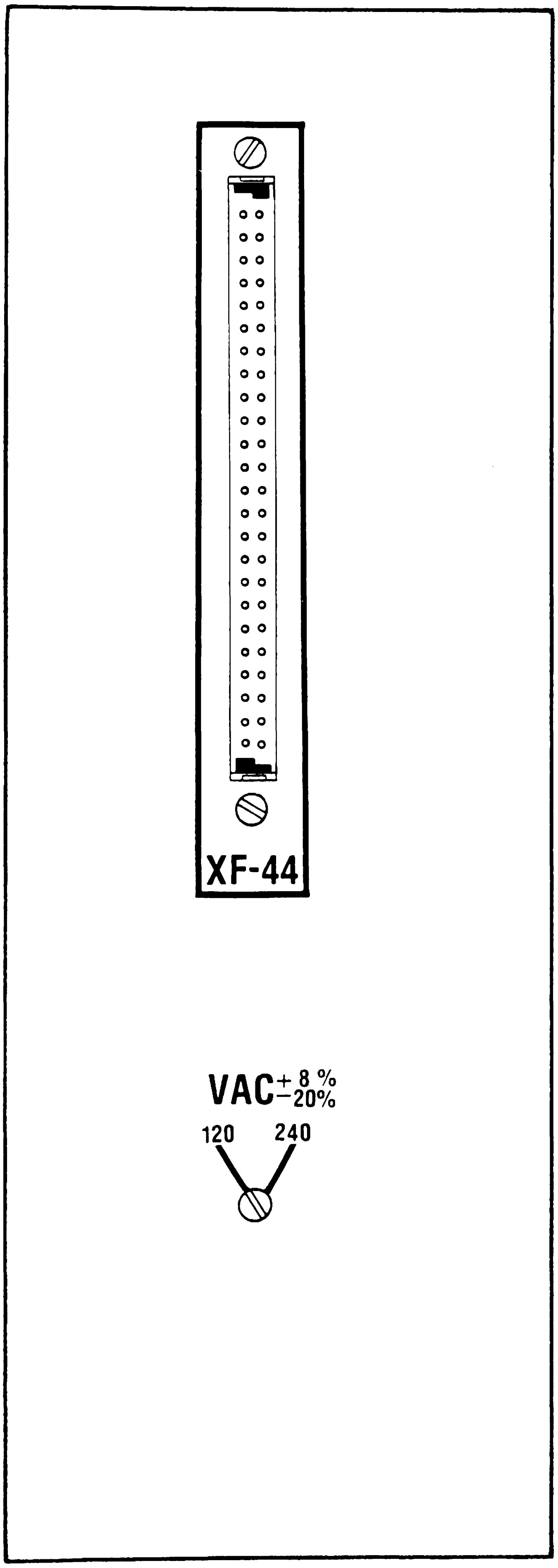
12-5
12-7
CRT
FOCUS
INTENSITY
VAC +8% −20%
120
240
12-3
XF-44
12-3
MODEL [redacted]
SERIAL [redacted]
NICOLET INSTRUMENT CORPORATION
MADISON WISCONSIN MADE IN U.S.A.
PATENT NUMBER
3,836.851
3,787,666
3,859,556
"This equipment has not been fully tested to show compliance with new FCC Rules (47 CFR Part 15) designed to limit interference to radio and TV reception. Operation of this equipment in a residential area is likely to cause unacceptable interference to radio communication requiring the operator to take whatever steps are necessary to correct the interference."
12-4
PEN
RATE
PULL Y/T
VERT
HOR
LIFT
12-5
12-7
CRT DISPLAY
H
V
X
Y
ROTATION
CTR GAIN
AST
CTR GAIN

INTRODUCTION

The Mainframe's back panel contains an XF-44 interface connector, power selector switch, controls for either an XY or YT pen recorder, and controls to adjust the CRT display.

This section of the manual will primarily deal with the CRT display alignment controls and recommended procedures.

The remaining controls have been previously described and are referenced to the appropriate sections of this manual for more detailed information.



XF-44 CONNECTOR

Interfaces the Model 4094 oscilloscope to the XF-44 Dual Disk Recorder via a ribbon cable.

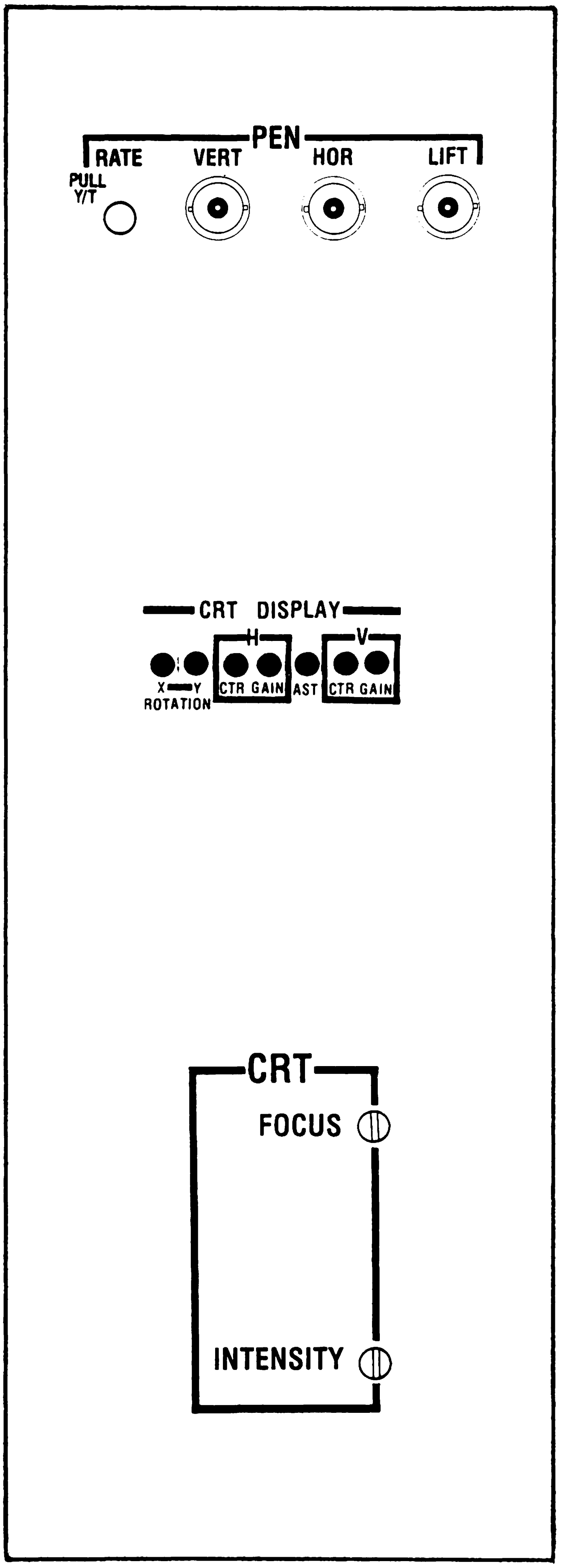
Refer to tab *Dual Disk Recorders*, page 11-3 for further information.

POWER SWITCH

Select according to the line voltage that will be used to power the Model 4094 oscilloscope

> WARNING: Before applying power to this instrument, refer to the *Receiving & Pwr Req's* tab, page 5-2.

BACK PANELS



PEN CONTROLS

Provides output and control of an XY or YT pen recorder.

Refer to tab *Mainframe*, page 7-33 for further information.

CRT DISPLAY ADJUST

Adjusts the X and Y rotation, horizontal center and gain, vertical center and gain, and astigmatism.

CRT ADJUST

Adjusts the CRT focus and intensity.

DISPLAY ADJUSTMENTS

Figure 12-1 has been included as a "quick guide" which summarizes the function of each CRT display adjustment control. The following alignment procedure should be followed when aligning the CRT display.

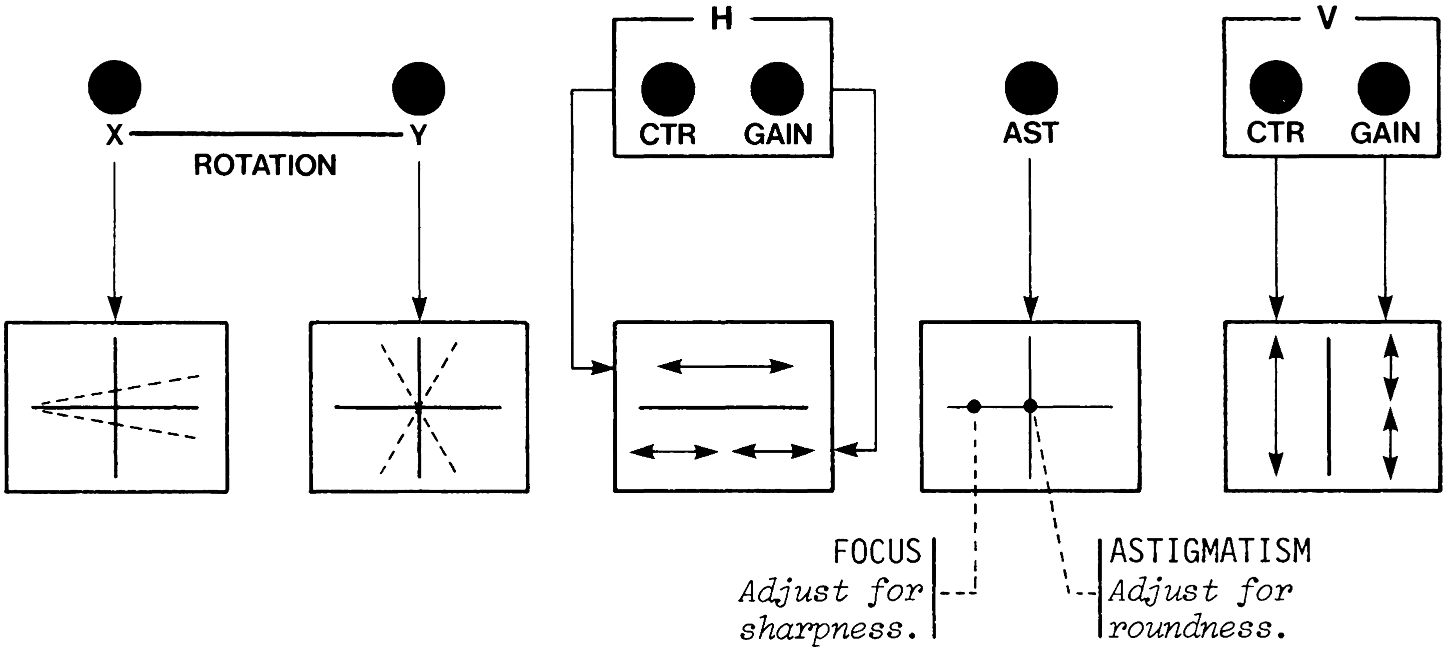


Figure 12-1

BACK PANELS

DISPLAY ALIGNMENT

The CRT display alignment controls are accessible from the rear panel of the Mainframe.

● ALIGNMENT PROCEDURE

It is recommended that the following alignment procedure be followed in the sequence listed and align the CRT only when necessary.

#1. Place all DC/AC/GND switches to the "GND" position.

#2. Place the AUTO/NORM switch to the "AUTO" trigger position.

#3. Place the Plug-in into the Live mode.

#4. Place the VERTICAL and HORIZONTAL EXPANSION switches to the "X2" position.

#5. X-ROTATION: Rotates the entire display with the left side of the screen acting as the pivot.
   a. Adjust until the horizontal cursor is parallel with the bottom of the screen.

#6. Y-ROTATION: Rotates the entire display with screen center acting as the pivot.
   a. Adjust until the vertical cursor is parallel with the side of the screen.

#7. HORIZONTAL CENTER: Positions the display either left or right.
   a. Adjust until the horizontal cursor is evenly centered on the screen.

#8. HORIZONTAL GAIN: Expands or contracts the entire display.
   a. Adjust until both ends of horizontal cursor are approximately 3/16" from the sides of the screen.

#9. VERTICAL CENTER: Positions the display either up or down.
   a. Adjust until the vertical cursor is evenly centered on the screen.

BACK PANELS

#10. VERTICAL GAIN: Expands or contracts the entire display.
  a. Adjust until the vertical cursor is approximately 1/8" from the bottom of the screen.

#11. Repeat Steps #9 and #10 until the vertical cursor is approximately 1/4" from the bottom of the screen.

#12. Increase the HORIZONTAL EXPANSION switch setting until individual data points can be easily discerned.

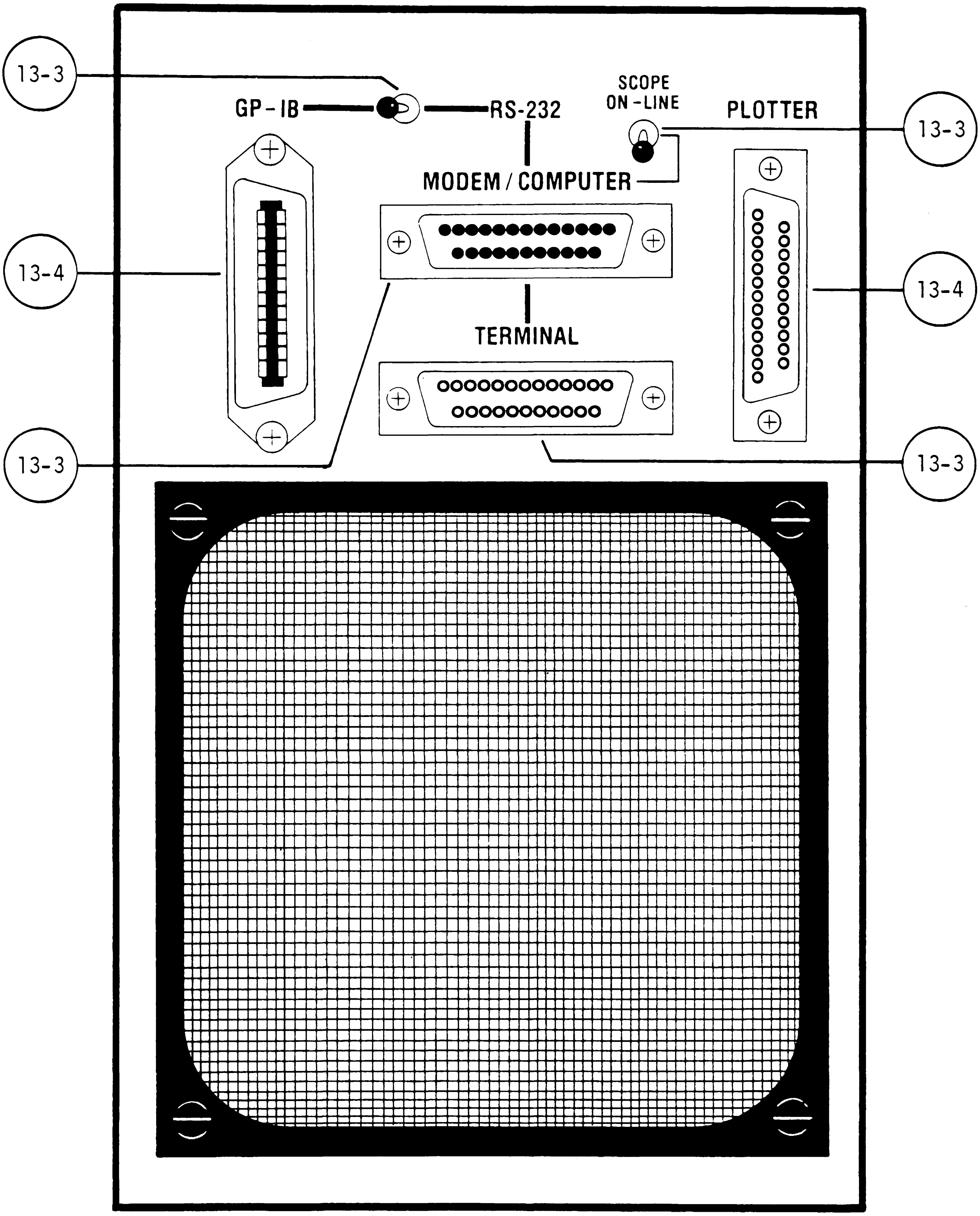
#13. Place the Mainframe into the Autocenter mode.

#14. ASTIGMATISM: Adjusts for round data points.
  a. Adjust until the data point at screen center is round.

#15. FOCUS: Adjusts for the sharpest data point detail.
  a. Locate a data point approximately 50% between screen center and the side of the display screen. Adjust the FOCUS until the data point is in focus.

#16. INTENSITY: Brightens or darkens the display. This control may be adjusted to obtain optimum results when photographing the display.

Input/Output Panel

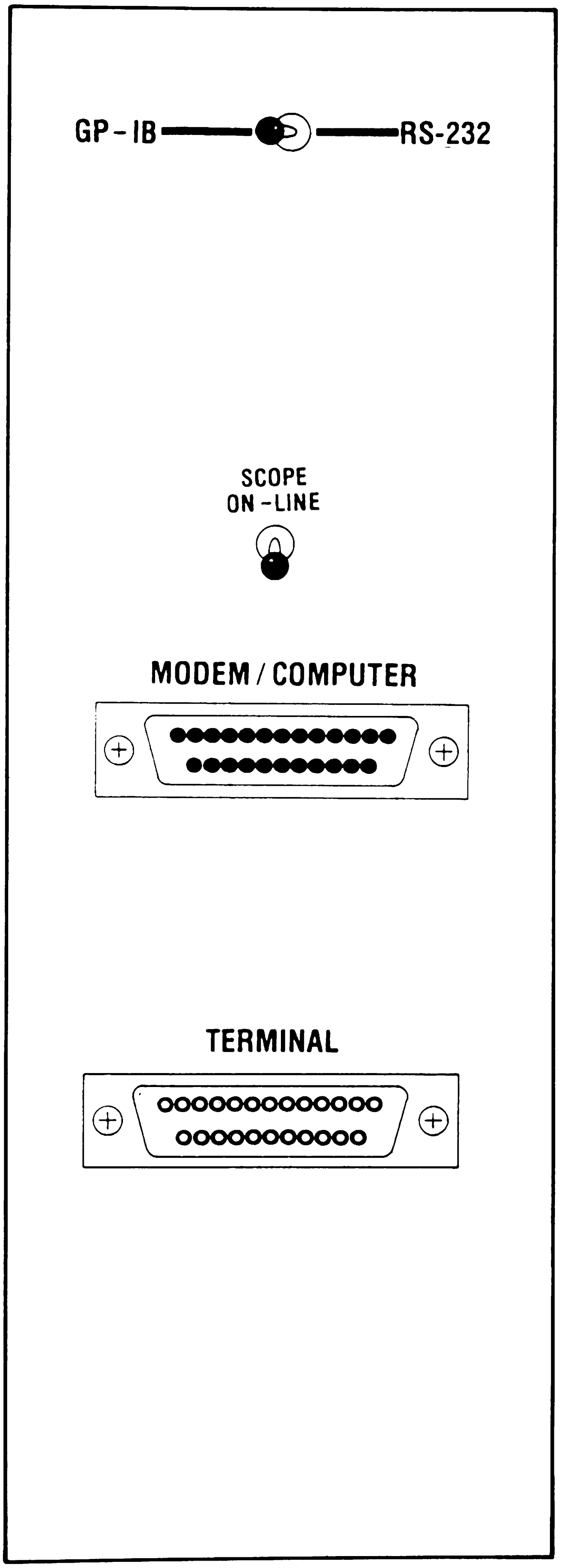


INTRODUCTION

This section of the manual describes the operation of the Input/Output features.

It is advisable to fully read the start-up procedure for the interface being used (RS-232C or GPIB). The actual interfacing commands are the same for both interfaces and, therefore, the command explanations are not partitioned by interface. Sample programs provided at the end of this section can be used as "real world" examples of command usage.

NOTE: The table of contents for this section is located on page 13-5.



GPIB/RS-232 SWITCH

Determines whether the GPIB or RS-232 computer interface connectors will be activated. Also used as a reset switch for the interfaces. During initial programming work, it is useful to be able to reset the interfaces without loss of waveform data.

SCOPE ON-LINE SWITCH

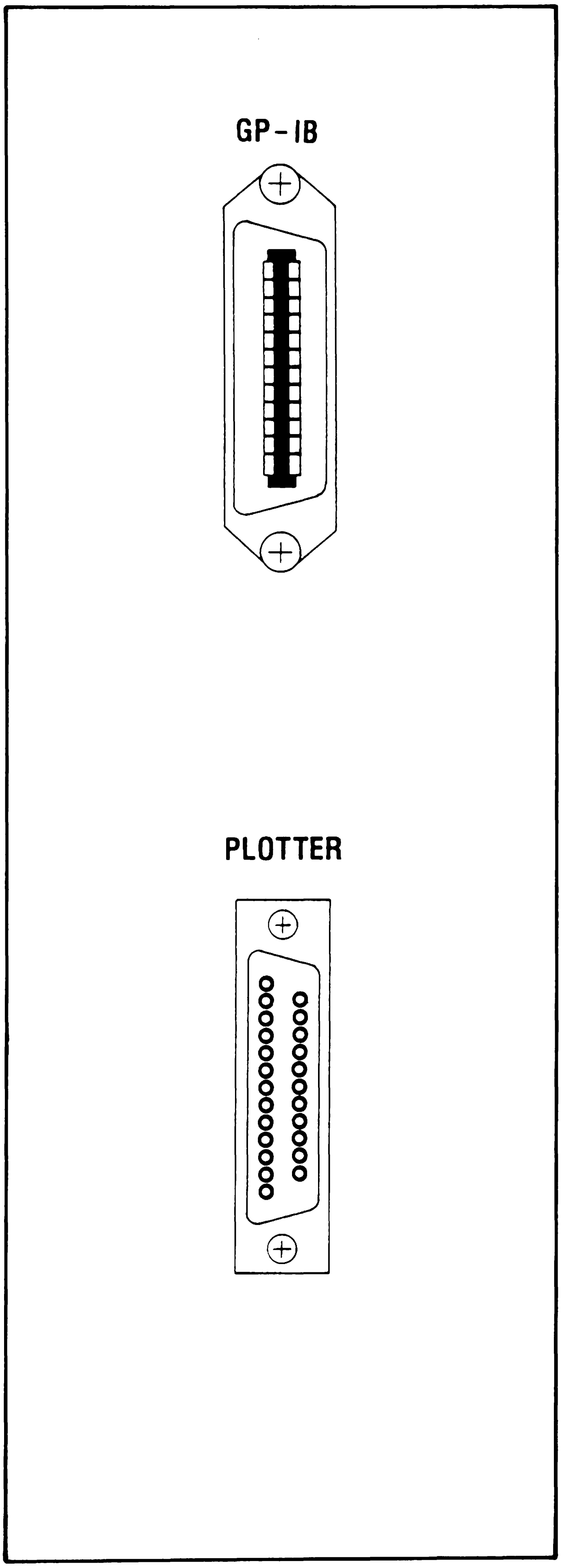
Activates the RS-232 computer interface connector when turned on.

MODEM/COMPUTER CONNECTOR

Interfaces the computer to the 4094 oscilloscope. Used with RS-232C interfaces. Any device which is intended to communicate with the 4094 oscilloscope via RS-232C must be connected to this port.

TERMINAL CONNECTOR

Interfaces an optional terminal, or other similar device, to the computer via RS-232C. This connector only permits communication with the computer, it can not be used to control the 4094 oscilloscope. This port is useful when two devices (4094 and a computer terminal) must be connected to a computer but only one RS-232C cable or phone line exists.



GPIB CONNECTOR

Connect a computer to the 4094 oscilloscope via the IEEE-488 (or GPIB) interface.

PLOTTER CONNECTOR

Interfaces Digital Plotters offered NICOLET for the 4094 oscilloscope.

TABLE OF CONTENTS

GLOSSARY OF TERMS

- ADDRESS: A number which represents a device attached to the GPIB or the RS-232C interface.
- ASCII: American Standard Code for Information Interchange. A seven bit system of representing characters such as numbers, letters, math symbols, etc.
- BASIC: A high level programming language.
- BAUD: Bit serial data transmission rate measured in bits per second.
- BIT: A single digit in the base two numbering system. A bit is either "0" or "1". Groups of bits (8 bits = 1 byte, 4 bits = 1 nibble, 16 bits in the 4094 = 1 word) are used to encode data used in digital electronic systems.
- BIT SERIAL: Data transmitted one bit at a time. RS-232C communic-ations are bit serial.
- BUS: Wires used to transmit groups of bits. Buses can be internal or external to a machine.
- BYTE: A group of eight bits.
- CAMAC: The IEEE-583 interface standard. Primarily used in the nuclear industry in place of the GPIB.
- CARRIAGE RETURN: A computer terminal key which causes the printing head or cursor to return to the start of the line.
- CARRIER FREQ.: A frequency which is modulated to carry binary information.
- CHARACTER: Standard symbols such as: A-Z, a-z, 0-9, +, -, etc.
- CONTROLLER: A device connected to an interface which commands other devices on the interface.
- DATA SET: See Modem.
- DELIMITER: ASCII character(s) used to separate or end strings of characters which belong together as a group. Carriage Return (CR) and Linefeed (LF) are common examples.
- DIP: Dual In-line Package. Standard physical structure of integrated circuits. Two rows of pins are attached to the IC body.
- EIA: Electronic Industries Association
- ECHO CHECK: A transmission error detection procedure in which the receiving device repeats everything back to the sender for verification. Used on RS-232C interfacing.

- END OF FILE (EOF): A delimiter which indicates the end of a data transmission.

- FORTRAN: A high level programming language.

- FSK: Frequency Shift Keying. Each binary state, 1 or 0, is represented with a single frequency. These two tones are transmitted over telephone lines in standard RS-232C communications. See Carrier, Modem.

- FULL DUPLEX: RS-232C communications which can take place in two directions simultaneously.

- GPIB: General Purpose Interface Bus. Specified by IEEE-488.

- HPIB: Hewlett Packard Interface Bus. Essentially the same as the GPIB/IEEE-488. Devices with the HPIB are compatible with the GPIB.

- HALF DUPLEX: RS-232C communications which pass in only one direction at any given time.

- HANDSHAKING: The process of synchronizing communications between devices. A system of questions (Ready?) and replies (Yes) are used to make sure sender and receiver are properly prepared.

- IEEE: Institute of Electronic and Electrical Engineers.

- IEEE-488: The IEEE specification for the GPIB.

- I/O: Input/Output.

- INTERFACE: The circuitry and programming necessary for the interconnection of electronic devices.

- LSB: Least Significant Bit. In most cases the LSB is a bit representing 2^0 or 1.

- LINEFEED: A computer terminal key which causes the paper or cursor to advance one line.

- LOCAL ECHO: The process of sending characters typed on a computer terminal keyboard to the computer terminal screen for display.

- MSB: Most Significant Bit. The bit in the highest binary location in a binary number.

- MODEM: Modulator-demodulator. An RS-232C device used to transmit and receive binary data on telephone lines. Each binary "1" or "0" is represented with a specific signal frequency.

- NOISE: Unwanted signals. Interface noise is usually caused by noisy telephone lines or radio frequency interference on connecting cables.

- NEGATIVE LOGIC: A low voltage represents a binary "1". This is the convention used by the GPIB and RS-232C data transmission lines.

- OCTAL: Base eight number system.

- PARITY BIT: A parity bit is an extra bit added to a binary word to create an even or odd number of binary bits equal to "1". By counting the number of 1's in a word and knowing whether the total should be even or odd, the receiving device can detect most errors due to interface noise. Used with RS-232C interfacing.

- POSITIVE LOGIC: A high voltage represents a binary "1". This is the convention used by RS-232C handshaking lines.

- RS-232C: Recommended Standard 232C. An EIA specification which defines bit serial data communications.

- RECORD SEPARATOR: A delimiter which separates data values in a transmission.

- SERIAL DATA: See Bit Serial.

- SIMPLEX: Similar to half duplex communications except that communications can travel only in one direction. It is impossible to transmit anything back to the sender.

- START BIT: A bit which precedes the eight bits (7 bits plus parity bit) representing an ASCII character. The start bit is a warning to the receiver that data will follow immediately. Start bits are at logic "0". Start bits are used with RS-232C communications.

- STOP BIT: The bit(s) which immediately follow the eight bits (7 bits plus parity bit) which compose an ASCII character. The stop bits (1 or 2) define the minimum spacing between characters. Stop bits are at logic "1". Stop bits are used with RS-232C communications.

- WORD: A group of bits of arbitrary length which form a single binary value. 4094 words are 16 bits long.

GENERAL OVERVIEW - IEEE-488/GPIB

The General Purpose Interface Bus (GPIB) has been widely accepted since April, 1975 when IEEE-488 was published. The GPIB offers interface compatibility which was previously unavailable. Since 1975, thousands of GPIB compatible products have been introduced on the market.

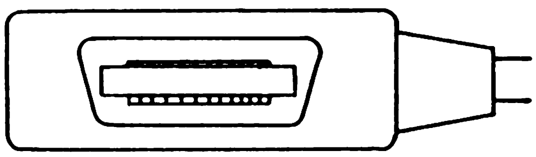
STANDARD GPIB CABLE & CONNECTOR	D8 pin 16 (MSB) D7 pin 15 D6 pin 14 Bidirectional D5 pin 13 Data Lines D4 pin 4 D3 pin 3 D2 pin 2 D1 pin 1 (LSB)
	NDAC pin 8 Data Transfer NRFD pin 7 Control Lines DAV pin 6 (Handshaking Lines)
Pins 12, and 18 thru 24 at ground potential.	ATN pin 11 IFC pin 9 General Control SRQ pin 10 Lines REN pin 17 EOI pin 5

Figure 13-1

- PHYSICAL LIMITATIONS

#1. Maximum of 15 devices on one GPIB.

#2. Maximum of 2 meters of cable between any two devices or 20 meters of cable in total, whichever is less.

#3. Maximum data transfer rates are set by the slowest device involved in the data transfer. Computer program execution speed is an important factor in data transfer

● GPIB PIN EXPLANATIONS

The following are explanations of the GPIB PINS as they relate to the Nicolet Model 4094 Digital oscilloscope.

NOTE: "1" is represented by a low voltage, (approx. 0V). "0" is represented by a high voltage, (approx. 3V).

D1 through D8: Carry data into or out of the 4094. Carry addresses into the 4094. Carry specialized controller commands into the 4094.

NDAC: Not Data Accepted
1 = ready to accept data.

NRFD: Not Ready For Data
1 = not OK to send data.

DAV: Data Valid
1 = data valid on data lines.

ATN: Attention
0 = data lines have data.
1 = data lines have address or GPIB command.

IFC: Interface Clear
1 = "clears" all devices attached to the GPIB so that they are off the GPIB.

SRQ: Service Request
1 = tells the controlling computer that some device on the GPIB has information to be released. Not supported in the 4094.

REN: Remote Enable
1 = all devices on the GPIB will ignore their front panel controls and operate strictly under GPIB control. Not supported in the 4094.

EOI: End Or Identify
1 = indicates to the device receiving information that the last information to be transmitted is on the data lines. Not supported in the 4094.

IEEE-488/GPIB Operation

The 4094 GPIB connector is located on the back panel of the Model 4094-2 oscilloscope.

The RS-232/GPIB switch must be switched to GPIB before transfers can take place.

The RS-232/GPIB switch also performs an added useful function. Each time the switch is moved the I/O processor internal to the 4094 (controlling interfaces, disk recorders, digital plotter, and disk programs) is reset.

Data stored in the 4094 memory is not lost in this process. This simple resetting action can prove very useful when computer programs are being debugged.

A computer reset and a 4094 reset will manually return both pieces of equipment to their start-up conditions.

The 4094 GPIB is also capable of performing bidirectional transmissions with the RS-232C plotter port.

This means that a controlling computer can input to the 4094 on the GPIB and have that transmission outputted on the RS-232C plotter interface.

The GPIB interface will not be permitted to run faster (through normal handshaking procedures) than the plotter port can transfer information.

However, in the reverse direction, the GPIB must keep up with information coming from the plotter port. This will not strain most GPIB controllers since this only amounts to a data transfer rate of 2000 bytes/sec. Interconnection of the GPIB and the RS-232 plotter port is covered in detail in the Advanced Interfacing Section under the J command.

● IEEE-488/GPIB "Clear" Commands

The three commands listed below allow the programmer to "clear" the bus of one or all addressed devices. These can be used in addition to the standard untalk, unlisten addresses shown on Table 13-1, (page 13-16).

The actual computer statement used to send out each "clear" command should be listed in the computer manual.

#1. INTERFACE CLEAR - See the GPIB line explanations. This command clears off all devices addressed on the GPIB and each device returns to its initial, unaddressed state. Computer statements such as "INIT' in BASIC are used to turn on Interface Clear.

#2. DEVICE CLEAR (DCL) - This command removes all devices which support Device Clear from the GPIB and returns them to their unaddressed state. In ASCII, DCL is represented by "DC4". This command is not addressed to specific devices.

#3. SELECTED DEVICE CLEAR (SDC) - Similar to Device Clear except that it affects only the devices addressed by the command. In ASCII, SDC is represented by "EOT".

● ADDRESSING

Each device that is connected to the GPIB must be assigned an address (decimal number) so that it can be distinguished from other devices also on the GPIB.

Each address can be subdivided into a "talk" address for outputting data and a "listen" address for inputting data.

The 4094 GPIB address is set via a five segment DIP switch located on the large circuit board visible when the 4094 right side cover is removed. Table 13-1 ties together DIP switch setting, GPIB address, listen address, and talk address.

Many computers simplify programming by allowing the programmer to refer to a single GPIB address. The computer will correctly translate this into a talk or listen address depending on the program statement. A "PRINT" statement in BASIC infers that a listen address is required. An "INPUT" statement in BASIC would indicate that a talk address is needed. The programs shown at the end of this interfacing section show practical examples.

Table 13-1 equates the DIP switch setting to the GPIB address and also to the corresponding talk and listen addresses. These may have to be used if the computer does not automatically convert addresses. Consult your computer manual to find out if talk and listen addresses must be specified.

Note that talk and listen addresses are expressed in decimal numbers and their ASCII character equivalents. These represent binary numbers which are derived from the DIP switch address setting by turning on bit 6 or 7 in addition to the five bits already shown on the switch. A DIP switch OPEN represents a binary 1. Switch 1 is the most significant bit. (e.g., decimal 1 = binary 00001, add bit 6 = 1; binary 100001 = decimal 33 = ! in ASCII). See Table 13-1.

Unlisten and untalk addresses cause all devices on the GPIB to be removed as a listener or a talker.

Note 1: Turn the oscilloscope off before setting dip switch.

Note 2: OP = Switch open.
CL = Switch closed.

DIP SWITCH					GPIB ADDRESS		LISTEN ADDRESS		TALK ADDRESS	
(1)	(2)	(3)	(4)	(5)	Decimal	Octal	Decimal	ASCII	Decimal	ASCII
CL	CL	CL	CL	CL	0	0	32	space	64	@
CL	CL	CL	CL	OP	1	1	33	!	65	A
CL	CL	CL	OP	CL	2	2	34	"	66	B
CL	CL	CL	OP	OP	3	3	35	#	67	C
CL	CL	OP	CL	CL	4	4	36	$	68	D
CL	CL	OP	CL	OP	5	5	37	%	69	E
CL	CL	OP	OP	CL	6	6	38	&	70	F
CL	CL	OP	OP	OP	7	7	39	'	71	G
CL	OP	CL	CL	CL	8	10	40	(	72	H
CL	OP	CL	CL	OP	9	11	41	)	73	I
CL	OP	CL	OP	CL	10	12	42	*	74	J
CL	OP	CL	OP	OP	11	13	43	+	75	K
CL	OP	OP	CL	CL	12	14	44	,	76	L
CL	OP	OP	CL	OP	13	15	45	-	77	M
CL	OP	OP	OP	CL	14	16	46	.	78	N
CL	OP	OP	OP	OP	15	17	47	/	79	O
OP	CL	CL	CL	CL	16	20	48	0	80	P
OP	CL	CL	CL	OP	17	21	49	1	81	Q
OP	CL	CL	OP	CL	18	22	50	2	82	R
OP	CL	CL	OP	OP	19	23	51	3	83	S
OP	CL	OP	CL	CL	20	24	52	4	84	T
OP	CL	OP	CL	OP	21	25	53	5	85	U
OP	CL	OP	OP	CL	22	26	54	6	86	V
OP	CL	OP	OP	OP	23	27	55	7	87	W
OP	OP	CL	CL	CL	24	30	56	8	88	X
OP	OP	CL	CL	OP	25	31	57	9	89	Y
OP	OP	CL	OP	CL	26	32	58	:	90	Z
OP	OP	CL	OP	OP	27	33	59	;	91	[
OP	OP	OP	CL	CL	28	34	60	<	92	\
OP	OP	OP	CL	OP	29	35	61	=	93	]
OP	OP	OP	OP	CL	30	36	62	>	94	^
OP	OP	OP	OP	OP	Do Not Use		Do Not Use		Do Not Use	
Unlisten/Untalk							63	?	95	_

Table 13-1

- IEEE-488 FUNCTION SUBSETS

SH1: Source Handshake, complete capability

T8: Basic talker & Unaddress if MLA

L4: Basic Listener & Unaddress if MTA

SRØ: Service Request, no capability

RLØ: Remote Local, no capability

AH1: Acceptor Handshake, complete capability

PPØ: Parallel Poll, no capability

DC1: Device Clear, complete capability

DTØ: Device Trigger, no capability

CØ: Controller, no capability

GENERAL OVERVIEW - RS-232C

The Electronic Industries Asociation (EIA) Recommended Standard 232C has become the accepted bit-serial data transmission specification. Bit-serial interfacing was primarily developed for long distance communications over telephone lines. Widespread acceptance of RS-232C has prompted its use in non-telephone data transmissions as well.

STANDARD RS-232C CABLE & CONNECTOR

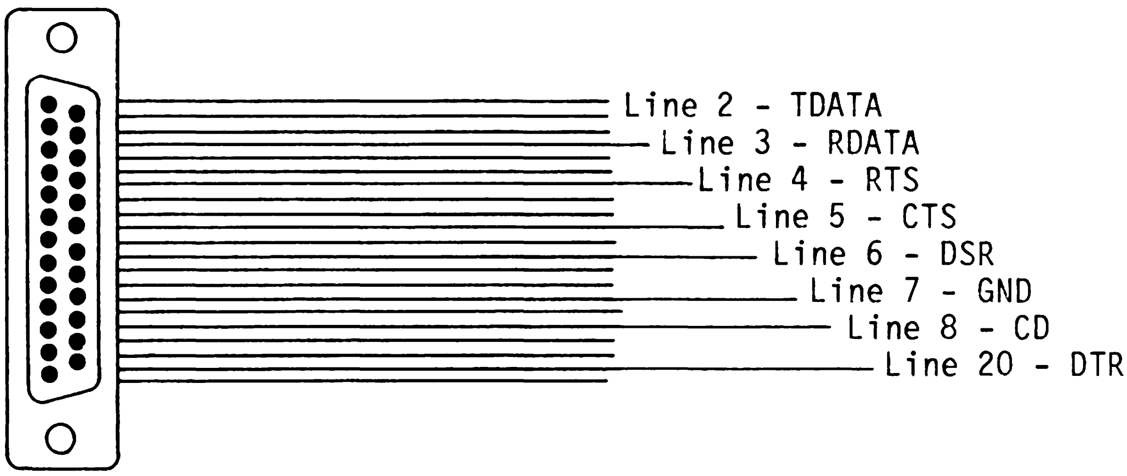


Figure 13-2

- PHYSICAL LIMITATIONS

1. The maximum transmission distance is unlimited if telephone lines are utilized. Direct cable link-ups are limited to 50 feet.
2. The maximum data transfer rate is set by the allowable baud rates (bits per second) of the communicating devices. The Nicolet 4094 can run at 110 to 19200 baud.

● RS-232 LINE EXPLANATIONS

The following are explanations of the RS-232C Lines as they relate to the Nicolet Model 4094 Digital Oscilloscope.

#1. PROTECTIVE GROUND

#2. TDATA: TRANSMITTED DATA
Path for outgoing data.

#3. RDATA: RECEIVED DATA
Path for incoming data.

#4. RTS: REQUEST TO SEND
Activated by the sending device to tell the sending modem to get ready for data transmissions.

#5. CTS: CLEAR TO SEND
Activated by the sending modem to tell the sending device that it is ready for transmissions. The 4094 will pause during data transmission if this line is turned OFF (-10V). Data transmissions from the 4094 will resume as soon as this line is turned ON (+10V). No characters will be lost.

NOTE: Lines not discussed are not supported by the 4094.

#6. DSR: DATA SET READY
A data set is a modem. This line is activated by the sending modem to tell the sending device that it is ready for a Request to Send.

#7. SIGNAL GROUND

#8. CD: CARRIER DETECTED
Activated by the receiving modem to tell the receiving device that a carrier signal has been detected and data will soon follow.

#20. DTR: DATA TERMINAL READY
Activated by the sending device to tell the sending modem that it is ready to transmit data.

Voltage	Status (for handshaking lines)	Binary (for data)
-3 volts to -25 volts	OFF	1
+3 volts to +25 volts	ON	0

Table 13-2

● START-UP PROCEDURE

Several manual switch settings must be made before the 4094, RS-232C interface can be put into service. These settings are used to select baud rate, parity, and number of stop bits.

The 4094 interface must have settings which match the connected device specifications. Factory settings are as follows:

a. 300 baud
b. no parity check
c. one stop bit

The above settings may be changed with the 8 segment DIP switch located on the large circuit board visible when the 4094 right side cover is removed. After turning the oscilloscope OFF, remove the right side cover and use the following information to set the switch.

RS-232C SWITCH							
1	2	3	4	5	6	7	8
Baud Rate (BPS)				Plotter Baud Rate (not discussed here)	Odd/Even Parity	Parity ON/OFF	Stop Bits

Figure 13-3

#1. Set the baud rate (bits per second) to match the baud rate of the connected device as tabulated in the table below.

BAUD RATE	SWITCH SETTINGS			
	1	2	3	4
300	Closed	Closed	Closed	Closed
1200	Closed	Closed	Closed	Open
9600	Closed	Closed	Open	Closed
110	Closed	Closed	Open	Open
150	Closed	Open	Closed	Closed
450	Closed	Open	Closed	Open
600	Closed	Open	Open	Closed
1800	Closed	Open	Open	Open
2000	Open	Closed	Closed	Closed
2400	Open	Closed	Closed	Open
3600	Open	Closed	Open	Closed
4800	Open	Closed	Open	Open
7200	Open	Open	Closed	Closed
14400	Open	Open	Closed	Open
19200	Open	Open	Open	Closed

Table 13-3

#2. Set the parity. The parity bit is an eighth bit sent with each group of seven bits (each ASCII character). By checking parity bits the receiving device can determine when transmission errors have occurred. If parity is turned off, parity bit checking will not be done. Transmissions from the 4094 will have the parity bit set at "0" if parity is turned off. With parity off, the 4094 will accept a parity bit "1" or "0".

Switch 6 (only used if switch 7 is OPEN)	
OPEN	Odd parity
CLOSED	Even parity

Table 13-4

Switch 7	
OPEN	Parity checking on
CLOSED	Parity checking off

Table 13-5

#3. Set the number of stop bits. Each ASCII character (seven bits plus a parity bit) transmitted is preceded by a start bit and followed by one or two stop bits. Communicating devices must agree on the number of stop bits to be used.

Switch 8	
OPEN	Two stop bits.
CLOSED	One stop bit.

Table 13-6

NOTE: After setting switches 1 through 8 the side cover should be put back in place.

#4. The 4094 RS-232C interface should be switched ON LINE if it is expected to participate in any communications. The ON LINE switch controls pin 20 (DTR) on the MODEM/COMPUTER connector, the TERMINAL connector is unaffected by this switch.

The RS-232/GPIB switch must be switched to RS-232 before transfers can take place. The RS-232/GPIB switch also performs an added useful function. Each time the switch is moved the I/O processor internal to the 4094 (controlling interfaces, disk recorders, digital plotter, and disk programs) is reset. Data stored in the 4094 memory is not lost in this process. This simple resetting action can prove useful when computer programs are being debugged. A computer reset and a 4094 reset will manually return both pieces of equipment to their start-up conditions.

#5. The RS-232C connectors on the back of the 4094 are standard 25 pin, D subminiature rectangular connectors (such as Cannon DB-25S, DB-25P, DBSP-25S, and DBSP-25P). The MODEM/COMPUTER connector is the input/output port for the 4094. The TERMINAL connector allows both the 4094 and a computer terminal to communicate with a computer connected to the MODEM/COMPUTER port. Commands sent to the TERMINAL connector will not directly control the 4094. Any device expected to input to the 4094, or receive data from the 4094, must be connected to the MODEM/COMPUTER port. The MODEM/COMPUTER port is designed to transmit and receive to/from modems and computer input/output ports configured for use with terminals.

Direct connection of the MODEM/COMPUTER port to computer terminals, teletypes, and non-terminal configured computer ports will necessitate use of the Nicolet null modem printed circuit board supplied with the 4094. The null modem board is attached to the 4094 as shown in Figure 13-4.

The null modem board provides the following:

a. Cross-connections of the transmit and receive lines.

b. Access to control lines so that specialized handshaking can be patched in if desired. For example, a computer which can control its Request To Send (RTS) line could control the 4094 data output. The computer's RTS could be patched together with the 4094 Clear to Send (CTS). When the computer RTS turns the 4094 CTS line OFF (-3 to -25 volts) the 4094 data transmission will cease. Transmissions will resume as soon as the 4094 CTS line is turned ON (+3 to +25 volts). It should be noted that this can also be accomplished by using the commands XON, XOFF if supported by the controlling computer.

c. Access to all 4094 supported RS-232C lines for test purposes.

d. Interconnection of handshaking lines so that each device will "think" that it is connected to a modem providing standard handshaking functions.

● NULL MODEM CONNECTION

Figure 13-4 illustrates the use of the Null Modem circuit board.

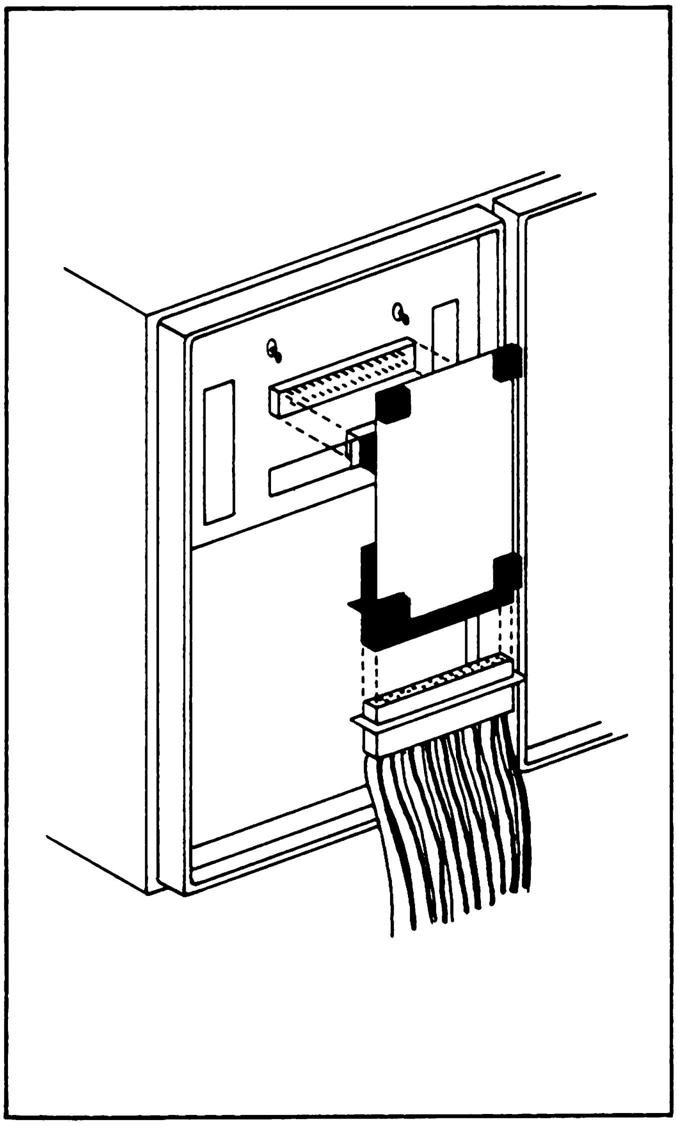


Figure 13-4

● RS-232C CONTROL CHARACTERS

The RS-232C control characters are ASCII characters which initiate RS-232C transmissions, abort 4094 input transmissions, and address multiple 4094 oscilloscopes.

Command C (at end of Basic Interfacing Commands section) shows how to change all default RS-232C control characters to different characters. The explanations below use the default control characters in all examples.

#1. Activate RS-232C Transmissions: Two ASCII characters are required to activate the 4094 RS-232C interface (the MODEM/COMPUTER port). Before further RS-232C communications can take place these two characters must be transmitted to the 4094.

Character 1 - SOH (CNTL A, two keys pressed simultaneously)

Character 2 - RS-232C address (see Table 13-7)

The RS-232C address gives the unique possibility of being able to attach multiple 4094 oscilloscopes on a single RS-232C interface. The first 4094 is connected to the computer via its MODEM/COMPUTER port.

The next 4094 MODEM/COMPUTER port is connected to the first 4094 TERMINAL port, and so on. This also gives the ability to connect one additional RS-232C compatible device to the last 4094 TERMINAL port if an actual terminal is not being used.

The RS-232C address is a character which is equated in Table 13-7 (page 13-27) to the GPIB address setting. The C command described under Basic Interfacing Commands allows the RS-232C address to deviate from the DIP switch setting.

● EXAMPLE

SOH> activates the RS-232C interface addressed at 14.

NOTE: SOH and the address will <u>not</u> be displayed on the 4094 screen.

NOTE: See Table 13-1, page 13-16.

DIP Switch Setting	RS-232C Address Character	DIP Switch Setting	RS-232C Address Character
0	0	16	@
1	1	17	A
2	2	18	B
3	3	19	C
4	4	20	D
5	5	21	E
6	6	22	F
7	7	23	G
8	8	24	H
9	9	25	I
10	:	26	J
11	;	27	K
12	<	28	L
13	=	29	M
14	>	30	N
15	?		

Table 13-7

NOTE: See the Q command for general deactivation of the RS-232C interface.

#2. Pause during RS-232C Transmission: Many large computers which service many users at one time must be able to hold back low priority transmissions if high priority demands arise. This is accomplished by use of XON, XOFF control characters. The 4094 default XON, XOFF characters are "DC1" and "DC3". Command C allows these characters to be changed to any ASCII character.

Upon receipt of the XOFF character the 4094 will cease its transmission after completion of the character in process. The XON character will cause the 4094 to resume the RS-232C transmission at the point it left off. It should be noted that the XON, XOFF characters will be seen on the 4094 display. DC1 will appear as Q̲, DC3 will appear as S̲.

#3. Abort input transmissions to 4094: RS-232C transmissions to the 4094 can be aborted by use of the ASCII abort character. The default abort character is "z". The abort character can be changed by use of the C command. Use of the abort character will result in a transmission error code 21 which says that the transmission was aborted. See the Q command for general deactivation of the RS-232C interface.

BASIC INTERFACING COMMANDS

Included in the basic interfacing section are commands to:

1. Output descriptive waveform information.
2. Input/output data.
3. Input/output normalization.
4. Disk Recorder Store/Recall/ Unprotect/Autocycle modes.
5. Acquire new waveforms: run LIVE/HOLD NEXT/Abort sweep.
6. Output status.
7. Input/output titles.
8. Change delimiters and control characters.
9. Make 4094 output audio "beep."

All commands are sent to the 4094 in the form of ASCII characters. A series of ASCII characters is referred to as a "character string." Computer programming manuals will have information on the correct format for statements using character strings.

Every command sent to the 4094 will generate an error code number in response. The error code number must be accepted by the computer before any additional interface transfers with the 4094 can take place.

All delimiters are shown in their correct locations. Even though in many situations delimiters are not used, it is necessary to know what delimiters are available. Delimiters are discussed under the C command.

Messages may be included with commands for display on the 4094 screen. Any non-command messages should be preceded by a NUL character and included with the normal command character string.

W

Input/Output Data

- COMMAND FORMAT: W
- PURPOSE: The W command is used to determine the number and length of waveforms in the 4094 memory, the corresponding normalization sets, corresponding titles, input channel used, and whether retain reference was switched on. All waveforms in memory will be included, not just displayed data. This command is not manditory for data transfer (D command) but is very useful in most practical programming examples. The explanations for the D and N commands cover the uses of the waveform specifications.

- TRANSMISSION SEQUENCE:
  - 4094 input
    #1. W
    Command del. (page 13-58)
  - 4094 output
    #2. Error code for command (00-31)
    Error delimiter (page 13-58)
  - 4094 output
    #3. a. Total number of waveforms (01-32)
    Record sep. (page 13-58)
    b. End of File delimiter (page 13-58)
  - 4094 output
    #4. a. Waveform number (01-32)
    Record sep. (page 13-58)
    b. Number of data points (+00496 to +15872)
    Record sep. (page 13-58)

    NOTE: Spaces can be used interchangeably with + signs and leading zeros.

W

c. Normalizing set number (00-31)
Record sep. (page 13-58)

NOTE: Normalizing set numbers range from 00 to 31 not from 1 to 32 as with waveform numbers.

d. Normalizing step (01-32)
Record sep. (page 13-58)

e. Channel number (see Table 13-8)
Record sep. (page 13-58)

f. Retain reference (1 = RR on, 0 = RR off)
Record sep. (page 13-58)

g. Title number (see Table 13-9)
Record sep. (page 13-58)

h. End of File (EOF) delimiter (page 13-58)

Output #4 (a - h) will be repeated for each of the waveforms contained in memory. Output #3(a) gives the total number of waveforms.

- 4094 output
  #5. Error code (00-31)
  Error delimiter (page 13-58)

Channel No.	Input Location
0	Plug-in 1, Channel A
1	Plug-in 1, Channel B
2	Plug-in 2, Channel A
3	Plug-in 2, Channel B

Table 13-8

Title No.	Where Title is Visible
1	Q1, H1, or ALL
2	Q2 or H2
3	Q3 or H1
4	Q4 or H2

Table 13-9

D

- COMMAND FORMAT: D, Mode, Waveform No., Starting Pt., Total Pts, Step (Any non-numeric character can be used to separate numeric values.)

- PURPOSE: Initiate data transfers and specify data parameters and format.

- SPECIFICATIONS:

#1.

Mode	Data Format
0	output in ASCII (Record Separator, EOF)
2	output in printable binary (EOF)
4	output in binary (no Record Separator or EOF)
1	input in ASCII (Record Separator, EOF)
3	input in printable binary (EOF)
5	input in binary (No Record Separator or EOF)

Table 13-10

#2. Waveform Number - see W command. Use of Waveform Number = 0 will access all of memory rather than individual waveforms.

#3. Starting pt. - The first data point on the waveform which is to be transferred (0-15871)

#4. Total pts. - The total number of data points to be transferred from the waveform (1-15872). If Total Pts. is set to 0 error code 25 will result.

#5. Step - Count spacing between data point numbers. A step of 2 means every other data point will be transferred.

- TRANSMISSION SEQUENCE:
  - 4094 Input
    #1. D, Mode, Waveform Number, Starting Point, Total Points, Step
    Command del. (page 13-58)
  - 4094 Output
    #2. Error code for command (00-31)
    Error delimiter (page 13-58)
  - 4094 Input or Output
    #3. Data values (see formats below)
    Record sep. (page 13-58)
    Note: I/O of standard binary data values cannot include record sep. delimiters.
  - 4094 Input or Output
    #4. End of File (EOF) delimiter, (page 13-58)
    Note: I/O of standard binary data values cannot include EOF delimiters.
  - 4094 Output
    #5. Error code for data transmission (00-31)
    Error delimiter. (page 13-58)

- DATA FORMAT: Data point values range from -32768 to +32767 regardless of input voltage range, voltage offset, or any other front panel setting. To translate each data point value into the correct voltage, normalizing information is required (see the N command). Data point values can be input/output in 3 possible formats. Each format is discussed below.

#1. ASCII Data Values

Six ASCII characters transferred for each data point.

For example, -16421 or +00125 (a space may be used interchangeably with + signs and leading zeros).

- Advantages:
  a. Usually easiest to program in computer; translations from ASCII characters into computer integers is usually unnecessary.
  b. Compatible with RS-232C interface equipment.

D

- Disadvantages:
  a. Slow data transfer due to the large number of characters transferred.

  b. Large computer memory required if brought in as a long ASCII character string. (15872 data pts. x 6 characters/data pt. = 95232 bytes.)

#2. Printable Binary Data Values

Three ASCII characters are transferred for each data point. The three characters need to be correctly converted into standard binary form and combined before they can be treated as a single numeric value by the computer. The ASCII characters are transmitted in their order of numeric significance. Likewise, data to be sent from a computer to the 4094 must undergo a conversion into printable binary if Mode 3 is selected. The conversion scheme to transform printable binary into standard binary is given below.

a. Convert the printable ASCII characters (printable binary) into their binary equivalents. See the ASCII chart on page 13-72.

   Ignore parity bits (bit 2^7) included during transmission.

   Data Point 1 = $')
   Data Point 2 = /U^

$	=	0100100	/	=	0101111
'	=	0100111	U	=	1010101
)	=	0101001	^	=	1011110

b. Subtract 32 (0100000) from each binary number. Thirty-two was added to the original data to bring it into the range of printable ASCII characters.

```
$ 0100100        / 0101111
- 0100000        - 0100000
  -------          -------
  0000100          0001111

' 0100111        U 1010101
- 0100000        - 0100000
  -------          -------
  0000111          0110101

) 0101001        ^ 1011110
- 0100000        - 0100000
  -------          -------
  0001001          0111110
```

c. Multiply the most significant number by 4096, the next most significant by 64, and add up all three. This operation sets each number to the correct binary significance and combines them to form one value, (see Example 13-1).

d. Each 4094 data word is a sixteen bit, 2's compliment word. Bit 16 of the word resulting from part c indicates the correct sign (1 = negative no., 0 = positive no.). Note that bits 17, 18, and 19 resulting from part c will always be 0 and are meaningless. Word lengths in computers vary considerably and therefore it is necessary to ensure that the sign bit is repeated to the necessary number of places. The easiest way to do this is to subtract 65536 if the result from part c is greater than or equal to 32768. This action effectively extends the sign bit out to the necessary number of places.

```
(0000100)(4096) + (0000111)(64) + (0001001) = 0000100000111001001
(0001111)(4096) + (0110101)(64) + (0111110) = 0001111110101111110
```

Example #13-1

D

```
        16 bit word
0000100000111001001 = 16841
    Sign bit

    $') = 16841

        16 bit word
0001111110101111110 =  -642
    Sign bit

    /U^ =  -642
```

Example 13-2

```
Sign bit extension for computer
with 20 bit words.

 00011111101011111110
+11110000000000000000 add -65536
 --------------------
 11111111110101111110  =  -642

     20 bit word
```

Example 13-3

- Advantages:
  - a. Faster than straight ASCII data due to fewer transmitted characters.
  - b. Compatible with RS-232C equipment.
- Disadvantages:
  - a. Added programming necessary to translate ASCII characters into binary or binary into ASCII characters.
  - b. Slower than standard binary transmissions due to greater number of transfers.

#3. Standard Binary Data Values

Each data point is transmitted as two 8 bit bytes. The high byte (places 2^{15} through 2^{8}) is transferred first followed by the low byte (places 2^{7} through 2^{0}). Each high byte/low byte pair must be combined in order to form a single binary value. Likewise, binary data sent into the 4094 must be transformed into high and low bytes for transmission. A scheme to combine high and low bytes is given below.

a. Multiply the high byte by decimal 256 and add the result to the low byte. This operation sets the high byte to the correct binary significance and combines the high and low bytes. The resulting binary number is a standard 16 bit 2's compliment representation of a single data point.

b. Since standard computer word lengths vary considerably it should be noted that it may be necessary to extend the sign bit (bit 2^{15}) to fill the remaining bit positions. This can be done in one of two ways:

   i. Check the value of bit 2^{15} and set the remaining unspecified bits to equal bit 2^{15}, (see Example #13-4).

```
Computer word length = 20 bits

    1111111100010110 = 4094 data
    ↑
    └── bit 2^15

←── extend sign bits

 11111111111100010110
└────────────────────┘
   20-bit word
```

Example #13-4

   ii. Check the value of the result from step a and if greater than or equal to 32768 subtract decimal 65536(2^{16}). This effectively extends the sign bits out to the most significant place, (Example #13-5).

```
Computer word length = 20 bits.

     1111111100010110 = 4094 data
+11110000000000000000 add -65536
─────────────────────
 11111111111100010110
└────────────────────┘
     20-bit word
```

Example #13-5

D

- Advantages:
  a. Fastest possible data transmission rate due to minimum number of transfers.
  b. Extra translations are unnecessary, a simple procedure combines high and low bytes.

- Disadvantages:
  a. Not commonly compatible with RS-232C equipment.
  b. Binary transmissions on the GPIB may require different I/O commands inside the computer than those used for ASCII transfers. Sometimes talk and listen addresses must be given (review GPIB addressing, page 13-15).

N

Input/Output Normalization Data

- COMMAND FORMAT:

  a. To output from 4094: N, Norm. Set no.

  b. To input to 4094: N, Norm. Set no., Norm. Step (Any non-numeric character can be used to separate numeric values.)

- Purpose:

  Initiate transfer of normalization data necessary to convert data point values into time and voltage measurements.

- Specifications:

  #1. Norm. Set No. - The number of the normalization set to be transferred. The normalization set number, corresponding to a given waveform, results from the W command.

  #2. Norm. Step - A number allowing the 4094 to place a given normalization set into the correct memory locations. The normalization step must be sent to the 4094 before the normalization sets are sent. This number is only important for internal 4094 operation. The W command gives the normalization step number for each set.

N

- Transmission Sequence:
  - 4094 input
    - #1. N, Norm. Set No., (Norm. Step required to send normalization to the 4094)
      Command del. (page 13-58)
  - 4094 output
    - #2. Error code for command (00-31)
      Error del. (page 13-58)
  - 4094 input or output
    - #3. a. Waveform validity, (see page 13-41).
        Record sep. (page 13-58)
      b. Sweep size index, (see page 13-42).
        Record sep. (page 13-58)
      c. Channel no., (see page 13-42).
        Record sep. (page 13-58)
      d. Display characters, (see page 13-43).
        Record sep. (page 13-58)
      e. Vnorm, (see page 13-43).
        Record sep. (page 13-58)
      f. Hnorm, (see page 13-44).
        Record sep. (page 13-58)
      g. Vzero, (see page 13-44).
        Record sep. (page 13-58)
      h. Hzero (upper), (see page 13-45).
        Record sep. (page 13-58)
      i. Hzero (lower), (see page 13-45).
        Record sep. (page 13-58)
      j. Reset Norm. Vzero, (see page 13-45).
        Record sep. (page 13-58)
      k. Reset Norm. Hzero, (see page 13-46).
        Record sep. (page 13-58)
      l. End of File (EOF) delimiter (page 13-58)
  - 4094 output
    - #4. Error code for norm. transmission (00-31)
      Error del. (page 13-58)

N

- Normalization Format:

Normalization data is required if the actual voltage and time for each data point is desired. Unnormalized data values range from -32768 to +32767 regardless of any front panel setting.

Normalization allows data values to be converted into voltages, and data point locations into time values. "Standard" normalization reflects the original front panel settings during signal acquisition. "Reset" normalization values have meaning after the front panel function RESET NUM is used. RESET NUM causes the zero time, zero voltage location to be changed on the display, thus requiring new normalization values. Standard and reset normalization sets exist for every waveform in memory.

Vnorm, Hnorm, Vzero and Hzero are the most commonly used and important normalization parameters. The following paragraphs present portions of the normalization set in order of transmission.

#1. Waveform validity - This number is used to determine if the waveform is valid. It is possible that the waveform data has resulted from a trigger VIEW display or is being transferred while in the trigger set-up mode (see relevant plug-in descriptions). This data does not reflect an actual measurement condition and is usually avoided. The waveform validity number makes it easy to avoid these undesirable conditions.

Waveform Validity	Condition of Data
0	Data is a valid waveform
1	Data is derived from set-up mode
2	Data is derived from trigger VIEW
3	Data is derived from simultaneous trigger VIEW and set-up mode
6	Data is derived from the external trigger input while in trigger VIEW
7	Data is derived from simultaneous set-up mode, trigger VIEW, and external trigger input

Table 13-11

N

#2. Sweep size index - A number which specifies the fraction of total memory occupied by the waveform. The 4094 requires this number to tie the normalization information to the correct data points. If a normalization set is sent into the 4094 the sweep size index must be correctly specified in order to correctly normalize the data. Normally the sweep size index sent out by the 4094 is used when inputting to the 4094. 15872 pts./2^{SSI} = pts. in waveform.

Sweep size Index	Fraction of Total Memory
0	ALL = 15872 pts.
1	1/2 = 7936 pts.
2	1/4 = 3968 pts.
3	1/8 = 1984 pts.
4	1/16 = 992 pts.
5	1/32 = 496 pts.

Table 13-12

#3. Channel no. - An indication of which input channel and plug-in was used to acquire the waveform. This number is also given by the W command. Internal to the 4094, this number generates the 1A, 1B, 2A, 2B designators shown on the normal waveform display.

Channel No.	Input Location
0	Plug-in 1, ChA
1	Plug-in 1, ChB
2	Plug-in 2, ChA
3	Plug-in 2, ChB

Table 13-13

N

#4. Display character no. - This number indicates the characters displayed along with the specified waveform. Normally the display character number sent out by the 4094 is used when normalization is sent into the 4094. However, under some conditions it may be desirable to blank off time and voltage units for a waveform which results from a computer calculation.

Display Character Number	Characters on Display
0	None of the conditions below
1	"R" shown to indicate Retain Ref. points
2	Blank time & voltage units
3	Combination of 1 & 2

Table 13-14

#5. Vnorm - A number in the form x.xxxE+xx which is equal to the voltage between data point values (for example: +16842 to +16843) at the time the waveform was acquired. The letter "E" precedes the signed exponent value. The decimal point must be located as shown when Vnorm is sent into the 4094. Before using Vnorm to calculate a data point voltage Vzero must be taken into account. The calculation example on page 13-46 shows the correct usage of Vnorm and Vzero. Vnorm is related to the voltage range setting on the front panel.

$$\text{Vnorm} = \frac{\text{Voltage Range Setting}}{32000}$$

Example 13-6

N

#6. Hnorm - A number in the form x.xxxE+xx which is equal to the time between data points (time per point) on the specified waveform. The letter "E" precedes the signed exponent value. The decimal point must be located as shown when Hnorm is sent into the 4094. Before Hnorm is used to calculate the waveform time base Hzero should be taken into account. The calculation example on page 13-46 shows the correct usage of Hnorm and Hzero.

#7. Vzero - The data value which represents the vertical location of zero volts (ground potential) for the chosen waveform. Vzero ranges from -32768 to +32767. All data point voltages on the 4094 display are with respect to ground regardless of their vertical positioning on the screen. Vzero must be subtracted from data point values to correct for the vertical location of ground potential. The calculation example on page 13-46 shows the correct usage of Vzero.

#8. Hzero (upper), Hzero (lower) - Hzero represents the location of the trigger point (zero time) on the waveform. Through use of the plug-in trigger delay controls the trigger point (zero time) can be located to the left of the screen or at any point on the screen. Hzero ranges from -67,158,527 to +15859 and, therefore, is broken up into two numbers, upper and lower. The total Hzero results from the operation illustrated in Example 13-7.

(Hzero (upper)) x (65536) + Hzero (lower) = Total Hzero

Example 13-7

Subtraction of the total Hzero from each data point location (0 - 15871) gives the correct relative location from the zero time trigger point. The calculation example on page 13-46 shows the correct usage of Hzero.

#9. Reset Norm. Vzero - This number has a meaning similar to Vzero except that it pertains only to reset numerics. The RESET NUM function on the 4094 allows zero time, zero voltage to be moved to any point on a wave-form. The resulting reset numerics (only seen while in RESET NUM) require additional reset normalization parameters to be preserved along with the standard normalization. Reset norm. Vzero ranges from -32768 to +32767 to give the location of zero voltage while using reset numerics.

N

#10. Reset Norm. Hzero - This number is similar to Hzero except that it pertains only to reset numerics. The RESET NUM function allows zero time to be located at any displayed waveform data point. The resulting reset numerics (only seen while in RESET NUM) require additional reset normalization parameters to be preserved along with the standard normalization. Reset norm. Hzero ranges from +00000 to +15871.

- Normalization Example

The typical normalization set (below) is shown as a character string without record separator delimiters. Spaces can be used interchangably with + signs and leading zeros.

- TIME for given data pt. = (Data point location - Total Hzero) Hnorm
- VOLTAGE for given data pt. = (Data point value - Vzero) Vnorm
- RESET TIME numerics for given data pt. = (Data point location - Reset norm. Hzero) Hnorm
- RESET VOLTAGE numerics for given data pt. = (Data point value - Reset norm. Vzero) Vnorm

For example, using Example 13-8, assume data point no. 1063 equals +00422. Note: The first data point in a waveform is counted as location 0, the second point is location 1, etc.

TIME at pt. 1063 =
$(1063-(65536(-21)+50614))(1 \times 10^{-6})$ Sec.

VOLTAGE at pt. 1063 =
$(422-4096)(3.125 \times 10^{-8})$ Volts

RESET TIME at pt. 1063 =
$(1063-14271)(1 \times 10^{-6})$ Sec.

RESET VOLTAGE at pt. 1063 =
$(422+20942)(3.125 \times 10^{-8})$ Volts

	0	0	1	0	3.125E-08	1.000E-06	+04096	-00021	+50614	-20942	+14271
See Description No.:	1	2	3	4	5	6	7	8	8	9	10

Example 13-8

S

Disk Recorder Operation

- COMMAND FORMAT:

  S, Drive No., Record No., Memory Section (Any non-numeric character can be used to separate numeric values)

- Purpose:

  Store displayed waveform on designated disk and record number.

- Specifications:

  #1. Drive no. -
  0 = single disk drive or left hand drive on dual disk recorder.
  1 = right hand disk drive on dual disk recorder.

  #2. Record no. - The record no. (1-20) on which data is to be stored. Record 0 can be used to store on whichever record is displayed.

  #3. Memory section - Specifies the section of memory to be recorded onto disk. Q1 of memory will go to F1 on disk, etc., (see Table 13-15).

Memory Section	Portion of Memory to be Recorded
0	ALL
1	Q1
2	Q2
3	Q3
4	Q4
5	H1
6	H2

Table 13-15

- Transmission Sequence:
  - 4094 input

    #1. S, Drive no., Record no., Memory Section.
    Command del. (page 13-58)
  - 4094 output

    #2. Error code for command and disk recorder (00-93)
    Error delimiter (page 13-58)

    NOTE: Before the error code is sent out by the 4094 the disk recorder STORE must be completed. The error code can be used as an indication that the STORE has been completed.

R

- COMMAND FORMAT:

R, Drive No., Record No., Memory Section (Any non-numeric character can be used to separate numeric values.)

- Purpose:

Recall waveform data from the specified disk and record into the 4094 display memory.

- Specifications:

#1. Drive no. -
0 = single disk drive or left hand drive on dual disk recorder.
1 = right hand disk drive on dual disk recorder.

#2. Record no. - Corresponds to the record no. (1-20) which is to be recalled into the 4094 memory. Record 0 can be used to recall whichever record is displayed.

#3. Memory section - Specifies the section of memory to be filled by recalling from disk. F1 on disk will go into Q1 of memory, etc., (see Table 13-16).

Memory Section	Portion of Memory to be Filled
0	All
1	Q1
2	Q2
3	Q3
4	Q4
5	H1
6	H2

Table 13-16

- Transmission Sequence:

- 4094 input

#1. R, Drive No., Record No., Memory Section.
Command del. (page 13-58)

- 4094 output

#2. Error code for command and disk recorder (00-93)
Error delimiter (page 13-58)

NOTE: Before the error code is sent out by the 4094, the disk recorder RECALL must be completed. The error code can be used as an indication that the RECALL has been completed.

• COMMAND FORMAT:

U, Drive No., Record No., Memory Section (Any non-numeric character can be used to separate numeric values.)

• Purpose:

Unprotect specified record on disk recorder.

• Specifications:

#1. Drive no. -

0 = single disk drive or left hand drive on dual disk recorder.

1 = right hand drive on dual disk recorder.

#2. Record no. - Record (1-20) to be unprotected. Record 0 can be used to unprotect whichever record is displayed.

#3. Memory section - Record segment to be unprotected, (see Table 13-17).

Memory Section	Record Segment to be Unprotected
0	All
1	F1
2	F2
3	F3
4	F4
5	H1
6	H2

Table 13-17

• Transmission Sequence:

• 4094 input

#1. U, Drive No., Record No., Memory Section.
Command del. (page 13-58)

• 4094 output

#2. Error code for command and disk recorder (00-93).
Error delimiter (page 13-58)

NOTE: Before the error code is sent out by the 4094 the disk recorder UNPROTECT must be completed. The error code can be used to indicate that the UNPROTECT is completed.

A

- COMMAND FORMAT:

  A, Drive No., Record No., Memory section (Any non-numeric character can be used to separate numeric values.)

  NOTE: Computer Control must be turned on before command A can be used, see Transmission Sequence)

- Purpose:

  Initiate the disk recorder AUTOCYCLE mode of operation.

- Specifications:

  #1. Drive no. -
  0 = single disk drive or left hand drive on dual disk recorder.
  1 = right hand drive on dual disk recorder.

  #2. Recorder no. - The record no. (1-20) on which AUTOCYCLE is started. Record 0 will start the AUTOCYCLE on whichever record is displayed. No protected records can exist between the starting record and record 20.

  #3. Memory section - Portion of memory in which the AUTOCYCLE recordings are to be made. Q1 of memory will go into F1 on disk, etc., (see Table 13-18).

Memory Section	Portion of Memory to be Autocycled
0	All
1	Q1
2	Q2
3	Q3
4	Q4
5	H1
6	H2

Table 13-18

- Transmission Sequence:
  - 4094 input
    #1. Z1
    Command del. (page 13-58)
  - 4094 output
    #2. Error code for command (00-31)
    Error delimiter (page 13-58)
    Z1 is used to turn on computer control. This is required before the auto-cycle command can be used. Z1 is covered under Advanced Interfacing Commands, beginning on page 13-61.
  - 4094 input
    #3. A, Drive No., Record No., Memory Section.
    Command del. (page 13-58)
  - 4094 output
    #4. Error code for command and disk recorder (00-93).
    Error delimiter (page 13-58)

    NOTE: AUTOCYCLE must be completed before the disk recorder error code is sent out. The error code can be used to indicate completion of AUTOCYCLE.
  - 4094 input
    #5. ZØ
    Command del. (page 13-58)
  - 4094 output
    #6. Error code for command (00-31)
    Error delimiter (page 13-58)

    ZØ is used to turn off computer control.

H

Waveform Acquisition

- COMMAND FORMAT:

  H, Mode, Plug-in No.
  (Any non-numeric character can be used to separate numeric values)

  NOTE: Computer Control must be turned on before command H can be used, see Transmission Sequence)

- Purpose:

  The H command sets up the 4094 for waveform acquisition by running LIVE and HOLD NEXT.

- Specifications:

  #1. Mode - Indicates the operation to be performed.

Mode	Plug-in Operation
0	Live/Hold Next and wait, command error code is output when plug-in goes into HOLD LAST
1	LIVE/HOLD NEXT, immediate output of command error code
2	Abort sweep, plug-in goes into HOLD LAST
3	LIVE

Table 13-19

  #2. Plug-in No. -
  0 = all plug-ins,
  1 = plug-in on left,
  2 = plug-in on right.

- Transmission Sequence:

  - 4094 input
    #1. Z1
    Command del. (page 13-58)
  - 4094 output
    #2. Error code for command (00-31)
    Error delimiter (page 13-58)
    Z1 is used to turn on Computer Control. This is required before the H command can be used. Z1 is covered under Advanced Interfacing Commands.
  - 4094 input
    #3. H, Mode, Plug-in No.
    Command delimiter (page 13-58)
  - 4094 output
    #4. Error code for command (00-31)
    Error delimiter (page 13-58)
  - 4094 input
    #5. ZØ
    Command del. (page 13-58)
  - 4094 output
    #6. Error code for command (00-31)
    Error delimiter (page 13-58)
    ZØ is used to turn off Computer Control.

Display Titling

- COMMAND FORMAT:

  T, I/O, Title No.

  (Any non-numeric character can be used to separate numeric values)

- Purpose:

  The T command allows titles to be sent into or out of the 4094. In most cases, long titles can be input more easily through computer interfacing than by use of the disk program TITLE. A disk recorder is not necessary for computer titling.

- Specifications:

#1. I/O - Indicates the direction of title transfer.

I/O	Direction
0	4094 output
1	4094 input

Table 13-20

#2. Title No. - Specifies the title number to be transferred. The 4094 is able to hold a title for each quarter of memory.

Title Number	Where Title is Visible
1	Q1, H1,ALL
2	Q2, H2
3	Q3
4	Q4

Table 13-21

T

Transmission Sequence:

- 4094 input
  #1. T, I/O, Title No.
  Command delimiter (page 13-58)
- 4094 output
  #2. Error code for command (00-31)
  Error delimiter (page 13-58)
- 4094 input or output
  #3. 32 character title
  End of File (EOF) delimiter, (page 13-58)
- 4094 output
  #4. Error code for title (00-31)
  Error delimiter (page 13-58)

It is important to note that any title sent into the 4094 must be exactly 32 characters long. This can only be accomplished reliably if formatted output statements are used by the computer.

Nonformatted output statements may allow excess characters to be output. Delimiters count as output characters and should be eliminated if not desired as part of the title.

Control characters which are normally non-printable ASCII characters are displayed as an appropriate ASCII character with an underline, (e.g., SOH = Control A = $\underline{A}$). See Table 13-37, page 13-78.

If end of file delimiters are used, a title may contain fewer than 32 characters. It will, however, result in a premature end of file error.

L

Status

- COMMAND FORMAT:

  L, Status No.

- Purpose:

  The L command is used to determine whether a plug-in is in LIVE or HOLD LAST. This is commonly used to check for waveform acquisition after the 4094 is placed into LIVE/HOLD NEXT. L can also return information on the type of disk in each disk recorder.

- Specifications:

  #1. Status No. - Specifies the information to be returned by the 4094.

Status Number	Status Returned
0	LIVE status: 0 = All plug-ins in HOLD LAST, 1 = At least one plug-in in LIVE
1	LIVE Status (as above), Drive 0 diskette status (0-4), Drive 1 diskette status (0-4), see Table 13-23.

Table 13-22

Diskette Status	Type of Diskette
0	Disk recorder empty, no diskette
1	2090 diskette
2	4094 diskette
3	Program diskette, front panel execution type
4	Program diskette, computer interface execution type

Table 13-23

L

- Transmission Sequence:
  - 4094 input
    #1. L, Status No.
    Command del. (page 13-58)
  - 4094 output
    #2. Error code for command (00-31)
    Error delimiter (page 13-58)
  - 4094 output
    #3. LIVE status (0 or 1)
    Record sep. (page 13-58)
    End Of File. (page 13-58)
    (command L,Ø results in transmission #3)

#4. a. LIVE status (0 or 1)
Record sep. (page 13-58)

b. Drive 0 diskette status (0-4)
Record sep. (page 13-58)

c. Drive 1 diskette status (0-4)
Record sep. (page 13-58)

d. End Of File (EOF) delimiter, (page 13-58)
(command L,1 results in transmission 4 only)

#5. Error code for status transmission.
Error delimiter (page 13-58)

C

Delimiters/Control Characters

- COMMAND FORMAT:

  C, Address, Character

  OR

  C, Address, Count, Character 1, Character 2, Character 3

  (Any non-numeric character can be used to separate numeric values)

- Purpose:

  The C command is used to set delimiters, control characters, and the RS-232C turn around time.

NOTE: Use of command delimiters can be avoided by making the command exactly 32 characters long (by including blank spaces). This may be useful in situations where the C command must be used to change the command delimiter but the programmer cannot supply the correct delimiter to end the C command.

- Specifications:

Table 13-24 shows the relationship between command addresses (not related to GPIB addresses) and the character to be set.

Default characters are used by the 4094 unless new choices are specified. Each character in the C command is specified as a decimal number which is equivalent to the chosen ASCII character, see the ASCII chart on page 13-77.

For Example:

CR = 0001101 = 13

LF = 0001010 = 10

$ = 0100100 = 36

Record separators, end of files, and error delimiters can have up to three characters specified by the count number. A count of 0 means that no delimiters are used.

All remaining characters can have only one character specified, thus a count is not necessary

To turn a character off, (where only one character is used) specify a character number from 128 to 255.

C

Address	Control Function	Default Character	Max. no. of Characters
0	End of File (EOF) delimiter	no EOF	3
4	Record Separator delimiter	no record sep.	3
8	Error delimiter	Carrage Return Line Feed (CR/LF)	3
12	Abort RS-232C transmission	z	1
13	Command delimiter	Line Feed (LF)	1
14	Exponent character	E	1
15	RS-232C turn around time	0 msec.	1 number (000-255)
16	RS-232C XON	DC1 (Control Q)	1
17	RS-232C XOFF	DC3 (Control S)	1
18	Activate RS-232C transmission	SOH (Control A)	1
19	RS-232C address	DIP Switch address, (See page 13-16)	1 number (000-127)

Table 13-24

- Transmission Sequence:
  - 4094 input

    #1. C, Address, Character
    Command del. (page 13-58)

    OR

    C, Address, Count,
    Character 1, Character 2,
    Character 3
    Command del. (page 13-58)

- 4094 output

  #2. Error code for command (00-31)
  Error delimiter (page 13-58)

Beep

- COMMAND FORMAT:

  B

- Purpose:

  Causes the 4094 to make one audio frequency beep.

- Transmission sequence:

  - 4094 input

    #1. B

    Command del. (page 13-58)

  - 4094 output

    #2. Error code for commands (00-31).

    Error delimiter (page 13-58)

RS-232C Deactivate

- COMMAND FORMAT:

  Q

- Purpose:

  The Q command is used only in RS-232C interfacing to deactivate the interface. It has an effect opposite of the activation control character and RS-232C address shown in the RS-232C OVERVIEW. After use of the Q command the RS-232C interface must be reactivated before additional RS-232C communications can take place. Command Q will deactivate all 4094's chained together on a single RS-232C line.

- Transmission Sequence:

  - 4094 input

    #1. Q

    Command del. (page 13-58)

  - 4094 output

    #2. Error code for command (00-31).

    Error delimiter (page 13-58)

Error Code Numbers

NOTE: Disk recorder error numbers are located under Tab 9, page 9-25.

Error Code No.s	Description
00	No error.
02	Write protected (PRO).
03	Data CRC error (Checksum error, try again).
04	ID CRC error (Checksum error, try again).
05	Bad diskette or not a 4094 diskette.
06	Bad diskette, not a 4094 diskette, or no diskette present.
07	Broken drive or broken drive cable.
08	Diskette not correctly formatted.
09	Illegal front panel operation (ERR)
10	Disk program not understood (try again)
11	Disk program not understood (try again)
12	Program too large.
20	Mixed data error (See Note 1).
21	Aborted I/O operation.
22	No command in input string.
23	Wrong parameter count in input string.
24	A parameter is out of range.
25	Waveform parameters go past end of waveform or total point count is zero.
26	D-mode Number too large.
29	No disk or not a data diskette.
30	Premature EOF.
31	No EOF on input stream.
91	No Drive 0.
92	Bad or no disk controller.
93	90-Buss down.

Table 13-25

Note 1: A mixed data error indicates that the 4094 display memory contains waveforms which are missing data points due to newly acquired waveforms. For instance, a waveform put into ALL would be partially destroyed by a later waveform put into H2. The mixed data error alerts the programmer to the fact that normalization data for the ALL waveform does not take into account the missing points.

ADVANCED INTERFACING COMMANDS

The advanced 4094 I/O commands require a deeper understanding of internal 4094 operation than the basic interfacing commands.

Operations included in the advanced I/O commands are:

#1. Computer Control ON/OFF

#2. Reading and setting plug-in front panel

#3. Reading and setting mainframe front panel

#4. GPIB/Plotter port I/O

#5. MODEM/COMPUTER and PLOTTER port parameters

Advanced commands are similar in structure to the basic commands. The advanced commands allow the programmer to influence fundamental 4094 front panel actions and, therefore, must be used with care.

➤ **IMPORTANT:** The "P" command for the 4562 and 4851 (pages 13-63a through 13-70a) plug-ins is different than that of the 4175 plug-in (pages 13-63b through 13-74b).

Z

Computer Control ON/OFF

- COMMAND FORMAT:

  Z Mode

- PURPOSE:

  The Z command turns on/off the 4094 computer control mode. Computer control refers to an internal mode of operation in which the I/O processor (which normally runs the disk recorders, interfaces, digital plotter, and disk programs) takes charge of the internal 4094 procedures and prevents external manipulation of front panel functions. When the 4094 is in computer control the characters CC are shown on the display screen. Computer control must be turned on for the advanced front panel controls and for the basic commands A and H. When computer control is turned off, the 4094 reverts back to normal operation with standard, manually manipulated front panel controls.

- Specifications:

  #1. Mode - A number to indicate whether computer control is to be turned on or off.
  0 = computer control off
  1 = computer control on

- Transmission Sequence:

  - 4094 input
    #1. Z Mode
    Command del. (page 13-58)

  - 4094 output
    #2. Error code for command (00-31).
    Error delimiter (page 13-58)

P

4562 & 4851 Plug-in Front Panel Manipulation

➤ **IMPORTANT:** Pages 13-63a through 13-70a describes the Plug-in Front Panel Manipulations for the 4562 and 4851 plug-ins. See pages 13-63b through 13-74b for the 4175 plug-in.

- COMMAND FORMAT:
  a. To input to 4094: P, Address, Setting, Mask
  b. To output from 4094: P, Address
- Purpose:

  The P command allows plug-in front panel controls to be changed via computer commands and permits actual front panel switch settings to be read. If front panel controls are to be changed away from the actual switch settings, Computer Control must be turned on. Even while Computer Control is on and new settings are being used, the actual front panel switch settings can be read.

  Through use of the P command, the actual front panel settings can be read at any time without turning on Computer Control. The P command also allows the sweep average count (no. of sweeps taken while in AVERAGE) to be read and allows trigger delays to be set or read.

- Specifications:

  #1. Address - A number (0-41) which defines the quantity to be read or changed. See Tables 13-26a and 27a, (page 13-67a).

  #2. Setting - A number representing the control to be turned on or the actual numeric value to be sent into the 4094.

  Table 13-26a shows a variety of front panel controls and the settings which cause them to be actuated. A group of settings with a single address can be actuated with a single P command by adding up the corresponding settings. Note that many front panel controls are represented in negative logic (e.g., "CH A OFF") so that a zero placed in that position causes the control to be asserted. The Mask number makes it possible to access only specific control functions.

4175 Plug-in Front Panel Manipulation

➤ **IMPORTANT:** Pages 13-63b through 13-74b describes the Plug-in Front Panel Manipulations for the 4175 plug-in. See pages 13-63a through 13-70a for the 4562 and 4851 plug-ins.

- COMMAND FORMAT:

  a. To input to 4094: P, Address, Setting, Mask

  b. To output from 4094: P, Address

- Purpose:

  The P command allows plug-in front panel settings to be either read or changed by a remote computer. Computer control must be turned on before any setting can be changed, and the plug-in settings will remain at their new positions after computer control is turned off. However, all front panel settings can be read regardless of whether computer control is on or off.

The P command allows the reading and adjustment of several other controls as well. They are:

a. Sweep Average Abort Count - This sets a limit on the number of sweeps already taken while in the Average mode.

b. Sweep Average Count (read only) - Gives the number of sweeps already taken while in the Average mode.

c. Over-voltage Error (read only) - Warns if an over-voltage occurred at the external trigger input or any of the channel inputs.

d. P Command Input Error (read only) - Warns if an illegal P command has been input.

P

Table 13-27a shows settings which directly place numeric values into internal 4094 control locations. Masks are not needed for Table 13-27a.

#3. Mask - A number which indicates the control to be changed.

Settings made using Table 13-26a, (page 13-67a) are generally made with a mask equal to the setting. Inputting a new setting without a mask will generate multiple changes as other controls located at the same address are zeroed.

As with settings, a single mask number can access several controls at the same address by summing the mask numbers.

To assert a negative logic control (e.g., turn CH B on) a setting of 0 must be combined with a suitable mask number.

CH B on = P, 2, 0, 1 (for plug-in 1)

NOTE: Masks are not needed with addresses 4-9 and 36-41.

P

● DEFINITION OF TERMS

CONTROL - Front panel control such as TRG VIEW. When TRG VIEW is turned on, the 4175 will go into the Trigger View mode.

ADDRESS - A number (3-29) which defines the quantity to be read or changed. See Tables 13-26b and 13-27b (pages 13-67b & 13-68b).

SETTING - A number that will cause a control to be turned either on or off. A setting can also be an actual numeric value to be sent to the 4094 (see Table 13-27b, page 13-68b).

MASK - Only used to change the controls listed in Table 13-26b (page 13-67b). A mask allows one control to be changed without changing other controls at the same address. Use the mask number found in the same column (in Table 13-26b, page 13-67b) as the control to be changed.

● EXAMPLE #1

The command to put the 4175 into the Trigger View mode is: P, 13, 4, 4

Where;

"P" specifies a plug-in command.

"13" is the address used. This was found by locating TRG VIEW in Table 13-26b (in the top left corner), then looking over to the address located on the same row.

"4" (the first "4") is the setting used to turn TRG VIEW on. This was found by locating TRG VIEW, then looking up to - "THE SETTING TO TURN ON CONTROL" located in the same column as TRG VIEW. A "Ø" would be used to turn the control off.

"4" (the second "4") is the mask. This was found by locating the number that is both in the MASK row and the TRG VIEW column.

- Transmission Sequence:

A. To READ Plug-in Settings
(Computer Control on or off),

- 4094 input
  #1. P, Address
  Command del. (page 13-58)
- 4094 output
  #2. Error code for command (00-31)
  Error delimiter (page 13-58)
- 4094 output
  #3. Setting number (0-65535)
  Record sep. (page 13-58)
- 4094 output
  #4. End of File (EOF) delimiter (page 13-58)
- 4094 output
  #5. Error code (00-31)
  Error delimiter (page 13-58)

B. To INPUT Plug-in Settings
(Computer Control must be on),

- 4094 input
  #1. Z1
  Command del. (page 13-58)
- 4094 output
  #2. Error code for command (00-31)
  Error delimiter (page 13-58)
- 4094 input
  #3. P, Address, Setting, Mask
  Command del. (page 13-58)
- 4094 output
  #4. Error code for command (00-31)
  Error delimiter (page 13-58)

Computer Control (Z1) must remain on as long as the 4094 is expected to ignore actual front panel settings and perform based on the new settings.

- EXAMPLE #2

To read the settings at address #14, use the following procedure:

#1. Input P,14
NOTE: See TRANSMISSION SEQUENCE (page 13-70b) for needed Error and Delimiter checking.

#2. The 4094 will return a number such as: 8234.
Record this number as in Figure 13-1b.

#3. From Table 13-26b, select the largest SETTING TO TURN CONTROL ON that is smaller than the number recorded in Step #2. (In this example, the setting would be 8192.) Record this setting underneath the first number recorded in Step #2 (see Figure 13-1b). Next to the setting, write the name of the control on address #14 which is turned on by the setting. (In this case, the control is TRIG 1 MEG OHM.)

#4. Subtract the setting from the returned 4094 number (see Figure 13-1b).

#5. Use the remaining number to repeat Steps #3 and #4.

	8234	Original 4094 Output
-	8192	Trig 1 megohm (trigger 1 megohm input impedance)
	42	Remaining Number
-	32	Trig DC Coup (DC coupling)
	10	Remaining Number
-	8	Trig INT (internal trigger)
	2	Remaining Number
-	2	Int Trig B (internal trigger source: channel B)
	0	

Figure 13-1b

NOTE: The above four controls are turned on and all other controls on address #14 are turned off.

P

ADDRESS For PLUG-IN NUMBER #1	#2	I/O DIRECTION	SETTINGS AND MASK 1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768
0	32	Read only. See Note 1.	ChB off	not slav trig	not neg slpe	not B delay pddle right	not used	not B Ret Ref	not A Ret Ref	not B delay pddle left	Enter delay set'g	not Hold Next	not A delay pddle right	not Hold Last	not A delay pddle left	do not use	not pos slpe	ChA off
1	33	Read only. See Note 1.	ChA voltage range Read only. A1	A2	A3	A4	not ChA X10 Prbe	ChB voltage range Read only. B1	B2	B3	B4	not ChB X10 Prbe	Auto Trig	Time Per Point T1	T2	T3	T4	T5
2	34	Read/Write. See Note 2.	Same as for Addresses 0 and 32															
3	35	Read/Write. See Note 2.	Same as for Addresses 1 and 33															

NOTE 1: Read only to see actual switch positions.
NOTE 2: Read/Write to access settings used by 4094. Computer control must be ON to set a value.
ADDITIONAL NOTE: Tables 13-28a and 13-29a contain clarifications of A1-A4, B1-B4, and T1-T5, (pages 13-68a & 13-69a).

Table 13-26a

ADDRESS For PLUG-IN NUMBER #1	#2	QUANTITY	SETTING
4	36	Sweep average count	0 through 21800 (Read only)
5	37	Not used	Not used
6	38	Channel B Trigger Delay (low order)	See Notes 1, 2 and 3, (page 13-67a).
7	39	Channel B Trigger Delay (high order)	See Notes 1, 2 and 3, (page 13-67a).
8	40	Channel A Trigger Delay (low order)	See Notes 1, 2 and 3, (page 13-67a).
9	41	Channel A Trigger Delay (high order)	See Notes 1, 2 and 3, (page 13-67a).

Table 13-27a

P

- Transmission Sequence:

A. To READ Plug-in Settings (Computer Control on or off),

- 4094 input
  - #1. P, Address
    Command del. (page 13-58)
- 4094 output
  - #2. Error code for command (00-31)
    Error delimiter (page 13-58)
- 4094 output
  - #3. Setting number (0-65535)
    Record sep. (page 13-58)
- 4094 output
  - #4. End of File (EOF) delimiter (page 13-58)
- 4094 output
  - #5. Error code (00-31)
    Error delimiter (page 13-58)

B. To INPUT Plug-in Settings (Computer Control must be on),

- 4094 input
  - #1. Z1
    Command del. (page 13-58)
- 4094 output
  - #2. Error code for command (00-31)
    Error delimiter (page 13-58)
- 4094 input
  - #3. P, Address, Setting, Mask
    Command del. (page 13-58)
- 4094 output
  - #4. Error code for command (00-31)
    Error delimiter (page 13-58)

NOTE: There are two types of error checking performed when a P command is entered. Error Code for Command warns if a command was entered with a syntax error (such as a misplaced comma). The 4094 outputs an "Error Code for Command" after every command it receives. The other type of error checking warns of illegal plug-in settings and can only be accessed by reading addresses 28 and 29. See Table 13-27b on page 13-68b.

NOTE 1: Use the following equations to compute trigger delay settings.

- To position the trigger to any point on the screen:

a. Trigger Delay (high order) = 0

b. Trigger Delay (low order) = $\dfrac{|\text{Trigger Pt. Time}|}{\text{Time Per Point}}$ = No. of data points to the right.

- To position the trigger left of screen:

a. If $\dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}} \leq 65535$, then Trigger Delay (high order) = 65535

Trigger Delay (low order) $= 65536 - \dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}}$

b. If $\dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}} > 65535$, then divide $\dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}}$ by 65536

Separate the answer into whole and fractional portions, (e.g., 1.6249 ⟶ 1 and 0.6249).
65535 - Whole portion = Trigger Delay (high order).
65536 - (Frac. portion x 65536) = Trigger Delay (low order).

NOTE 2: The decimal arithimetic in Note 1 is one way of correctly working with 32 bit 2's compliment binary numbers. Trigger delay values which lie on the screen are positive 32 bit numbers. Trigger delay values which lie off the display screen to the left are negative 32 bit numbers (2's compliment). Each 32 bit number is separated into two 16 bit groups; high order, low order. Programmers familiar with manipulation of 32 bit binary numbers will find it unnecessary to follow the procedure in Note 1.

NOTE 3: In order to set trigger delays it is necessary to first turn on the "Enter delay set'g" shown on Table 13-26a, addresses 2 or 34, setting 256. After the trigger delay setting is made, the "Enter delay set'g" should be turned off by using a setting of 0 and a mask of 256.

ADDRESS	SETTING TO TURN CONTROL ON															
	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768
	SETTING TO TURN CONTROL OFF															
	N/A	N/A	Ø	N/A	N/A	N/A	N/A	Ø	N/A	Ø	Ø	Ø	N/A	N/A	N/A	Ø
13	Trig Auto	Trig Norm	Trig View										Trig (+) Slpe	Trig Dual Slpe	Trig (-) Slpe	
14	Int Trig ChA	Int Trig ChB	Not Used	Trig Int	Trig Ext	Trig DC Coup	Trig AC Coup	Not Used	Not Used	Trig Hi F Rej	Not Used	Trig Lo F Rej	Trig Slav	Trig 1Meg Ohm	Trig 50 Ohm	Avg
15	ChB +DC Coup	ChB +AC Coup	ChB +GND	ChB 1Meg Ohm	ChB 50 Ohm	ChB -DC Coup	ChB -AC Coup	ChB -GND	Not Used	ChB Fltr	ChB On	ChB Save Ref				
16	ChA +DC Coup	ChA +AC Coup	ChA +GND	ChA 1Meg Ohm	ChA 50 Ohm	ChA -DC Coup	ChA -AC Coup	ChA -GND	Not Used	ChA Fltr	ChA On	ChA Save Ref				
MASK	3		4	24		96		128	256	512	1024	2048	28672			32768
	NOTE: Masks are required for the above addresses.															

Table 13-26b

NOTE: On some controls, SETTING TO TURN CONTROL OFF is marked N/A (not applicable). If the correct mask is used, these controls will be turned off when another mutually exclusive control is turned on.

EXAMPLE: Turning on ChB + DC COUP will automatically turn off ChB + AC COUP. Turning off these controls by using a Ø will induce a P command input error.

P

VOLTAGE RANGE		A1/B1	A2/B2	A3/B3	A4/B4
Model 4562	Model 4851				
±100mV		1	1	0	1
±200mV	±100mV	1	1	0	0
±400mV	±200mV	1	1	1	0
± 1V	±400mV	0	1	0	1
± 2V	± 1V	0	1	0	0
± 4V	± 2V	0	1	1	0
±10V	± 4V	1	0	0	1
±20V	±10V	1	0	0	0
±40V	±20V	1	0	1	0
	±40V	0	0	0	1

Table 13-28a

Note 1: Front panel voltage range settings represented by A1-A4 and B1-B4 should only be read. New settings can not be made via computer interfaces.

P

ADDRESS	QUANTITY	SETTING
4	Sweep average count	00000 through 21800 (Read only)
6	Channel B Trigger Delay (low order)	See Notes #3 and #4, (page 13-70b).
7	Channel B Trigger Delay (high order)	See Notes #3 and #4, (page 13-70b).
8	Channel A Trigger Delay (low order)	See Notes #3 and #4, (page 13-70b).
9	Channel A Trigger Delay (high order)	See Notes #3 and #4, (page 13-70b).
10	Lower Trigger Threshold	-00128 to 00127 (See Note #1 and Note #2, page 13-69b)
11	Upper Trigger Threshold	-00128 to 00127 (See Note #1 and Note #2, page 13-69b)
12	Sweep average abort count	00000 through 21800
18	Time Per Point	00000 to 00031 (See Table 13-30b, page 13-71b)
20	Channel B Position	-00128 to 00127 (See Note #1, page 13-69b)
21	Channel A Position	-00128 to 00127 (See Note #1, page 13-69b)
23	Channel B Volts Full Scale	00000 to 00008 (See Table 13-29b, page 13-71b)
24	Channel A Volts Full Scale	00000 to 00008 (See Table 13-29b, page 13-71b)
28	P Command Error A (read only)	00000 to 32768 (See Table 13-31b, page 13-72b)
29	P Command Error B (read only)	00000 to 00016 (See Table 13-32b, page 13-73b)
30	Over-voltage Error (Read Only)	00000 to 00007 (See Table 13-28b, page 13-69b)

NOTE: Masks are not used for these addresses.

Table 13-27b

P

TIME PER POINT		T1	T2	T3	T4	T5
Model 4562	Model 4851					
0.5us	10us	0	1	1	1	1
1	20	1	0	1	1	1
2	50	0	0	1	1	1
5	100	1	1	0	1	1
10	200	0	1	0	1	1
20	500	1	0	0	1	1
50	1ms	0	0	0	1	1
100	2	1	1	1	0	1
200	5	0	1	1	0	1
500	10	1	0	1	0	1
1ms	20	0	0	1	0	1
2	50	1	1	0	0	1
5	100	0	1	0	0	1
10	200	1	0	0	0	1
20	500	0	0	0	0	1
50	1sec.	1	1	1	1	0
100	2	0	1	1	1	0
200	5	1	0	1	1	0
500	10	0	0	1	1	0
1sec.	20	1	1	0	1	0
2	50	0	1	0	1	0
5	100	1	0	0	1	0
10	200	0	0	0	1	0
20	500	1	1	1	0	0
50	1000	0	1	1	0	0
100	2000	1	0	1	0	0
200	5000	0	0	1	0	0
EXT I	EXT I	0	1	0	0	0
EXT II	EXT II	1	0	0	0	0

Table 13-29a

Note: Use mask = 63488 when inputting settings shown in Table 13-29a.

SETTING	OVER-VOLTAGE DETECTED
Ø	No over-voltage detected
1	Channel A only
2	Channel B only
3	Channel A and Channel B
4	Trigger only
5	Trigger and Channel A
6	Trigger and Channel B
7	Trigger, ChA, and ChB

Table 13-28b

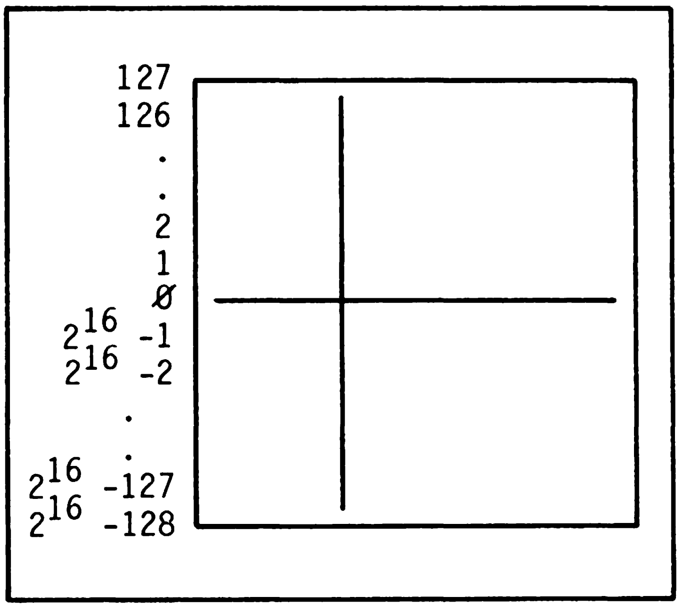


Figure 13-2b

NOTE 1: Levels above vertical screen center are represented by numbers Ø - 127. Ø represents screen center and 127 represents the top of the screen. Levels below vertical screen center are represented by the numbers 65535 - 65408. 65535 (2^{16} -1) represents the first level below screen center, and 65408 (2^{16} -128) represents the bottom of the screen. See Figure 13-2b.

NOTE 2: The upper trigger threshold should always be equal to or greater than the lower trigger threshold.

P

NOTE 3: Use the following equations to compute trigger delay settings.

- To position the trigger to any point on the screen

  a. Trigger Delay (high order) = 0

  b. Trigger Delay (low order) = $\dfrac{|\text{Trigger Pt. Time}|}{\text{Time Per Point}}$ = No. of data points to the right.

- To position the trigger left of screen

  a. If $\dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}} \leq$ 65535, then Trigger Delay (high order) = 65535

  Trigger Delay (low order) = 65536 - $\dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}}$

  b. If $\dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}} >$ 65535, then divide $\dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}}$ by 65536

  Separate the answer into whole and fractional portions,
  (e.g., 1.6249 $\longrightarrow$ 1 and 0.6249).
  65535 - Whole portion = Trigger Delay (high order).
  65536 - (Frac. portion x 65536) = Trigger Delay (low order).

NOTE 4: The decimal arithmetic in Note 3 is one way of correctly working with 32 bit 2's compliment binary numbers. Trigger delay values which lie on the screen are positive 32 bit numbers. Trigger delay values which lie off the display screen to the left are negative 32 bit numbers (2's compliment). Each 32 bit number is separated into two 16 bit groups; high order, low order. Programmers familiar with manipulation of 32 bit binary numbers will find it unnecessary to follow the procedure in Note 3.

P

SETTING	VOLTS FULL SCALE
0	±100mv
1	±200mv
2	±400mv
3	±1V
4	±2V
5	±4V
6	±10V
7	±20V
8	±40V

Table 13-29b

SETTING	TIME PER POINT
0	2nS
1	5
2	10
3	20
4	50
5	100
6	200
7	500
8	1μS
9	2
10	5
11	10
12	20
13	50
14	100
15	200
16	500
17	1mS
18	2
19	5
20	10
21	20
22	50
23	100
24	200
25	500
26	1S
27	2S
28	5S
29	10S
30	EXT I
31	EXT II

Table 13-30b

P

P COMMAND ERROR A	
ADDRESS FOR PLUG-IN #1 = 28	
ERROR SETTING (Read Only)	ERROR MESSAGE
0	No errors
1	Illegal Sweep Average Abort Count (only 0-21800 allowed)
2	Illegal Trigger Slope setting
4	Illegal Trigger Source (INT, EXT) setting
8	Illegal Internal Trigger (channel A, channel B) setting
16	Illegal External Trigger Impedance (50 ohm, 1 megohm) setting
32	Illegal B+ input Coupling (AC, DC coupling) setting
64	Illegal B- input Coupling (AC, DC coupling) setting
128	Illegal B input Impedance (50 ohm, 1 megohm) setting
256	Illegal A+ input Coupling (AC, DC coupling) setting
512	Illegal A- input Coupling (AC, DC coupling) setting
1024	Illegal A input Impedance (50 ohm, 1 megohm) setting
2048	Illegal Trigger Mode (AUTO, NORMAL, VIEW) setting
4096	Illegal Trigger Coupling (AC, HF, LF, DC, SLAVE) setting
8192	Illegal Time Per Point setting (only 0-31 allowed)
16384	Illegal Channel A Volts setting (only 0-8 allowed)
32768	Illegal Channel B Volts setting (only 0-8 allowed)

Table 13-31b

NOTE: P command errors are caused either by a setting being out of range, or two (or more) mutually exclusive settings being set to the same state.

EXAMPLE: If channel input A has both 50 ohm and 1 megohm impedances turned on, the 4175 will "beep", the CC LED will flash, and the P command error A setting will be 1024.

P

P COMMAND ERROR B	
ADDRESS FOR PLUG-IN #1 = 29	
ERROR SETTING (Read Only)	ERROR MESSAGE
0	No Errors
1	Illegal Lower Trigger Threshold setting (only 0-256 allowed)
2	Illegal Higher Trigger Threshold setting (only 0-256 allowed)
4	Illegal Channel B Position (only 0-256 allowed)
8	Illegal Channel A Position (only 0-256 allowed)
16	Illegal Trigger Threshold setting (the upper threshold must be greater than the lower threshold setting)

Table 13-32b

Mainframe Front Panel Manipulation

- COMMAND FORMAT:

  a. To INPUT to 4094: M, Address, Setting, Mask

  b. To OUTPUT from 4094: M, Address

- Purpose:

  The M Command allows mainframe front panel controls to be changed via computer commands and permits actual front panel switch settings to be read.

  If front panel controls are to be changed away from the actual switch settings, Computer Control must be turned on. Even while Computer Control is on and new settings are being used, the actual front panel switch settings can be read. Through use of the M command, the actual front panel settings can be read at any time without turning on Computer Control. The M command also makes it possible to read or set horizontal and vertical cursor positions while in XY or YT.

- Specifications:

#1. Address - A number (0-15) which defines the quantity to be read or changed. See Tables 13-30 and 31, (page 13-77).

#2. Setting - A number which represents the control to be turned on or the actual numeric value to be sent into the 4094. Table 13-30 shows a variety of front panel controls and the settings which will cause them to be actuated. A group of non mutually exclusive settings at a single address can be actuated with a single M command by adding up the settings. Settings at address 6 are mutually exclusive. Some settings at address 8 are non mutually exclusive. Since nearly all mainframe settings are mutually exclusive a single setting without a mask is generally used. Turning on multiple settings which cannot normally be set on the front panel (for example, x16 and x256 together) will lead to unpredictable results. Table

M

13-31 shows settings which directly place numeric values into the 4094 to affect cursor locations.

#3. Mask - A number which indicates the control to be changed. Mask numbers are only necessary when settings at address 8 are made. All other groups of settings are mutually exclusive or read only and thus mask numbers should not be used. Use of mask numbers at addresses containing mutually exclusive settings (such as 6, 7, 9, 10, and 11) will give unpredictable results.

- Transmission Sequence:

A. To READ mainframe settings (Computer Control on or off),

- 4094 input
  #1. M, Address
  Command del. (page 13-58)

- 4094 output
  #2. Error code for command (00-31)
  Error delimiter (page 13-58)

- 4094 output
  #3. Setting number (0-65535)
  Record sep. (page 13-58)
- 4094 output
  #4. End Of File (EOF) delimiter (page 13-58)
- 4094 output
  #5. Error code (00-31)
  Error delimiter (page 13-58)

B. To INPUT mainframe setting (Computer Control must be on),

- 4094 input
  #1. Z1
  Command del. (page 13-58)

- 4094 output
  #2. Error code for command (00-31)
  Error delimiter (page 13-58)

- 4094 input
  #3. M, Address, Setting, Mask
  Command del. (page 13-58)

- 4094 output
  #4. Error code for command (00-31)
  Error delimiter (page 13-58)

Computer Control (Z1) must remain on as long as the 4094 mainframe is expected to ignore actual front panel settings and perform based on the new settings.

ADDRESS	I/O DIRECTION	FUNCTION	SETTINGS AND MASK								
			1	2	4	8	16	32	64	128	256
0	Read only to determine actual front panel switch locations	Vert. Exp.	OFF	X2	X4	X8	X16	X32	X64	X128	X256
1		Hor. Exp.	OFF	X2	X4	X8	X16	X32	X64	X128	X256
2		Cursor Cont, Execute	Crsr ◄	Crsr ►	Crsr ▲	Crsr ▼	Exec	Y/T	Auto Ctr	Zero	
3		Not Used									
4		Function Sw.	Prgm	Invrt	Sub	Data Move	Rst	Grd	Pen		
5		Memory Sw.	Q1	Q3	H1	All	H2	Q2	Q4		
6	Read/Write to influence scope behavior - Computer Control must be turned ON	Vert. Exp.	OFF	X2	X4	X8	X16	X32	X64	X128	X256
7		Hor. Exp.	OFF	X2	X4	X8	X16	X32	X64	X128	X256
8		Cursor Cont, Execute	Do not use (Cursor position keys) See Table 13-31.				Exec	Y/T	Auto Ctr	Zero	
9		Not Used									
10		Function Sw.	Prgm	Invrt	Sub	Data Move	Rst	Grd	Pen		
11		Memory Sw.	Q1	Q3	H1	All	H2	Q2	Q4		
NOTE: Mask numbers need only be used when accessing address 8.											

Table 13-30

READ/WRITE CURSOR POSITIONS		
ADDRESS	CURSOR	SETTING
#12 #13	X/Y Vert. Cursor X/Y Hor. Cursor	32768 thru 65535 (for -32768 thru -1), 0 thru 32767 32768 thru 65535 (for -32768 thru -1), 0 thru 32767
#14 #15	Y/T Vert. Cursor Y/T Hor. Cursor	49664 thru 65535 (0 + 49664 thru 15871 + 49664) 32768 thru 65535 (for -32768 thru -1), 0 thru 32767
NOTE: Negative settings for addresses 12,13, and 15 must have 65536 added to them. Settings for address 14 must have 49664 added to them.		

Table 13-31

J

GPIB/PLOTTER Port I/O

- COMMAND FORMAT:

  J

- Purpose:

  The J command puts the 4094 into a unique mode of operation in which the 4094 acts as a GPIB/RS-232C translator. Normal GPIB communications will be passed through the 4094 and will be sent out the PLOTTER port. The GPIB transmission speed will be held down to equal the plotter port baud rate.

  Switch 5 (see pg. 13-21) allows two plotter baud rates to be set:
  OPEN = Baud rate set on Switches 1-4
  CLOSED = 2400 baud.

  The K command allows additional baud rates and RS-232C parameters to be selected. The PLOTTER port will have the same parity and number of stop bits as set for the RS-232C MODEM/COMPUTER port unless changed by the K command. The preprogrammed digital plotters offered by Nicolet modify the baud rate, parity, and stop bits during use, therefore, it is safest to make necessary settings with the K command before using the J command.

The 4094 GPIB/RS-232C translation is bidirectional. After issuing the J command into the GPIB port, transmissions coming into the PLOTTER port will be relayed out the GPIB. PLOTTER port to GPIB communications will proceed at the baud rate selected, the GPIB controller must be able to keep pace.

This is not a genuine restriction since it only requires a controller to run at approximately 2000 bytes/sec. (at maximum). Slower transmission speeds can be chosen by selecting a slower plotter port baud rate.

The GPIB/PLOTTER port interconnection can be terminated by issuing a Device Clear, Selected Device Clear, or Interface Clear from the GPIB controller.

NOTE: Initiation and termination of this mode of operation must come from the GPIB controller.

The PLOTTER port is configured as data communications equipment and is, therefore, directly compatible with printers, terminals, digital plotters, and computers configured as data terminal equipment. The primary difference between data terminal equipment and data communications equipment is the location of the transmit and receive lines.

- Data Terminal Equipment:
  a. line 2 = transmit
  b. line 3 = receive
- Data Communications Equipment:
  a. line 2 = receive
  b. line 3 = transmit

A modem connected to the plotter port will require lines 2 and 3 to be crossed since it is also data communications equipment. Handshaking lines may need to be hardwired together (see the RS-232C Start-up, page 13-21) to correctly connect two pieces of data communications equipment together.

There are many possible uses of this unique GPIB/RS-232C translator. The most obvious is the ability to directly communicate between a GPIB compatible computer and a RS-232C compatible digital plotter. However, this mode of operation can be considered to be a general purpose GPIB/RS-232C converter. Any GPIB controller is capable of communicating with a variety of RS-232C devices.

- Transmission Sequence:
  - GPIB 4094 input
    #1. J
    Command del. (page 13-58)
  - GPIB 4094 output
    #2. Error code for command (00-31)
    Error delimiter (page 13-58)
  - Bidirectional GPIB/Plotter Port communications are now possible.
  - GPIB 4094 input
    #3. Device Clear, Selected Device Clear, or Interface Clear. A computer manual must be consulted to determine the correct command to issue the necessary clear.

K

MODEM/COMPUTER and PLOTTER Port Parameters

- COMMAND FORMAT:

K, Port, Mode, Baud Rate No.

- Purpose:

The K command is used to vary the parameters affecting the RS-232C MODEM/COMPUTER port and the RS-232C PLOTTER port. Baud rate, parity on/off, parity odd/even, and number of stop bits can all be set using the K command. The 8 segment DIP switch discussed, starting on page 13-21 is another way to set these parameters. The PLOTTER port and the MODEM/COMPUTER port will operate according to the DIP switch settings unless modified by the K command. When using the GPIB/PLOTTER port interconnection (see command J), it is best to first use the K command to ensure that the PLOTTER port is set up as needed. The preprogrammed digital plotters offered by Nicolet modify the plotter port baud rate, parity, and stop bits during use and, therefore, it is safest to make necessary settings with the K command before using the J command.

- Specifications:

#1. Port - A number corresponding to the RS-232C port to be modified.
0 = MODEM/COMPUTER port
1 = PLOTTER port

#2. Mode - A number used to specify parity, number of stop bits and corresponding character length. The mode numbers given below can be added up to create the total setting.

Mode	No. of Stop Bits
0	1-1/2
64	2
128	1

Table 13-32

Mode	Parity
0	None
32	Even
48	Odd

Table 13-33

Mode	Character Length
0	5 bits
1	6 bits
2	7 bits
3	8 bits

Table 13-34

K

Examples:

a. 1 stop bit, no parity = 128+0+3
b. 1 stop bit, odd parity = 128+48+2
c. 1 stop bit, even parity = 128+32+2
b. 2 stop bit, no parity = 64+0+3

Normal RS-232C transmissions are set up to handle 7 bit characters plus parity bit, plus start and stop bits. Even when parity is turned off it is usually desirable to keep the total bit count the same as when parity is turned on. This can be accomplished by setting the character length to 8 bits. The eighth bit will be ignored by the 4094 when parity checking is turned off. See page 13-22.

#3. Baud Rate No. - A number which specifies the baud rate (bits per second) of the transmissions.

Baud Rate No.	Baud Rate
1232	300
417	1200
52	9600
1592	110
1441	150
1163	450
1128	600
278	1800
250	2000
208	2400
139	3600
104	4800
69	7200
35	14400
26	19200
13	38400

Table 13-35

- Transmission Sequence:
  - 4094 input
    #1. K, Port, Mode, Baud Rate No. Command del. (page 13-58)
  - 4094 output
    #2. Error code for command (00-31)
    Error delimiter (page 13-58)

ASCII CODE CHART

BITS 2^6 2^5 2^4 / 2^3 2^2 2^1 2^0	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
0 0 0 0	NUL	DLE	space	0	@	P	`	p
0 0 0 1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	STX	DC2	"	2	B	R	b	r
0 0 1 1	ETX	DC3	#	3	C	S	c	s
0 1 0 0	EOT	DC4	$	4	D	T	d	t
0 1 0 1	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	ACK	SYN	&	6	F	V	f	v
0 1 1 1	BEL	ETB	'	7	G	W	g	w
1 0 0 0	BS	CAN	(	8	H	X	h	x
1 0 0 1	HT	EM	)	9	I	Y	i	y
1 0 1 0	LF	SUB	*	:	J	Z	j	z
1 0 1 1	VT	ESC	+	;	K	[	k	{
1 1 0 0	FF	FS	,	<	L	\	l	¦
1 1 0 1	CR	GS	-	=	M	]	m	}
1 1 1 0	SO	RS	.	>	N	^	n	~
1 1 1 1	SI	US	/	?	O	_	o	delete

Table 13-36

ASCII CODE CHART TRANSLATION INTO 4094 DISPLAY CHARACTERS

BITS 2^3 2^2 2^1 2^0 \ 2^6 2^5 2^4	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
0 0 0 0	$\underline{@}$	$\underline{P}$	space	0	@	P	space	0
0 0 0 1	$\underline{A}$	$\underline{Q}$	!	1	A	Q	!	1
0 0 1 0	$\underline{B}$	$\underline{R}$	"	2	B	R	"	2
0 0 1 1	$\underline{C}$	$\underline{S}$	#	3	C	S	#	3
0 1 0 0	$\underline{D}$	$\underline{T}$	$	4	D	T	$	4
0 1 0 1	$\underline{E}$	$\underline{U}$	%	5	E	U	%	5
0 1 1 0	$\underline{F}$	$\underline{V}$	&	6	F	V	&	6
0 1 1 1	$\underline{G}$	$\underline{W}$	'	7	G	W	'	7
1 0 0 0	$\underline{H}$	$\underline{X}$	(	8	H	X	(	8
1 0 0 1	$\underline{I}$	$\underline{Y}$	)	9	I	Y	)	9
1 0 1 0	$\underline{J}$	$\underline{Z}$	*	:	J	Z	*	:
1 0 1 1	$\underline{K}$	$\underline{k}$	+	;	K	k	+	;
1 1 0 0	$\underline{L}$	$\underline{m}$	,	<	L	m	,	<
1 1 0 1	$\underline{M}$	$\underline{u}$	-	=	M	u	-	=
1 1 1 0	$\underline{N}$	$\underline{n}$	.	>	N	n	.	>
1 1 1 1	$\underline{O}$	$\underline{p}$	/	?	O	p	/	?

Table 13-37

The 4094 display shows non-printable ASCII characters as underlined ASCII characters (for example, CR=$\underline{M}$). Lower case alphabet characters and several other miscellaneous characters also undergo a translation in order to be displayed on the 4094. It is important to note that these translations are for the visual display only. The correct, unmodified 7 bit code is contained in the 4094 memory and can be sent out if requested.

To erase displayed characters which result from computer interfacing, turn the FUNCTION switch to PRGM and then away from PRGM.

SAMPLE COMPUTER PROGRAMS

The following sample programs are intended to show basic usage of the 4094 interfacing commands. Even if your computer is programmed in a different language, the samples will help with general formatting concepts. Portions of these sample programs may be usable in actual application programs. Normal application programs will be longer and more highly specialized than those shown.

All of the following programs were written on computers using the IEEE-488 (GPIB) interface. This was done for the sake of simplicity and uniformity. The 4094 commands are the same for the IEEE-488 and the RS-232 Interfaces, however the computer command structure will differ somewhat.

HP-85/HP-87 COMPUTER programs begin on page 13a-3.
TEKTRONIX 4051/4052/4054 COMPUTER programs begin on page 13b-3

HP-85/HP-87 COMPUTERS

All of the following programs use a 4094 address of 14 and a computer select code of 7.

PROGRAM #1

This is a simple test program to make sure that the interface is functioning correctly. The program causes the 4094 to make one audio "beep".

1Ø OUTPUT 714; "B"	Computer outputs command B as a character string from select code 7 to GPIB address 14 (4094). 4094 will beep as soon as it receives command B.
2Ø ENTER 714; E	The 4094 command error code is entered into the computer and stored in variable E.
3Ø END	End of program.

PROGRAM #2

The 4094 is instructed to recall record number 1 from disk into the display memory.

1Ø OUTPUT 714; "R,Ø,1,Ø"	Command R is sent out as a character string from select code 7 to GPIB address 14 (4094).
2Ø ENTER 714; E	The 4094 command error code is entered into the computer and stored in variable E.
3Ø DISP "RECALL COMPLETE"	Computer displays "RECALL COMPLETE".
4Ø BEEP	Computer beeps.
5Ø END	End of program.

PROGRAM #3

The 4094 (plug-in 1) is placed into LIVE/HOLD NEXT. Upon receiving a trigger and completing the sweep the 4094 will go into HOLD LAST. The command error code (line 40) is used to tell the computer that the sweep has been completed. Use AUTO triggering and a fast time per point if an actual input signal is not being provided.

1Ø OUTPUT 714; "Z1"	Command Z is sent as a character string from select code 7 to GPIB address 14 (4094). Z1 turns on computer control.
2Ø ENTER 714; E	The 4094 command error code is entered into the computer and stored in variable E.
3Ø OUTPUT 714; "H,Ø,Ø"	Command H is sent to the 4094.
4Ø ENTER 714; E	The 4094 command error code is entered.
5Ø DISP "SWEEP COMPLETE"	Computer displays "SWEEP COMPLETE". 4094 will now be in HOLD LAST.
6Ø BEEP	Computer beeps.
7Ø OUTPUT 714; "ZØ"	Command Z is sent to the 4094 to turn off computer control.
8Ø ENTER 714; E	The 4094 command error code is entered.
9Ø END	End of program.

PROGRAM #4

A check is made of 4094 plug-ins to determine whether they are in LIVE or HOLD LAST.

`10 OUTPUT 714; "C,4,2,13,10"`	Command C is sent as a character string from select code 7 to GPIB address 14 (4094). This is used to set the record separator delimiter (which follows the status reply) to CR/LF.
`20 ENTER 714; E`	The 4094 command error code is entered into the computer and stored in variable E.
`30 OUTPUT 714; "L,0"`	Command L is sent to the 4094 to determine plug-in status.
`40 ENTER 714; E`	The 4094 command error code is entered.
`50 ENTER 714; S`	The plug-in status number is entered.
`60 IF S=0 THEN DISP "ALL PLUG-INS IN HOLD"`	Check value of status number.
`70 IF S=1 THEN DISP "AT LEAST ONE PLUG-IN IN LIVE"`	Check value of status number.
`80 ENTER 714; E`	Enter error code for status transmission.
`90 END`	End of program.

PROGRAM #5

Waveform information is taken from the 4094 and displayed. The waveform information contains the total number of waveforms in memory, number of data points in each waveform, etc.

Note that record separator delimiters are used so that each item in the waveform parameter set can be placed into the numeric array W. If the entire waveform parameter set is entered as a single character string it will be necessary to break apart the string to determine the value of each item.

```
10 OUTPUT 714; "C,4,2,13,10"
```

Command C is sent as a character string from select code 7 to GPIB address 14 (4094). This is used to set the record separator delimiter to CR/LF so that each waveform data number can be brought into a numerical array (lines 70-130).

```
20 ENTER 714; E
```

The 4094 command error code is entered into the computer and stored in variable E.

```
30 DIM W(32,7)
```

Dimension array W large enough to contain all the waveform information for up to 32 waveforms.

```
40 OUTPUT 714; "W"
```

Command W is sent out to the 4094

```
50 ENTER 714; E
```

The 4094 command error code is entered.

```
60 ENTER 714; W1
```

Enter the total waveform count into variable W1.

```
70 FOR I=1 TO W1
80 FOR J=1 TO 7
90 ENTER 714; W(I,J)
100 DISP W(I,J)
110 NEXT J
120 DISP "-------"
130 NEXT I
```

Lines 70 through 130 enter waveform information into array W and display the data. A dashed line is inserted between each waveform parameter set.

```
140 ENTER 714; E
```

The transmission error code is entered.

```
150 IF E=20 THEN
  DISP "MIXED DATA"
```

Check for mixed data.

```
160 END
```

End of program.

PROGRAM #6

The 4094 outputs the first 10 data points in waveform 1 in ASCII code. The data values are stored in numerical array D. Binary data transmissions (Programs 7 and 8) should be used if transfer time is important.

`1Ø OUTPUT 714; "C,4,2,13,10"`	Command C is sent as a character string from select code 7 to GPIB address 14 (4094). This is used to set the record separator delimiter to CR/LF so that each data point can be stored separately in a numerical array.
`2Ø ENTER 714; E`	The 4094 command error code is entered into the computer and stored in variable E.
`3Ø OUTPUT 714; "D,Ø,1,Ø,1Ø,1"`	Command D is sent to the 4094.
`4Ø ENTER 714; E`	The 4094 command error code is entered.
`5Ø DIM D(10)`	Dimension array D to contain 10 numeric values.

`6Ø FOR I=1 TO 1Ø`
`7Ø ENTER 714; D(I)`
`8Ø DISP D(I)`
`9Ø NEXT I`
	Lines 60 through 90 enter the ASCII data point values from the 4094 and store them into numeric array D.

`1ØØ ENTER 714; E`	Enter data transmission error code.
`11Ø END`	End of program.

PROGRAM #7

The 4094 outputs 4000 data points in binary form to the computer. After the data transfer the computer pauses so that the 4094 display screen can be erased (press LIVE then HOLD LAST). The continue key (CONT) can then be pressed to transfer the binary data back to the 4094. It is assumed that record separator delimiters and end of file delimiters are turned off in the 4094 since they cannot be used with binary transfers. Use command C or the RS-232/GPIB reset switch to remove the record sep. and EOF delimiters.

`10 OUTPUT 714; "D,4,1,0,4000,1"`	Command D is sent as a character string from select code 7 to GPIB address 14 (4094).
`20 ENTER 714; E`	The 4094 command error code is entered into the computer and stored in variable E.
`30 DIM A$[8008]`	Dimension character string A$ to contain 8000 characters plus the HP required 8 extra string locations. Each data point transferred in binary will result in two 8 bit characters to be stored.
`40 IOBUFFER A$`	Declare the buffer used in I/O operation to be A$.
`50 CONTROL 7,16;0`	Turn off the CR/LF delimiter used inside the computer.
`60 TRANSFER 714 TO A$ FHS; COUNT 8000`	Enter 8000 bytes of data from the 4094 into string A$ using the "fast handshake" transfer mode.
`70 CONTROL 7,16;2`	Turn the CR/LF delimiter back on inside the computer.
`80 ENTER 714; E`	Enter the data transmission error code.

Program #7 continued.

`90 DISP "PRESS 'CONT' TO TRANSFER DATA BACK TO SCOPE"`	Display message on computer.
`100 PAUSE`	Pause during program execution. Press CONT to finish program.
`110 OUTPUT 714; "D,5,1,0,4000,1"`	Command D is sent to the 4094 to specify that data will be sent back.
`120 ENTER 714; E`	The 4094 command error code is entered.
`130 CONTROL 7,16;0`	Turn off the internal computer CR/LF delimiter.
`140 TRANSFER A$ TO 714 FHS`	Dump the 8000 bytes of data contained in A$ to the 4094.
`150 CONTROL 7,16;2`	Turn the computer CR/LF delimiter back on.
`160 ENTER 714; E`	Enter the data transmission error code.
`170 DISP "TRANSFER COMPLETE"`	Display message on computer.
`180 BEEP`	Computer beeps.
`190 END`	End of program.

PROGRAM 8

The 4094 is instructed to output 100 data points to the computer in binary form. Each data point is transferred as two 8 bit bytes. The last part of this program combines the two bytes to form a single numeric value. It should be noted that while binary data transfers are very fast, the process of combining bytes can be quite slow. High speed computers can, of course, speed up this process. It is assumed that record separator delimiters and end of file delimiters are turned off in the 4094 since they cannot be used with binary transfers. Use command C or the RS-232/GPIB reset switch to remove the record sep. and EOF delimiters.

`1Ø OUTPUT 714; "D,4,1,Ø,1ØØ,1"`	Command D is sent as a character string from select code 7 to GPIB address 14 (4094).
`2Ø ENTER 714; E`	The 4094 command error code is entered into the computer and stored in variable E.
`3Ø CONTROL 7,16;Ø`	Turn off the CR/LF delimiter inside the computer.
`4Ø DIM B$[208]`	Dimension character string B$ to contain 200 characters plus the HP required 8 extra string locations. Each data point transferred in binary will result in two 8 bit characters to be stored.
`5Ø IOBUFFER B$`	Declare the buffer used in the I/O operation to be B$.
`6Ø TRANSFER 714 TO B$ FHS; COUNT 2ØØ`	Enter 200 bytes of data from the 4094 into string B$ using the "fast handshake" transfer mode.
`7Ø CONTROL 7,16;2`	Turn the internal computer CR/LF delimiter back on.

Program #8 continued.

8Ø ENTER 714; E	Enter the data transmission error code.
9Ø J=1	Initialize variable J.
1ØØ DIM A(100)	Dimension array A to contain the 100 numeric data point values.
11Ø FOR I=1 TO 199 STEP 2 12Ø P=256*NUM(B$[I])+NUM(B$[I+1]) -65536*(NUM(B$[I])>=128) 13Ø A(J)=P 14Ø DISP A(J) 15Ø J=J+1 16Ø NEXT I	Lines 110 through 160 are used to combine the high and low bytes of data and store the resulting number in array A.
17Ø BEEP	Computer beeps.
18Ø END	End of Program.

Program #9

The 4094 outputs normalization set number 0 to the computer. Note that record separator delimiters are used so that each item in the normalization set can be placed into the numeric array N. If the entire normalization set is entered as a single character string it will be necessary to break the string apart to determine the value of each item.

`1Ø OUTPUT 714; "C,4,2,13,1Ø"`	Command C is sent as a character string from select code 7 to GPIB address 14 (4094). This is used to set the record separator delimiter to CR/LF so that each item in the normalization set can be brought into a numeric array.
`2Ø ENTER 714; E`	The 4094 command error code is entered into the computer and stored in variable E.
`3Ø OUTPUT 714; "N,Ø"`	Command N is output to the 4094.
`4Ø ENTER 714; E`	Enter the 4094 command error code.
`5Ø DIM N(11)`	Dimension numeric array N to contain the values in the normalizing set.

`6Ø FOR I=1 TO 11`
`7Ø ENTER 714; N(I)`
`8Ø DISP N(I)`
`9Ø NEXT I`
	Lines 60 through 90 are used to enter normalizing set values into array N.

`1ØØ ENTER 714; E`	Enter the normalization transmission error.
`11Ø END`	End of program.

PROGRAM #10

This program illustrates a method to input titles to the 4094. Titles sent to the 4094 must be exactly 32 characters long. To be assured of transmissions containing exactly 32 characters a formatted output statement is usually necessary.

1Ø DIM A$[4Ø]	Dimension character string A$ to contain the 32 character title.
2Ø DISP "TYPE IN 32 CHARACTER TITLE"	Display message on computer.
3Ø INPUT A$	Input title from computer keyboard.
4Ø OUTPUT 714; "T,1,1"	Command T is sent to the 4094.
5Ø ENTER 714; E	Enter the 4094 command error code.
6Ø CONTROL 7,16;Ø	Turn off the internal computer CR/LF delimiter. Delimiters would add excess characters (CR/LF) to the title.
7Ø OUTPUT 714 USING "K"; A$	Send the 32 character title into the 4094.
8Ø CONTROL 7,16; 2	Turn the internal computer delimiter CR/LF back on.
9Ø ENTER 714; E	Enter the title transmission error code.
1ØØ END	End of program.

PROGRAM #11

Plug-in front panel controls can be set via computer interfaces. This program sets the time per point to 500 nsec/pt. (Model 4562) or 10 usec/pt. (Model 4851).

10 OUTPUT 714; "Z1"	Command Z is sent as a character string from select code 7 to GPIB address 14 (4094). Z1 turns on computer control so that the actual front panel switch settings will be ignored.
20 ENTER 714; E	Enter the 4094 command error code.
30 OUTPUT 714; "P,3,61440,63488"	Command P is sent to the 4094 to set the new time base.
40 ENTER 714; E	Enter the 4094 command error code.
50 DISP "PRESS 'CONT' TO REVERT BACK TO KNOB SETTING"	Display message on computer.
60 PAUSE	Pause during program execution. Press CONT to finish program.
70 OUTPUT 714; "Z0"	Command Z is sent to the 4094 to turn off computer control.
80 ENTER 714; E	Enter the 4094 command error code.
90 END	End of program.

PROGRAM #12

Many front panel settings can be read out on the computer interfaces. This program reads the Channel A, plug-in 1 voltage range settings. See Table 13-28 on page 13-68 for the meanings of A1-A4.

1Ø OUTPUT 714; "C,4,2,13,1Ø"	Command C is sent as a character string from select code 7 to GPIB address 14 (4094). This is used to set the record separator delimiter to CR/LF so that the plug-in setting can be entered easily into variable P.
2Ø ENTER 714; E	Enter the 4094 command error code.
3Ø OUTPUT 714; "P,1"	Command P is used to request the value related to the plug-in front panel setting.
4Ø ENTER 714; E	Enter the 4094 command error code.
5Ø ENTER 714; P	Enter the plug-in front panel setting value.
6Ø ENTER 714; E	Enter the transmission error code.
7Ø A1=Ø 8Ø A2=Ø 9Ø A3=Ø 1ØØ A4=Ø	Lines 70 through 100 initalize A1 through A4.
11Ø IF P>32767 THEN P=P-32768	Reduce the size of P to within the range allowed to be used with BINAND.
12Ø IF BINAND (P,1)>Ø THEN A1=1 13Ø IF BINAND (P,2)>Ø THEN A2=1 14Ø IF BINAND (P,4)>Ø THEN A3=1 15Ø IF BINAND (P,8)>Ø THEN A4=1	Check bits 2^0, 2^1, 2^2, and 2^3 values to determine A1 through A4. See page 13-68.
16Ø DISP USING "D,X"; A1, A2, A3, A4	Display the values of A1-A4.
17Ø END	End of Program.

PROGRAM #13

Mainframe front panel controls can be set via computer interfaces. This program allows the horizontal and vertical expansions to be set.

10 DISP "TYPE IN DESIRED HORIZONTAL EXPANSION"	Display message on computer.
20 INPUT A	Set A equal to the desired horizontal expansion factor.
30 OUTPUT 714; "Z1"	Command Z is sent to the 4094 to turn on computer control.
40 ENTER 714; E	Enter the 4094 command error code.
50 OUTPUT 714; "M,7,";A	Command M is sent to the 4094 to set the horizontal expansion factor.
60 ENTER 714; E	Enter the 4094 command error code.
70 DISP "TYPE IN DESIRED VERTICAL EXPANSION"	Display message on computer.
80 INPUT B	Set B equal to the desired vertical expansion factor.
90 OUTPUT 714; "M,6,"; B	Command M is sent to the 4094 to set the vertical expansion factor.
100 ENTER 714; E	Enter the 4094 command error code.
110 DISP "PRESS 'CONT' TO RETURN TO KNOB SETTINGS"	Display message on computer.

PROGRAM #13 continued.

12Ø PAUSE	Pause during program execution. Press CONT to finish program.
13Ø OUTPUT 714; "ZØ"	Command Z is sent to the 4094 to turn off computer control.
14Ø ENTER 714; E	Enter the 4094 command error code.
15Ø END	End of program.

TEKTRONIX 4051/4052/4054

All of the following programs use a 4094 address of 14 on the GPIB.

PROGRAM #1

This is a simple test program to make sure that the interface is functioning correctly. The program causes the 4094 to make one audio beep.

1ØØ PRINT @ 37,26:1	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
11Ø PRINT @ 14: "B"	Command B is sent to the 4094 (address 14) as a character string. The 4094 should beep as soon as it receives command B.
12Ø INPUT @ 14: E	The 4094 command error code is entered into the computer and stored in variable E.
13Ø END	End of program.

PROGRAM #2

The 4094 is instructed to recall record number 1 from disk into the display memory.

1ØØ PRINT @ 37,26:1	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
11Ø PRINT @ 14: "R,Ø,1,Ø"	Command R is sent to the 4094 (address 14) as a character string.
12Ø INPUT @ 14: E	The 4094 command error code is entered into the computer and stored in variable E.
13Ø PRINT "RECALL COMPLETE"	Computer displays message.
14Ø END	End of program.

PROGRAM #3

The 4094 (plug-in 1) is placed into LIVE/HOLD NEXT. Upon receiving a trigger and completing the sweep the 4094 will go into HOLD LAST. Use AUTO triggering and a fast time per point if an actual input signal is not being provided.

1ØØ PRINT @ 37,26:1	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
11Ø PRINT @ 14: "Z1"	Command Z is sent to the 4094 (address 14) as a character string. Z1 turns on computer control.
12Ø INPUT @ 14: E	Enter the 4094 command error code and store it in variable E.
13Ø PRINT @ 14: "H,Ø,Ø"	Command H is sent to the 4094.
14Ø INPUT @ 14: E	Enter the 4094 command error code.
15Ø PRINT "SWEEP COMPLETE"	Computer displays message.
16Ø PRINT @ 14: "ZØ"	Command Z is sent to the 4094 to turn off computer control.
17Ø INPUT @ 14: E	Enter the 4094 command error code.
18Ø END	End of program.

PROGRAM #4

A check is made of 4094 plug-ins to determine whether they are in LIVE or HOLD LAST.

1ØØ PRINT @ 37,26:1	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
11Ø PRINT @ 14: "C,4,2,13,1Ø"	Command C is sent to the 4094 (address 14) as a character string. This is used to set the record separator delimiter (which follows the status reply) to CR/LF.
12Ø INPUT @ 14: E	Enter the 4094 command error code into variable E.
13Ø PRINT @ 14: "L,Ø"	Command L is sent to the 4094.
14Ø INPUT @ 14: E	Enter the 4094 command error code.
15Ø INPUT @ 14: S	Enter the plug-in status number.
16Ø IF S=Ø THEN 18Ø 17Ø GO TO 19Ø 18Ø PRINT "ALL PLUG-INS IN HOLD" 19Ø IF S=1 THEN 21Ø 2ØØ GO TO 22Ø 21Ø PRINT "AT LEAST ONE PLUG-IN IN LIVE"	Check the value of the status number and display appropriate message.
22Ø INPUT @ 14: E	Enter the status transmission error code.
23Ø END	End of program.

PROGRAM #5

Waveform information is taken from the 4094 and displayed. The waveform information contains the total number of waveforms in memory, number of data points in each waveform, etc. Note that record separator delimiters are used so that each item in the waveform parameter set can be placed into the numeric array W. If the entire waveform parameter set is entered as a character string it will be necessary to break apart the string to determine the value of each item.

`100 PRINT @ 37,26:1`	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
`110 PRINT @ 14: "C,4,2,13,10"`	Command C is sent to the 4094 (address 14) as a character string. This is used to set the record separator delimiters contained in the waveform parameter set to CR/LF.
`120 INPUT @ 14: E`	Enter the 4094 command error code into variable E.
`130 DIM W(32,7)`	Dimension array W to contain all possible sets of waveform parameters.
`140 PRINT @ 14: "W"`	Command W is sent to the 4094.
`150 INPUT @ 14: E`	Enter the 4094 command error code.
`160 INPUT @ 14: W1`	Enter the total waveform count into variable W1.

`170 FOR I=1 TO W1`
`180 FOR J=1 TO 7`
`190 INPUT @ 14: W(I,J)`
`200 PRINT W(I,J)`
`210 NEXT J`
`220 PRINT "-----"`
`230 NEXT I`
	Lines 170 through 230 enter waveform information into array W and display the data. A dashed line is inserted between each waveform parameter set.

Program #5 continued.

24∅ INPUT @ 14: E	Enter the transmission error code.
25∅ IF E=2∅ THEN 27∅ 26∅ GO TO 28∅	Check for mixed data.
27∅ PRINT "MIXED DATA"	Display message.
28∅ END	End of program.

PROGRAM #6

The 4094 outputs the first 10 data points in waveform 1 in ASCII code. The data values are stored in numerical array D. Binary data transmissions (Programs 7 and 8) should be used if transfer time is important.

`1ØØ PRINT @ 37,26:1`	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
`11Ø PRINT @ 14: "C,4,2,13,1Ø"`	Command C is sent to the 4094 (address 14) as a character string. This is used to set the record separator delimiters (separating data values) to CR/LF.
`12Ø INPUT @ 14: E`	Enter the 4094 command error code into variable E.
`13Ø PRINT @ 14: "D,Ø,1,Ø,1Ø,1"`	Command D is sent to the 4094.
`14Ø INPUT @ 14: E`	Enter the 4094 command error code.
`15Ø DIM D(1Ø)`	Dimension array D to contain 10 numeric values.

`16Ø FOR I=1 TO 1Ø`
`17Ø INPUT @ 14: D(I)`
`18Ø PRINT D(I)`
`19Ø NEXT I`
	Lines 160 through 190 enter the ASCII data point values from the 4094 and store them in numeric array D.

`2ØØ INPUT @ 14: E`	Enter the data transmission error code.
`21Ø END`	End of program.

PROGRAM #7

The 4094 outputs 3000 data points in binary form to the computer. After the data transfer the computer pauses so that the 4094 display screen can be erased (press LIVE then HOLD LAST). The statement RUN 21Ø can by typed into the computer to transfer the binary data back to the 4094. It is assumed that record separator delimiters and end of file delimiters are turned off in the 4094 since they cannot be used with binary transfers. Use command C or the RS-232C/GPIB reset switch to remove the record sep. and EOF delimiters.

`1ØØ PRINT @ 37,26:1`	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
`11Ø PRINT @ 14: "D,4,1,Ø,3ØØØ,1"`	Command D is sent to the 4094 (address 14) as a character string.
`12Ø INPUT @ 14: E`	Enter the 4094 command error code.
`13Ø DIM D(6ØØØ)`	Dimension array D to contain 6000 numeric values. Each data point transferred in binary results in two 8 bit bytes which are stored as numbers.
`14Ø WBYTE @ 78:`	Address the 4094 at the talk address which corresponds to GPIB address 14. This makes the 4094 a "talker". WBYTE is necessary only for binary transfers.

`15Ø FOR I=1 TO 6ØØØ`
`16Ø RBYTE D(I)`
`17Ø NEXT I`
	Lines 150 through 170 enter 6000 data bytes from the 4094. RBYTE is used only for binary transfers.

`18Ø WBYTE @ 63,95:`	Address the GPIB at the general unlisten, untalk addresses to remove the 4094 as a talker.
`19Ø INPUT @ 14: E`	Enter the 4094 data transmission error code.

Program #7 continued.

2ØØ STOP	Program execution will stop and can be restarted by typing in RUN 21Ø.
21Ø PRINT @ 14: "D,5,1,Ø,3ØØØ,1"	Command D is sent to the 4094 to specify that data will be sent back.
22Ø INPUT @ 14: E	Enter the 4094 command error code.
23Ø WBYTE @ 46:	Address the 4094 at the listen address which corresponds to GPIB address 14. This makes the 4094 a "listener". WBYTE is only needed for binary transfers.
24Ø FOR I=1 TO 6ØØØ 25Ø WBYTE D(I) 26Ø NEXT I	Lines 240 through 260 dump 6000 data bytes to the 4094.
27Ø WBYTE @ 63,95:	Address the GPIB at the general unlisten, untalk addresses to remove the 4094 as a listener.
28Ø INPUT @ 14: E	Enter the 4094 data transmission error code.
29Ø END	End of program.

PROGRAM #8

The 4094 outputs 100 data points to the computer in binary form. Each data point is transferred as two 8-bit bytes. The two bytes for each data point are then combined to form a single numeric value. It is assumed that record separator delimiters and end of file delimiters are turned off in the 4094 since they cannot be used with binary transfers. Use command C or the RS-232C/GPIB reset switch to remove the record separator and EOF delimiters.

`1ØØ PRINT @ 37,26:1`	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
`11Ø PRINT @ 14: "D,4,1,Ø,1ØØ,1"`	Command D is sent to the 4094 (address 14) as a character string.
`12Ø INPUT @ 14: E`	Enter the 4094 command error code.
`13Ø DIM D(1ØØ)`	Dimension numeric array D to contain 100 data point values.
`14Ø WBYTE @ 78:`	Address the 4094 at the talk address which corresponds to GPIB address 14. This makes the 4094 a "talker". WBYTE is necessary only for binary transfers.

`15Ø FOR I=1 TO 1ØØ`
`16Ø RBYTE H,L`
`17Ø D(I)=256*H+L-65536*(H=>128)`
`18Ø NEXT I`
	Lines 150 through 180 enter binary high and low bytes (H and L) and combine them to form a single numeric value. This data point value is stored in array D.

`19Ø WBYTE @ 63,95:`	Address the GPIB at the general unlisten, untalk addresses to remove the 4094 as a talker.

Program #8 continued.

2ØØ INPUT @ 14: E	Enter the 4094 data transmission error code.
21Ø PRINT D	Display the data values stored in array D on the computer screen.
22Ø END	End of program.

PROGRAM #9

The 4094 outputs normalization set number 0 to the computer. Note that record separator delimiters are used so that each item in the normalization set can be placed into numeric array N. If the entire normalization set is entered as a single character string it will be necessary to break the string apart to determine the value of each item.

`1ØØ PRINT @ 37,26:1`	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
`11Ø PRINT @ 14: "C,4,2,13,1Ø"`	Command C is sent to the 4094 (address 14) to set the record separator delimiter to CR/LF.
`12Ø INPUT @ 14: E`	Enter the 4094 command error code.
`13Ø PRINT @ 14: "N,Ø"`	Command N is sent to the 4094.
`14Ø INPUT @ 14: E`	Enter the 4094 command error code.
`15Ø DIM N(11)`	Dimension numeric array N to contain the 11 values in a single normalization set.

`16Ø FOR I=1 TO 11`
`17Ø INPUT @ 14: N(I)`
`18Ø PRINT N(I)`
`19Ø NEXT I`
	Lines 160 through 190 enter normalizing data into array N and display them on the computer screen.

`2ØØ INPUT @ 14: E`	Enter the 4094 normalization transmission error code.
`21Ø END`	End of program.

PROGRAM #10

This program illustrates a method to input titles to the 4094. Titles sent to the 4094 must be exactly 32 characters long. To be assured of transmissions containing exactly 32 characters a formatted output statement is usually necessary.

1ØØ PRINT @ 37,26:1	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
11Ø DIM A$(32)	Dimension A$ to contain a 32 character title.
12Ø PRINT "TYPE IN 32 CHARACTER TITLE"	Display message on computer screen.
13Ø INPUT A$	Enter the title into string A$.
14Ø PRINT @ 14: "T,1,1"	Command T is sent to the 4094 (address 14) as a character string.
15Ø INPUT @ 14: E	Enter the 4094 command error code.
16Ø PRINT @ 37,26:Ø	Change the internal computer delimiter to CR. The CR can be eliminated using S in the output format string (line 170).
17Ø PRINT @ 14: USING "32AS": A$	Output title in A$ to the 4094 using a formatted PRINT.
18Ø PRINT @ 37,26:1	Change internal computer delimiter to CR/LF.
19Ø INPUT @ 14: E	Enter the title transmission error code from the 4094.
2ØØ END	End of program.

PROGRAM #11

Plug-in front panel controls can be set via computer interfaces. This program sets the time per point setting to 500 nsec/pt. (model 4562) or 10 usec/pt. (model 4851).

1ØØ PRINT @ 37,26:1	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
11Ø PRINT @ 14: "Z1"	Command Z is sent to the 4094 (address 14) to turn on computer control.
12Ø INPUT @ 14: E	Enter the 4094 command error code.
13Ø PRINT @ 14: "P,3,6144Ø,63488"	Command P is sent to the 4094 to change the time per point setting.
14Ø INPUT @ 14: E	Enter the 4094 command error code.
15Ø STOP	Pause during program execution. Type in "RUN 160" to finish program.
16Ø PRINT @ 14: "ZØ"	Command Z is sent to the 4094 to turn off computer control. The 4094 will go back to front panel time per point settings.
17Ø INPUT @ 14: E	Enter the 4094 command error code.
18Ø END	End of program.

PROGRAM #12

Front panel settings can be read out on the computer interfaces. This program reads the Channel A, plug-in 1 voltage range settings. See Table 13-28 on page 13-68 for the meanings of A1-A4.

```
1ØØ PRINT @ 37,26:1
```

Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.

```
11Ø PRINT @ 14: "C,4,2,13,1Ø"
```

Command C is sent to the 4094 (address 14) to set the record separator delimiter to CR/LF. This will make it possible to enter the plug-in setting into numeric variable P.

```
12Ø INPUT @ 14: E
```

Enter the 4094 command error code.

```
13Ø PRINT @ 14: "P,1"
```

Command P is sent to the 4094.

```
14Ø INPUT @ 14: E,P,E
```

Enter the command error code, the plug-in setting number, and the transmission error code.

```
15Ø DIM B(16)
```

Dimension B to contain the values (1 or 0) of the sixteen bits which form the plug-in setting number.

```
16Ø N=32768
```

Set N equal to 2^{15} (sixteenth bit).

```
17Ø FOR I=16 TO 1 STEP -1
18Ø IF P=>N THEN 21Ø
19Ø B(I)=Ø
2ØØ GO TO 23Ø
21Ø P=P-N
22Ø B(I)=1
23Ø N=N/2
24Ø NEXT I
```

Lines 170 through 240 calculate the value (1 or 0) of the 16-bit word which makes up the plug-in setting number.
B(1) contains bit 2^0, B(2) contains bit 2^1, etc.

Program #12 continued.

25Ø PRINT B(1), B(2), B(3), B(4)	Bits 2^0 through 2^3 are displayed which correspond to A1-A4 on page 13-68.
26Ø END	End of program.

PROGRAM #13

Mainframe front panel controls can be set via computer interfaces. This program allows the horizontal and vertical expansions to be set.

1ØØ PRINT @ 37,26:1	Change the internal computer delimiter to CR/LF to match the default command and error code delimiters used by the 4094.
11Ø PRINT "TYPE IN DESIRED HORIZONTAL EXPANSION"	Display message on computer screen.
12Ø INPUT A	A equals chosen horizontal expansion.
13Ø PRINT @ 14: "Z1"	Command Z is sent to the 4094 to turn on computer control.
14Ø INPUT @ 14: E	Enter the 4094 command error code.
15Ø PRINT @ 14: "M,7,"; A	Command M is sent to 4094 to set horizontal expansion.
16Ø INPUT @ 14: E	Enter the transmission error code.
17Ø PRINT "TYPE IN DESIRED VERTICAL EXPANSION"	Display message on computer screen.
18Ø INPUT B	B equals chosen vertical expansion.
19Ø PRINT @ 14: "M,6,"; B	Command M is sent to 4094 to set vertical expansion.
2ØØ INPUT @ 14: E	Enter the transmission error code.

Program #13 continued.

210 STOP	Pause during program execution. Type "RUN 220" to finish program and cause expansions to revert back to front panel settings.
220 PRINT @ 14: "Z0"	Command Z is sent to the 4094 to turn off computer control.
230 INPUT @ 14: E	Enter the 4094 command error code.
240 END	End of program.

INTRODUCTION

The Standard Pak programs are alphabetically prerecorded on the program diskette. These programs enable the operator to easily perform arithmetic and display manipulations, and are designed for use with the optional F-43 and/or XF-44 Disk Recorders.

Standard Pak programs can be duplicated when the XF-44/2 Disk Recorder is used in conjunction with the *DISKETTE COPY* program. (Refer to the *Dual Disk Recorders* tab, page 11-8.)

➤ IMPORTANT: To enable an easy means by which program results can be compared, (and enable both positive and negative program results to be displayed), waveforms will be automatically repositioned to the center of the screen, when noted in the corresponding program's specifications.

In addition, the POSITION control setting is automatically taken into account when the program is executed. If the waveform is not acquired at screen center, care must be taken not to exceed the ±Full Scale Attenuator setting.

EXAMPLE #14-1

The waveform in Figure #1 was acquired with the ±Volts Full Scale switch in the ±10V position, and with a dc offset present at the input. Therefore, the maximum peak voltage may not exceed 10 volts. Otherwise, the resulting "wrapped-around" waveform displayed in Figure #2 will occur.

Peak voltages can be easily verified by positioning the vertical cursor across the waveform while observing the voltage numerics.

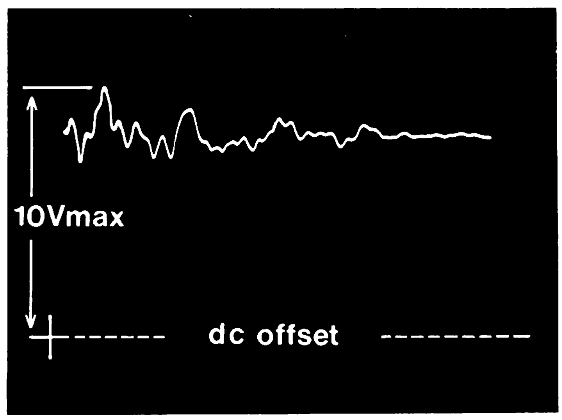


Figure #1

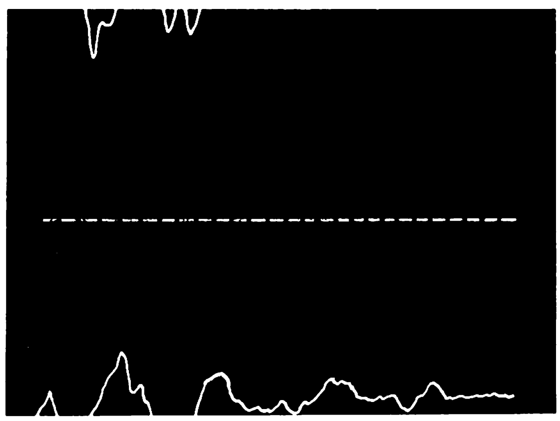


Figure #2

INTRODUCTION

➤IMPORTANT: The following tabulation of programs (and accompanying descriptions) correspond to the Version (1.0) program diskette, only. The Version Identification number can be verified by inspecting the label affixed to the diskette:

PART # 177-160001-1.0

The Version Identification number also appears at the end of the program titled *CATALOG* when that program is selected for display on the Status Line of the display screen, (e.g., Catalog -1.0).

PROGRAM NUMBER	PROGRAM TITLE	PROGRAM NUMBER	PROGRAM TITLE
P01	Catalog - 1.0	P13	Invert
P02	Absolute Value	P14	Maximum
P03	Addition X+Y=Y	P15	Minimum
P04	Area	P16	Multiply
P05	Average Value	P17	Rise Time
P06	Aves., # of Sweeps	P18	RMS
P07	Centering Ø Volts	P19	Scale 0-200%
P08	Differentiation	P20	Smoothing, 3 PT.
P09	Diskette Copy	P21	Subtraction X-Y=Y
P10	Horizontal Shift	P22	Title
P11	Integration	P23	Vertical Shift
P12	Integration (AC)		

INSERTING THE PROGRAM DISKETTE

The Program Diskette is inserted into the Disk Recorder in the same manner as previously described under the *Disk Recorder* tab, page 9-3; and the *Dual Disk Recorder* tab, page 11-5.

► IMPORTANT: The drive's door must be closed within 3 seconds after the diskette has been inserted. If the door is not closed within this time limit, the recorder will not recognize the presence of the diskette.

A properly inserted diskette is indicated by an illuminated numerical display with the letter "P" and program "Number."

If the time delay is exceeded before the door is closed, the diskette must be removed and then reinserted.

PROGRAM MEMORY

The Program Memory, located on the I/O board, stores the selected Program. Once a Program has become resident within the memory, it will remain resident until either the power is removed from the 4094 or a new Program is entered.

NOTE: If desired and unless otherwise noted in the program descriptions, the Program Diskette can be removed from the disk recorder once a program has become resident in the program memory. No operation will be performed if the operator attempts to execute a program and a program is not resident in the memory.

LOADING A PROGRAM INTO MEMORY

● SELECTING AN UNKNOWN PROGRAM

If the desired Program Number is not known, perform the following procedure.

#1. Insert the Program Diskette.
  a. A letter "P" and program "number" appears on the numerical display.

#2. Disk Recorder UP/DOWN buttons: Press until "P01" (Catalog Number) appears on the numerical display.

#3. RECALL button: Press.
  a. The phrase PROGRAM "CATALOG" appears on the status line at the top of the display.
  b. The Catalog Program becomes resident in the Program Memory. <u>The diskette must remain in the disk drive</u>.

#4. FUNCTION switch: PRGM

#5. EXECUTE button: Press.

#6. CURSOR Up/Down button: Press until the desired Program and Program Number appear on the status line. The Program Number will also appear on the numerical display.

#7. EXECUTE button: Press.
  a. The Catalog Program will be exited.

#8. RECALL button: Press.
  a. The selected Program becomes resident in the Program Memory.
  b. If desired, the Program Diskette may now be removed unless otherwise noted in the particular program description.

#9. EXECUTE button: Press.
  a. The Resident Program manipulates the displayed data, either automatically or via step-by-step instructions to the operator.

● SELECTING A KNOWN PROGRAM

If the desired Program Number is known, perform the following procedure.

#1. Insert the Program Diskette into the disk recorder.
   a. A letter "P" and program "number" appears on the numerical display.

#2. Disk Recorder UP/DOWN buttons: Press until the desired Program number appears on the numerical display.

#3. RECALL button: Press.
   a. The selected Program becomes resident in the Program Memory.
   b. If desired, the Program Diskette may now be removed unless otherwise noted under the particular program description.

#4. FUNCTION switch: PRGM

#5. EXECUTE button: Press.
   a. The Resident Program manipulates the displayed data, either automatically or via step-by-step instructions to the operator.

DISK PROGRAM GENERAL OPERATION

Programs stored on the diskette can be used in any NICOLET Model 4094 Digital Oscilloscope which has a built-in (F-43) or external (XF-44) disk recorder. The programs are recalled from the diskette in the same manner as waveform data.

► IMPORTANT: Many programs modify the original data. If it is necessary to maintain the original waveform, it must be stored on a diskette, or elsewhere in the display memory, before executing a program.

In addition, some of the Disk Programs inhibit the use of the Plug-in's and Mainframe's front panel controls. The letters "CC" (Computer Control) will appear under the Status Line when this condition exits, see *Mainframe* tab, page 7-7 for location.

The numerical display indicates the program to be recalled (e.g., P01 indicates Program #1). To execute any program, it is necessary to recall it from the diskette, turn the FUNCTION switch to "PRGM," and then press the EXECUTE button.

Operator intervention required by a program will be requested on the display screen. Such requests must be actioned before the program is allowed to continue. Automatic selection of settings by the 4094 (resulting from previous operator selections or initial program usage) can be altered each time the program is executed.

If the 4094 oscilloscope has a dual disk recorder (XF-44/2), it is possible to keep a program diskette in one disk drive and a data diskette in the other. A single disk recorder (F-43 or XF-44/1) necessitates the removal and insertion of program and data diskettes as required.

Once a program has been recalled from a diskette, it can be used any number of times and will remain resident in the memory until a new program is recalled, or the oscilloscope is turned off. Program execution, initiated by pressing the EXECUTE button, is indicated by the green LED above the EXECUTE button.

Operation of the disk recorder is not possible while a program is being executed. Mixed data groups are not acceptable inputs to any program. Mixed data groups occur when two waveforms on the display were acquired using dissimilar sized fractions of memory. Two examples follow:

#1. One waveform is acquired in ALL. A second waveform is acquired in H2. Processing is attempted in ALL.

#2. One waveform is acquired in H1. A second waveform is acquired in Q3. Processing is attempted in H1.

Mixed data groups can be avoided by processing waveforms using the fraction of memory where they were acquired. Once a mixed data error has occurred, it can be corrected by turning the MEMORY switch to a smaller fraction of memory which contains the necessary waveform.

DESCRIPTION

The CATALOG program contains an alphabetical list of all programs stored on the diskette.

NOTE: The Program Diskette must remain resident in the recorder during execution of the Catalog Program. In addition, the Catalog Program does not automatically recall any selected program from the diskette. Once the desired program is located, it is necessary to exit from the CATALOG program and recall the desired new program into memory.

The up/down CURSOR buttons allow the user to sequentially view the title of each program by observing the Status Line located at the top of the display screen. In addition, each program identification number is displayed on the numerical display, allowing a known program number to be easily selected.

The CATALOG program can be exited at any time by pressing the EXECUTE button.

DESCRIPTION

ABSOLUTE VALUE repositions the selected waveform to screen center, changes the sign of the negative data values to positive, and thus displays the modified waveform.

► IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting point and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if ABSOLUTE VALUE is used repeatedly.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be modified, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

EQUATION

Computed Voltages = | Original Voltages |

Computed Time Base = Original Time Base

DESCRIPTION

ADDITION moves the selected waveforms (X and Y) to the center of the screen, adds them together, and then displays the answer in the memory locations previously occupied by (Y). The resulting time numerics will be those of waveform (Y).

NOTE: Alignment of the X and Y time bases does not occur before addition. See the HORIZONTAL SHIFT program if time base alignment is necessary.

NOTE: The resultant waveform may not differ dramatically in physical size from the original waveform, but the numerics will be correct.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform, (use Auto-center to make this clear).

It is important to remember that each waveform must have been acquired on the same effective voltage range, (voltage range x calibrated probe attenuation).

The time base of the result will be the same as the time base of the original (Y) waveform.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

EQUATION

X_n = Voltages on waveform X
Y_n = Voltages on waveform Y

Computed $Y_n = X_n + Y_n$ (See note 1)

Computed Time Base = Time Base of Waveform Y

(Note 1: Vertical resolution is reduced by a factor of 2.)

DESCRIPTION

AREA moves the selected waveform to the center of the screen, computes the area between the waveform and the horizontal cursor (point by point), and then displays the resulting waveform.

► IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if AREA is used repeatedly.

When AREA is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform. Points lying outside of the chosen starting and ending points are zeroed after the AREA computation has been computed.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be manipulated, (use Autocenter to make the selection clear).

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

The horizontal cursor sets the baseline for the area computation. Note that both positive and negative going values, as measured from the baseline, contribute to the computed waveform. Voltage x time at any point on the computed waveform expresses the area (e.g., millisecond volts) up to that point.

Mathematically, the area computation is similar to integration, but the resulting waveform will be different. The AREA program simplifies area computations by requiring the operator to multiply the two values shown on the screen (time and voltage) rather than the integrated voltage times the TIME PER POINT setting. Compare the AREA equation (reverse side) with that of INTEGRATION.

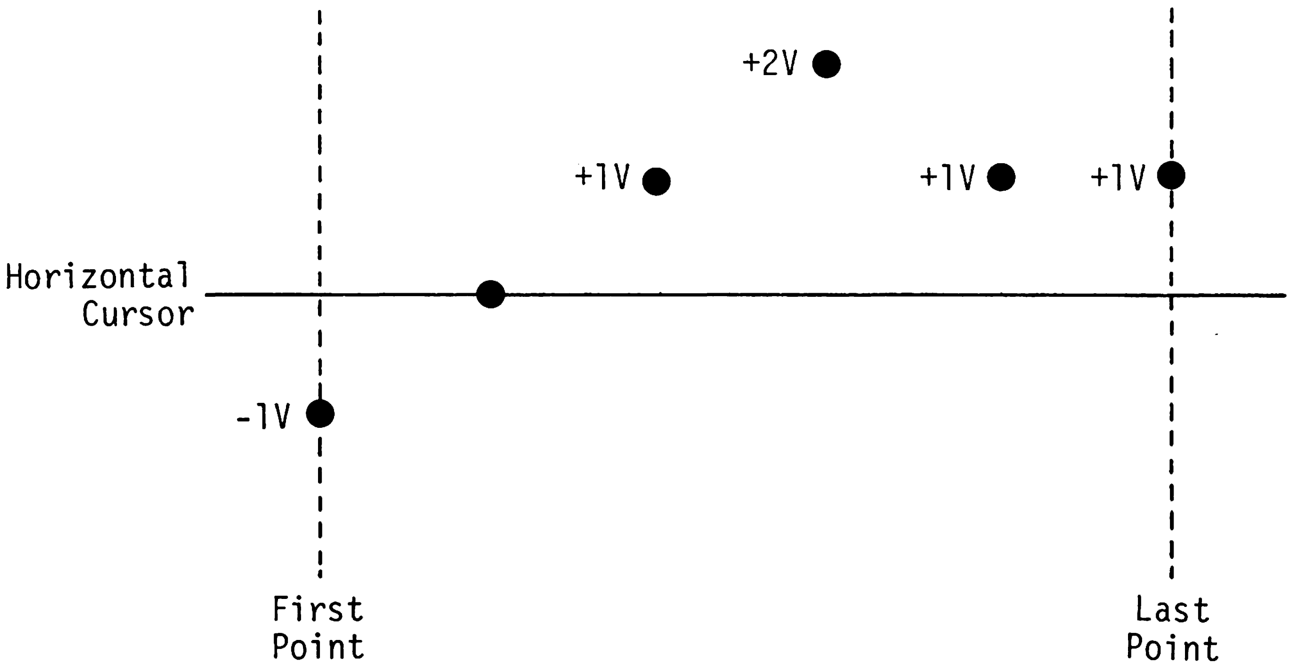
EQUATION

V_1 = Selected First Point

V_k = Selected Last Point

$$\text{Computed } V_n = \frac{V_n + V_{n-1} + V_{n-2} + \cdots\cdots\cdots V_1}{n} \quad \text{where } (1 \leq n \leq k)$$

EXAMPLE



$$\text{Computed Voltage (at third point)} = \frac{1+0-1}{3} = 0\text{V}$$

$$\text{Computed Voltage (at last point)} = \frac{1+1+2+1+0-1}{6} = 0.66\text{V}$$

Computed Time Base = Time Base of Original Waveform

$$\text{Area from First to Last Point} = \left(\frac{-1+0+1+2+1+1}{6}\text{ volts}\right) \text{x} \left(\text{time at last point}\right)$$

DESCRIPTION

AVERAGE VALUE moves the selected waveform to the center of the screen; computes the average voltage between the selected start and ending points and stores this value in the last data point of the waveform (far right side of screen); and then displays the average voltage with the horizontal cursor at the correct level. No other data points are changed.

Positive and negative waveform voltages are taken with respect to the original acquisition zero voltage level. The program requests a starting point and an ending point on the chosen waveform. Each point may be set by correctly positioning the vertical cursor and pressing the EXECUTE button. Selected starting and ending points remain in memory and are automatically recalled if AVERAGE VALUE is used multiple times.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

When AVERAGE VALUE is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

EQUATION

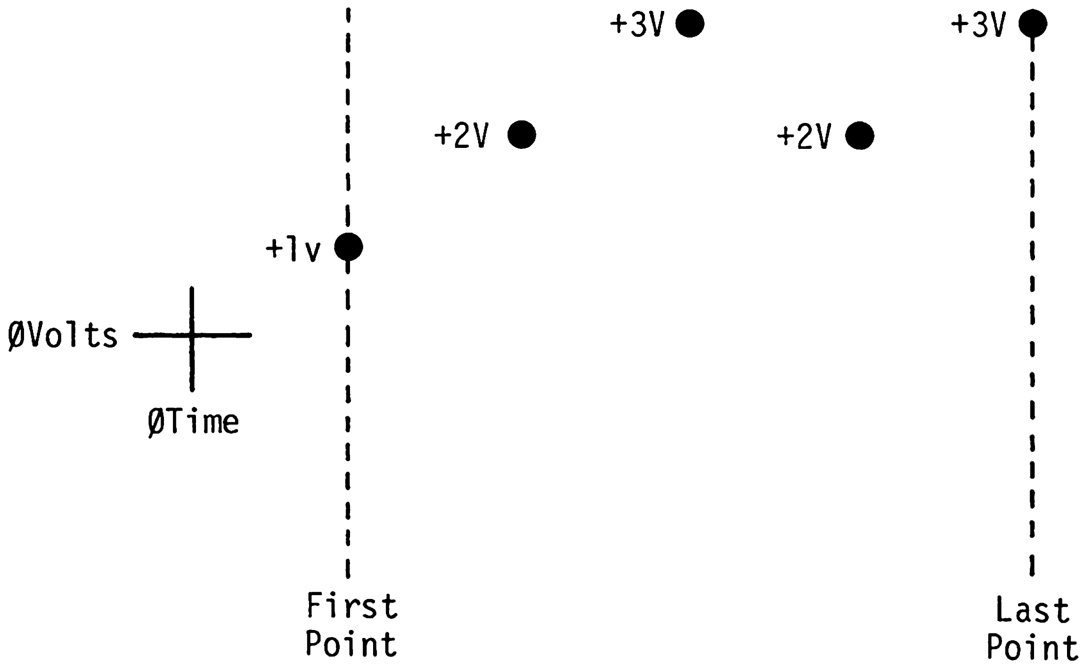
The Computed Average Voltage is stored in the very last waveform address.

V_1 = Selected First Point

V_k = Selected Last Point

$$\text{Computed Average Voltage} = \frac{\sum_{n=1}^{k} V_n}{k}$$

EXAMPLE



$$\text{Average Voltage} = \frac{1+2+3+2+3}{5} \text{ Volts}$$

Time Base = Original Waveform's Time Base

DESCRIPTION

AVES., # OF SWEEPS is used in conjunction with the plug-in sweep averaging function switch labeled AVERAGE. When executed, the program displays the number of sweeps taken by the plug-in.

If two plug-ins are in use, the displayed count reflects the number of sweeps for the waveform on which the vertical cursor is resting, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/ Channel A).

When a plug-in is put into HOLD LAST, the final count is held. Placing the plug-in back into LIVE will reset the count since LIVE initializes the plug-in and allows new incoming signals to be averaged.

Each plug-in (not each channel) operates independently and can be started and stopped without affecting the count for the other plug-in. To exit the program, press EXECUTE.

NOTE: Exiting the program does not affect the sweep counter.

SPECIFICATIONS

a. Maximum allowable count is 21,800. If a larger count is attempted, the resulting waveform will deviate from what would be predicted since the sweep count is an important factor in the averaging algorithm.

DESCRIPTION

BIT-MASKING modifies the selected waveform to illustrate reduction of vertical (voltage) resolution.

The primary use of this program is to provide a visual appreciation for resolution expressed in terms of binary bits. The connection between digital resolution and the "real world" can best be understood by using BIT-MASKING on actual waveforms.

➤ IMPORTANT: The resultant waveform replaces the original waveform in the display memory.

This program prompts the user to select the new vertical resolution, (in bits). The selection is made by use of the Up/Down cursor control buttons.

The user is also asked to place the vertical cursor on the waveform to be converted. If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be manipulated.

SPECIFICATIONS
a. Mainframe must be in YT.
b. One waveform may be processed at a time.

DESCRIPTION

CENTERING, Ø VOLTS moves the zero voltage level of all displayed waveforms to the center of the screen. Centering takes place as soon as the EXECUTE button is pressed.

► IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The primary use of this program is to move captured waveforms to the center of the screen so that visual comparisons can be made on waveforms which were acquired with different vertical positioning. It may also be used to make X-Y recorder and photographic records more pleasing to the eye.

The voltage and time values remain unchanged by this procedure.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. All waveforms shown on the screen are processed at the same time. To move only one waveform, the MEMORY switch must be used to show only the selected waveform on the screen.

DESCRIPTION

DATA MOVE moves the selected waveform to a new vertical position on the display. The small trigger cursor (zero time, zero volts indicator) is not moved in this process.

➤ IMPORTANT: The resultant waveform replaces the original waveform in the display memory.

This program is equivalent to the front panel function DATA MOVE, except one waveform out of several displayed waveforms can be manipulated.

NOTE: DATA MOVE is different from the VERTICAL SHIFT program. DATA MOVE causes voltage values to change while VERTICAL SHIFT merely repositions the waveform on the display without changing voltages.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if DATA MOVE is used repeatedly.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

When DATA MOVE is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform. Points outside of the chosen starting and ending points are left untouched by the operation.

If multiple waveforms are displayed, only the selected waveform will be manipulated, (use the Autocenter mode to make the selection clear).

This program will also request a reference point on the waveform and a new level. The reference point is selected by the vertical cursor and the new level with the horizontal cursor. During program execution, the reference point is shifted to coincide with the new level.

Excessive movement of a waveform, up or down, causes it to "wrap around" to the opposite side of the screen. The waveform can be recovered by an DATA MOVING in the opposite direction.

DESCRIPTION

DIFFERENTIATION computes point to point voltage differentials in a waveform and displays the resulting waveform.

➤IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting point and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory are are automatically recalled if DIFFERENTIATION is used repeatedly.

When DIFFERENTIATION is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform. Points lying outside of the chosen starting and ending points are zeroed after DIFFERENTIATION has been completed.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be differentiated, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

It is necessary to use vertical expansion to view the differentiated signal since each computed point rests at a voltage representing the difference between two points on the original waveform. In addition, to avoid overflow, vertical resolution is further reduced by a factor of two. Because of this, the computed difference voltages are generally quite small and the final waveform has a small amplitude.

High frequency noise is enhanced by differentiation since it has relatively large point-to-point voltage changes. Use of the 3 PT. SMOOTHING program is recommended before differentiation to reduce the influence of signal noise.

The DIFFERENTIATION equation is located on the reverse of this page.

EQUATION

V_1 = Selected First Point

V_k = Selected Last Point

Computed $V_1 = 0$ (by definition)

Computed $V_n = V_n - V_{n-1}$

where: $(2 \leq n \leq k)$

DESCRIPTION

DISKETTE COPY makes possible diskette copying in XF44/2 Dual Disk Recorders. The disk recorder on the left should contain the "master" diskette. The right hand disk recorder should contain the "copy" diskette.

NOTE: The "master" diskette should have a protect tab on it whereas the diskette to be recorded must not have a protect tab in place. If a protect tab is found, the numerical display will show "Pro" and the DISKETTE COPY program will be aborted. The title DISKETTE COPY will not be visible after the abort unless the FUNCTION switch is rotated away from "PRGM" and then back again. Absence of the title when the EXECUTE LED is off indicates that the transfer of data has not taken place.

The transfer of data from the "master" diskette to the "copy" diskette takes place even if individual records are protected on the "copy" diskette.

SPECIFICATIONS

a. Copying is limited to 4094 data and program diskettes.

b. Copy time for 4094 data diskettes is approximately 6 minutes.

c. Copy time for 4094 Program diskettes varies from 3 to 6 minutes depending on the number and length of the programs stored on the master diskette.

Standard program diskettes are copyable. Attempts to copy other Program diskettes will result in the message: ORIGINAL DISK IS COPY PROTECTED.

Copy errors will give the message: "ABORT" - VERIFY ERROR on the display screen's status line. All other errors are indicated on the numerical display.

The 4094's plug-in and mainframe remain operational during a diskette copy.

DESCRIPTION

FREQ = 1/T calculates the frequency (in Hz) of any waveform based on the user selected period.

The program prompts the user to select starting and ending points on the chosen waveform. Selection is made by use of the vertical cursor. Starting and ending points must be chosen which specify one cycle of the displayed waveform. The calculated frequency will be equal to the inverse of the waveform period specified by the starting and ending points.

For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if FREQ = 1/T is used repeatedly. When FREQ = 1/T is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

Since the frequency calculation is based directly upon the time spacing between selected starting and ending points, correct cursor placement is critical. If precise frequencies are desired, it is advisable to use horizontal and vertical expansion when locating the starting and ending points.

SPECIFICATIONS
a. Mainframe must be in YT.
b. One waveform may be processed at a time.

EQUATION

T1 = Time at chosen starting point.
T2 = Time at chosen ending point.

$$\text{Calculated Frequency} = \frac{1}{T2 - T1}$$

DESCRIPTION

HORIZONTAL SHIFT is used to move a captured waveform in either a left or right direction along the time axis. The time value associated with each point is not changed in this process. This is equivalent to changing the trigger location before waveform acquisition.

➤IMPORTANT: Portions of a waveform shifted off the screen are lost and can not be recovered by shifting the waveform back. The corresponding data points will be represented by a flat line on the left or right side of the screen.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if HORIZONTAL SHIFT is used repeatedly.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be shifted, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

The location of the starting point will be moved to the location of the ending point upon program execution. All other points on the waveform are shifted accordingly.

DESCRIPTION

INTEGRATE X*Y moves the selected X and Y waveforms to the center of the screen, multiplies them together, displays the result along with the original X waveform, and then integrates the resultant waveform between the chosen limits.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

► IMPORTANT: The original Y waveform is replaced in the memory by the multiplication result. If a single waveform is used for both X and Y, the waveform will effectively be squared and the result replaces the original waveform in the memory. The integrated waveform is replaced in the display memory by the resultant waveform.

The program prompts the user to select X and Y waveforms for multiplication. Each waveform is selected by positioning the vertical cursor on the waveform, (use Autocenter to help make the selection clear). The entire X and Y waveforms will under go multiplication. If the same waveform is used for X and Y, then it will be multiplied by itself.

After the multiplication step is complete, the program requests the selection of starting and ending points for integration, (usually on the waveform resulting from the multiplication operation). The program also requests the selection of a base line using the horizontal cursor. The base line will be used as "zero volts" in the integration procedure. Positioning the base line to the actual zero voltage location, (equivalent to ground potential during waveform acquisition) is easily accomplished by momentarily switching the Autocenter switch to the ZERO position. During integration, the waveform will be moved so that the selected baseline lies at the center of the screen.

Points outside of the chosen starting and ending points are zeroed after integration is completed. The final integrated waveform is scaled to fit on the display screen and the voltage numerics are modified accordingly.

A computed result which lies along a slope merely indicates that a constant voltage was systematically added across the entire waveform. Careful positioning of the base line will be necessary if DC voltage offsets are to be avoided. Even very small voltage offsets will greatly affect the final result. It should be noted that duty cycle variations and the chosen starting and ending points can dramatically change the final result.

The voltage prefixes are as follows:

10^{-6}	= μ (micro)	10^{12}	= T (tera)
10^{-3}	= m (milli)	10^{15}	= P (pata)
10^{0}	= blank	10^{18}	= E (exa)
10^{3}	= k (kilo)	10^{21}	= ?
10^{6}	= M (mega)	10^{24}	= !
10^{9}	= G (giga)		

EQUATIONS

- MULTIPLICATION STEP

X1 X2 X3 X4 X5 → etc.

Y1 Y2 Y3 Y4 Y5 → etc.

New Y1 = X1 x Y1,
New Y2 = X2 x Y2,
New Y3 = X3 x Y3, etc.

- INTEGRATION STEP:

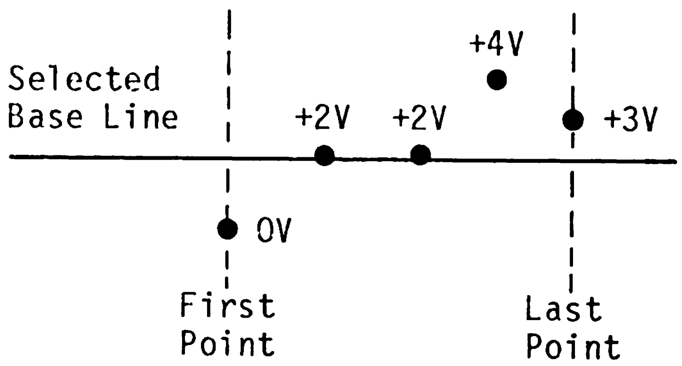
V1 = Selected First Point
Vk = Selected Last Point

Computed Vn = Vn + Vn-1 +Vn-2 + .. V1
where $(1 \leq n \leq k)$

NOTE: All voltages are measured with reference to the selected base line.

Time base, result = Time base, original

- INTEGRATION EXAMPLE



Computed Volts at third point equals
-2V + 0V + 0V = -2V

Computed Volts at last point equals
-2V + 0V + 0V + 2V + 1V = 1V

DESCRIPTION

INTEGRATION moves the selected waveform to the center of the screen, computes the integrated waveform, and displays the result.

►IMPORTANT: The resultant waveform replaces the original waveform in memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if INTEGRATION is used repeatedly.

When INTEGRATION is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform. Points lying outside of the chosen starting and ending points are zeroed after INTEGRATION has been completed. The final integrated waveform is scaled to fit on the screen and the voltage numerics reflect this change. It should be noted that duty cycle variations, DC voltage offsets, and the chosen starting and ending points will affect the integrated result.

NOTE: Multiple integrations are permissible.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

A computed result lying along a slope merely indicates that a constant voltage was systematically added across the entire waveform. If DC offsets were not intended in the original waveform, the INTEGRATION (AC) program should be used.

The prefixes used when indicating voltages are as follows:

10^{-6} = μ (micro)
10^{-3} = m (milli)
10^{0} = blank
10^{3} = K (kilo)
10^{6} = M (mega)
10^{9} = G (giga)
10^{12} = T (tera)
10^{15} = P (pata)
10^{18} = E (exa)
10^{21} = ?
10^{24} = !

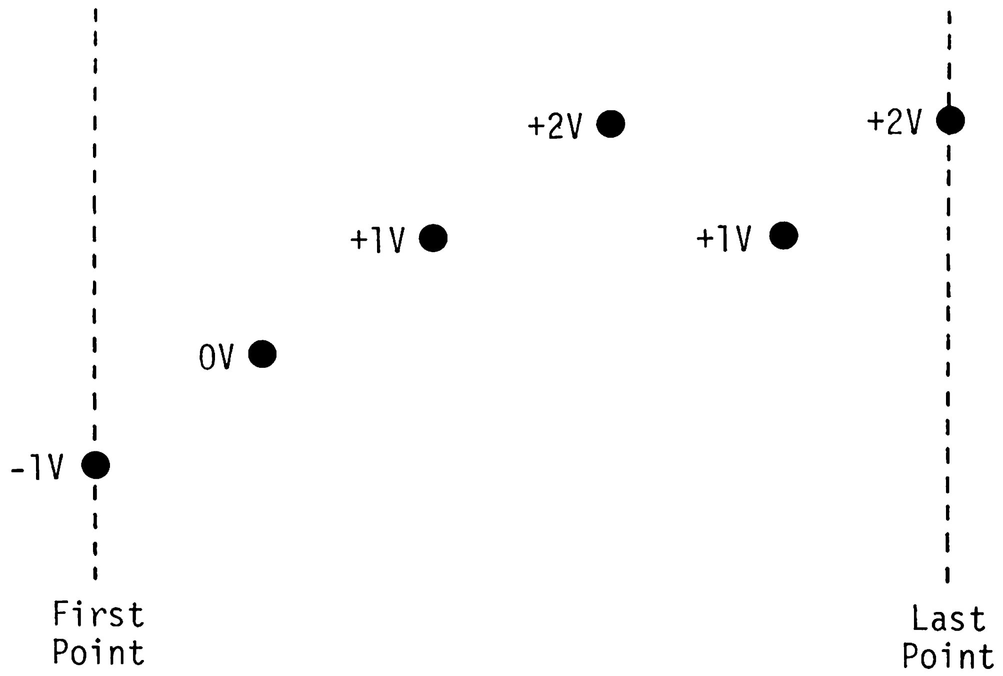
EQUATION

V_1 = Selected First Point
V_k = Selected Last Point

Computed $V_n = V_n + V_{n-1} + V_{n-2} + \cdots\cdots\cdots V_1$ where $(1 \leq n \leq k)$

Time Base Of Result = Time Base Of Original

EXAMPLE



Computed voltage (at third point) = 1+0-1 = 0V
Computed voltage (at last point) = 2+1+2+1+0-1 = 5V

DESCRIPTION

INTEGRATION (AC) is very similar to INTEGRATION. The only difference is that the average voltage is computed between the starting and ending points and subtracted from every point. This is used to remove unintentional DC voltage offsets which may exist on an acquired waveform.

► IMPORTANT: The resultant waveform replaces the original waveform in the memory.

For the computed average to be equal to the DC voltage offset, it is essential that an integral number of cycles lie between the starting and ending points. DC offsets which vary over the sweep time are not successfully removed. Refer to the INTEGRATION program for the operation specifics.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform can be processed at a time.

EQUATION

V_1 = Selected First Point

V_k = Selected Last Point

$$\text{Computed } V_n = \left[V_n - \frac{\sum_{n=1}^{k} V_n}{k}\right] + \left[V_{n-1} - \frac{\sum_{n=1}^{k} V_n}{k}\right] + \left[V_{n-2} - \frac{\sum_{n=1}^{k} V_n}{k}\right] + \cdots \left[V_1 - \frac{\sum_{n=1}^{k} V_n}{k}\right]$$

where $(1 \leq n \leq k)$

DESCRIPTION

INVERT moves the selected waveform to the center of the screen, multiplies each data point value by (-1), and displays the result.

➤IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if INVERT is used repeatedly.

When INVERT is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be inverted, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

The program INVERT is different than the INVERT present on the FUNCTION switch. Program INVERT rotates the waveform about zero volts (ground) while FUNCTION switch INVERT rotates the waveform about screen center (digital zero) which may or may not coincide with zero volts.

EQUATION

V_1 = Selected First Point

V_k = Selected Last Point

Computed $V_n = -1(V_n)$ where $(1 \leq n \leq k)$

DESCRIPTION

MAXIMUM scans a waveform for the maximum positive (or minimum negative) voltage and moves the horizontal and vertical cursors to the selected data point. The maximum positive voltage is indicated in the voltage numerics after the maximum has been located. If a single waveform has more than one point at the maximum voltage, only the first one will be shown.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if MAXIMUM is used repeatedly.

When MAXIMUM is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

DESCRIPTION

MINIMUM scans a waveform for the minimum positive (or maximum negative) voltage and moves the horizontal and vertical cursors to the selected data point. The minimum positive voltage is indicated in the voltage numerics after the minimum has been located. If a single waveform has more than one point at the minimum voltage, only the last one will be shown.

The program prompts the user to select a starting point and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, the selected starting and ending points remain in memory if MINIMUM is used repeatedly.

When MINIMUM is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

DESCRIPTION

MULTIPLY moves the selected waveforms (X and Y) to the center of the screen, multiplies them together, and displays the result along with the original waveforms. The result is stored in both the second half of the original X and the second half of the original Y data point locations. Half of the original X and Y data points remain untouched.

The primary reason for storing the resulting waveform as described is so that original vs. results can be compared. (e.g., voltage x current = power; voltage vs. power; and current vs. power comparisons can be made.)

The original X and Y waveforms may be acquired on any voltage range or time base. The time base of the result will vary depending on which half is viewed. The half associated with X will have the X time base. The half associated with Y will have the Y time base. Note that the time resolution of the original and resultant waveforms is reduced since each waveform has given up half of the acquired data points.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

EQUATION

X_n = Voltages on Waveform (X)
Y_n = Voltages on Waveform (Y)
Original Waveforms =

$X_1\ Y_1\ X_2\ Y_2\ X_3\ Y_3\ X_4\ Y_4\ X_5\ Y_5 \rightarrow$ etc.

Calculated $X_2 = Y_2 = (X_1) \times (Y_1)$
Calculated $X_4 = Y_4 = (X_3) \times (Y_3)$
Calculated $X_6 = Y_6 = (X_5) \times (Y_5)$

DESCRIPTION

MULTIPLY-CONSTANT moves the selected waveform to the center of the screen, multiplies it by a constant number, and displays the resulting waveform.

➤ IMPORTANT: The resultant waveform replaces the original waveform in the display memory.

A common use for this program is to modify experimental results to reflect a transducer scaling factor, (e.g., 3.142 psi = 1 volt).

NOTE: MULTIPLY-CONSTANT is different from SCALE 0-200% in that the scale factor is numerically selected rather than visually selected.

The program prompts the user to select the numerical multiplier by use of the Up/Down and Left/Right cursor control buttons. The digit being selected is marked by an underline. After the entire number is chosen, press the EXECUTE button.

The program also requests the selection of starting and ending points on the waveform to be multiplied. Selection is made by use of the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if MULTIPLY-CONSTANT is used repeatedly.

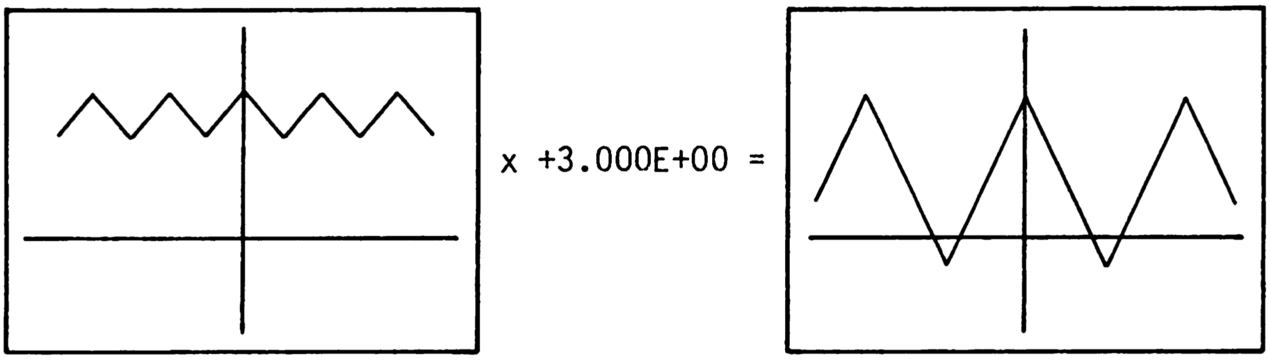
SPECIFICATIONS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.
c. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

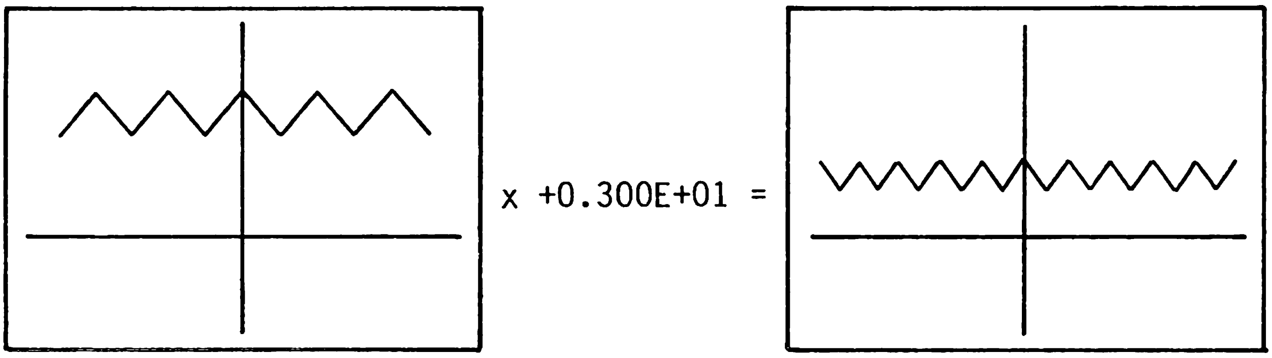
When MULTIPLY-CONSTANT is first recalled, the starting and ending points are automatically chosen to be the first and last points on the displayed waveform. If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed, (use Autocenter to make the selection clear).

Before a multiplication factor is entered, it is important to understand how the display will be affected by the chosen factor. The actual size of the displayed waveform is multiplied by the four digit number selected. The voltage numerics are affected by both the four digit multiplier and its exponent.

- EXAMPLE



— Example (A) —



— Example (B) —

From the above example, it can be seen that 3.000E+00 is NOT equivalent to 0.300E+01. In example (A), the display size is multiplied by 3.000 while in example (B) the multipler is 0.300. In either case the voltage "numerics" will be correct even though the displays are of different sizes.

If the four digit multiplier is made too large, the waveform will be clipped at the top or bottom of the screen. Portions of data that have been clipped cannot be retrieved by further multiplications.

DESCRIPTION

MULTIPLY X*Y=Y moves the selected waveforms (X and Y) to the center of the screen, multiplies them together, and displays the result in the memory locations originally occupied by waveform Y.

➤ IMPORTANT: The resultant waveform replaces the original Y waveform in the memory.

NOTE: MULTIPLY X*Y=Y differs from MULTIPLY in that the resulting waveform contains the same horizontal (time axis) resolution as the original waveforms. This feature means, however, that one of the original waveforms must be destroyed.

The program prompts the user to select X and Y waveforms for multiplication. Each waveform is selected by positioning the vertical cursor on the waveform, (use Autocenter to help make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/ Channel A).

> SPECIFICATIONS
>
> a. Mainframe must be in YT.
>
> b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

EQUATION

X1 X2 X3 X4 X5 → etc.

Y1 Y2 Y3 Y4 Y5 → etc.

Calculated Y1 = X1 x Y1,
Calculated Y2 = X2 x Y2,
Calculated Y3 = X3 x Y3, etc.

DESCRIPTION

PLUG-IN DELAY provides a simple procedure to set multiple channels to the same trigger locations in time. This program is particularly useful when trigger locations must be the same in three or four channel measurements.

The program prompts the user to select the trigger location for Plug-in #1/Channel A by using any of the trigger set-up procedures described in the PLUG-INS section of the 4094 OPERATION manual.

NOTE: Plug-in #1 is located in the left bay of the oscilloscope.

After the trigger is located for channel 1A, press EXECUTE to move the triggers of all other active channels to the same point.

➤ IMPORTANT: Each channel that is to be set for a delay must be turned on before pressing the EXECUTE button.

In addition, if the 4094 is configured with two plug-ins and both plug-ins are to be set for a delay, an equal number of channels for each plug-in must be activated in order to set equal delays.

For example, if one channel is activated on each plug-in, the delay for each plug-in will be equal. Likewise, if both plug-ins have two activated channels, the delay will be equal.

However, if three channels are activated, the plug-in with the single activated channel will be set to twice the delay of the plug-in with two activated channels. This is because the plug-in with the single channel has twice the number of data points to be acquired for display than the plug-in with two activated channels.

DESCRIPTION

RISE TIME calculates the time and voltage difference between two points on the rising or falling slope of a waveform.

➤IMPORTANT: Execution of this program destroys the original time and voltage numerics.

The program prompts the user to select a starting and ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in the memory and are automatically recalled if RISE TIME is used repeatedly.

When RISE TIME is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform. Typically, the chosen points should lie on a peak and a trough on each side of the slope in question.

RISE TIME calculates 10% and 90% of the voltage difference between the chosen data points. Upon program execution, the plug-in crosshair and the cursor are moved to points near the calculated 10% and 90% values.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

The actual points picked are:

#1. Rise time calculation.
   a. Crosshair at first point greater than 10%.
   b. Cursors at first point greater than 90%.

#2. Fall time calculation.
   a. Crosshair at first point less than 10%.
   b. Cursors at first point less than 90%.

The time and voltage between the 10% and 90% data values is immediately available on the numeric display after completion of RISE TIME. The accuracy of RISE TIME is dependent on the time resolution of the data and signal to noise ratio. Ideally, calculations should be done in areas with plenty of data points and low noise.

DESCRIPTION

RMS moves the selected waveform to the center of the screen; computes the Root Mean Square (RMS) between the selected start and ending points and stores this value in the last data point of the waveform (far right side of screen); and then displays the average voltage with the horizontal cursor at the correct level. No other data points are changed.

Note: Positive and negative waveform voltages are taken with respect to the original acquisition zero voltage level.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during muliple operations, selected starting and ending points remain in memory and are automatically recalled if RMS is used repeatedly.

When RMS is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed,

> SPECIFICATIONS
>
> a. Mainframe must be in YT.
>
> b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.
>
> c. One waveform may be processed at a time.

(use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

The calculated RMS voltage is dependent on all characteristics of the waveform including the DC offset, symmetry, duty cycle, and number of cycles chosen, (integral number or non-integral number).

EQUATION

V_1 = Selected First Point

V_k = Selected Last Point

$$\text{Computed } V_{RMS} = \sqrt{\frac{\sum_{n=1}^{k} (V_n)^2}{k}}$$

DESCRIPTION

SCALE 0-200% moves the selected waveform to the center of the screen and increases/decreases the displayed waveform's size according to the levels set by the user. This action effectively allows waveforms to be multiplied/divided by a constant.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if SCALE 0-200% is used repeatedly.

When SCALE 0-200% is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

The program will also request selection of a reference point and a new level. These are set by correctly positioning the vertical and horizontal cursors, (Autocenter must be switched off). A reference point chosen outside of the selected start/end range can still be used to scale, but it will not be affected by the scaling action.

NOTES:

#1. If a scaling factor of more than 200% is requested, a scale factor of 200% is used and the reference point voltage is doubled.

#2. If the reference point and the new level are of opposite sign, the scaling factor will be calculated on the absolute value of the two voltages. This permits the reference point to be scaled up/down but it will not be moved to the new level specified since the sign is incorrect.

DESCRIPTION

3 PT. SMOOTHING reduces the high frequency noise present on an acquired waveform by doing a weighted running average of the selected data points.

► IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if 3 PT. SMOOTHING is used repeatedly.

When 3 PT. SMOOTHING is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be smoothed, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS
a. Mainframe must be in YT.
b. One waveform may be processed at a time.

EQUATION

V_1 = Selected First Point

V_k = Selected Last Point

$$\text{Computed } V_n = \frac{V_{n-1}}{4} + \frac{V_n}{2} + \frac{V_{n+1}}{4}$$

Where $(2 \leq n \leq k-1)$

Computed V_1 = Original V_1

Computed V_k = Original V_k

DESCRIPTION

5 PT. SMOOTHING reduces the high frequency noise present on an acquired waveform by performing a weighted running average of the selected data points.

➤ IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select starting and ending points on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if 5 PT. SMOOTHING is used repeatedly.

When 5 PT. SMOOTHING is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be smoothed, (use Autocenter to make the selection clear). The Plug-in/ Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

EQUATION

V1 = Selected First Point
Vk = Selected Last Point

Computed Vn =

$$\frac{Vn-2}{8} + \frac{Vn-1}{4} + \frac{Vn}{4} + \frac{Vn+1}{4} + \frac{Vn+2}{8}$$

Where $(3 \leq n \leq k-2)$

Computed V1, V2, Vk-1, Vk =
Original V1, V2, Vk-1, Vk

DESCRIPTION

SUBTRACTION moves the selected waveforms (X and Y) to the center of the screen, subtracts them, and then displays the answer in the memory locations previously occupied by (Y). The resulting time numerics will be those of waveform (Y).

NOTE: Alignment of the X and Y time bases does not occur before subtraction. See the HORIZONTAL SHIFT program if time base alignment is necessary.

NOTE: The resultant waveform may not differ dramatically in physical size from the original waveform, but the numerics will be correct.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform, (use Autocenter to make this clear).

It is important to remember that each waveform must have been acquired on the same effective voltage range, (voltage range x calibrated probe attenuation).

The time base of the result will be the same as the time base of the original (Y) waveform.

> SPECIFICATIONS
>
> a. Mainframe must be in YT.
>
> b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

The SUBTRACTION program is substantially different from SUB position on the FUNCTION switch. The SUBTRACTION program manipulates waveforms with respect to zero voltage as shown by the crosshair location. The FUNCTION switch position "SUB" manipulates waveforms with respect to the center of the display screen (digital zero) which may or may not coincide with zero voltage.

EQUATION

X_n = Voltages on waveform X

Y_n = Voltages on waveform Y

Computed $Y_n = X_n - Y_n$ (See note 1)

Computed Time Base = Time Base of Waveform Y

(Note 1: Vertical resolution is reduced by a factor of 2.)

DESCRIPTION

TITLE allows the user to create up to four unique titles (T1, T2, T3, and T4) and store them in the display memory locations (Q1, Q2, Q3, and Q4, respectively). The titles can contain up to 32 characters each and will appear on the Status Line at the top of the display screen.

Titles written on the Status Line are stored into memory after exiting from the program. In addition, the titles saved in memory can also be stored on diskettes and be recalled along with normal waveform data. The titles can also be included with digital plots of waveform data.

Titles are written by manipulating the horizontal and vertical CURSOR control buttons. The left/right buttons position the vertical cursor to the next character location. The up/down buttons allow character selection. Holding the AUTOCENTER switch in the spring loaded "ZERO" position while moving the cursor allows rapid erasing of existing titles.

The completed title can be moved, as a unit, left/right by switching into DATA MOVE (while still executing the TITLE program) and manipulating the left/right CURSOR buttons. Care should be taken, however, since titles moved off the display to the left or right are lost from memory.

After completion of a title, use the MEMORY switch to determine which title locations are to be updated with the new title before exiting the program via the EXECUTE button, Table #1).

MEMORY POSITION AT EXIT	NEW TITLE LOCATION
ALL	T1,T2,T3,T4
H1	T1,T3
H2	T2,T4
Q1	T1
Q2	T2
Q3	T3
Q4	T4

Table #1

The completed title can be seen when the FUNCTION switch is moved away from "PRGM." The relationships between title location in memory and where the title can be viewed is shown in Table #2, located on the reverse of this page.

TITLE	MEMORY POSITION WHERE TITLE IS VISIBLE
T1	ALL, H1, Q1
T2	H2, Q2
T3	Q3
T4	Q4

Table #2

Titles saved in memory are not lost by the actions required to take in new waveforms. Titles can be destroyed only by:

a. Purposely erasing them, or
b. Turning off the oscilloscope, or
c. Recalling new ones from a diskette.

It is possible, therefore, to title experiments, dates, etc., and have the title appear with all new waveforms without the necessity of rewriting them each time. Titles will be stored on the diskette if the FUNCTION switch is not in the "PRGM" position; otherwise blanks will be stored in the title position on the diskette.

When storing titles and waveforms on the disk recorder, all titles (even those not visible) will accompany their corresponding waveforms. For example; Q1, Q2, Q3, and Q4 each contain a unique waveform and title. All four waveforms and titles can be stored on a single diskette record if the MEMORY switch is placed to the "ALL" position during a diskette recording.

● TRANSFERRING TITLES

Since the title location is determined by the position of the MEMORY switch when exiting the program, it is possible to transfer a title (either verbatim or modified) from one memory location to another.

EXAMPLE

The title "EXPERIMENT #1" is stored in Q1 and it is desired to title a waveform in Q2 as "EXPERIMENT #2." To accomplish this:

#1. MEMORY switch: Q1

#2. Enter TITLE program.

#3. Alter "EXPERIMENT #1," displayed on the Status Line, to read "EXPERIMENT #2."

#4. MEMORY switch: Q2

#5. EXECUTE button: Press.

  a. The waveform stored in Q2 is now titled "EXPERIMENT #2."

DESCRIPTION

VERTICAL SHIFT is used to move a captured waveform either up or down on the display screen. The voltage associated with each data point is not changed in this process. This is equivalent to changing the POSITION control before waveform acquisition.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

Portions of a waveform not chosen to be shifted will have voltage values changed since the zero voltage location has been shifted along with the shifted portion of the waveform.

The program prompts the user to select a starting and ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if VERTICAL SHIFT is used repeatedly.

When VERTICAL SHIFT is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be shifted, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

The program will also request a reference point on the waveform and a new level. These are set by positioning the vertical and horizontal cursors, (Autocenter must be switched off).

The selected reference point is shifted to coincide with the new level during program execution. A reference point lying outside of the chosen starting and ending points is acceptable, but will not be shifted.

Excessive movement of a waveform, up or down, will cause it to "wrap around" and appear on the opposite side of the screen. A waveform which has wrapped around can be recovered by an additional vertical shift in the opposite direction.

INTRODUCTION

The following special procedures have been included to serve as guidelines when performing "critical" measurements, or measurements requiring special considerations.

The preceding pages of this manual should be read before applying these discussions.

➤ IMPORTANT: The term "Hold mode" will be used in the following discussions to signify that the Plug-in is in the Hold Last mode. (The LIVE and HOLD NEXT LEDs are off and only the HOLD LAST LED is illuminated.)

SETTING UP FOR SLOW SWEEPS

The basic operation of the oscilloscope remains unchanged regardless of the time per point selection.

However, certain precautions in the setup should be observed when very slow sweeps and/or long delays are involved because there is no immediate visual feedback to indicate that the signal is being successfully captured.

Therefore, whenever possible, simulate the expected signal and execute several practice measurements to ensure the controls have been properly positioned.

NOTE: A faster time per point can be selected to expedite the practice sweeps. However, be sure to return the TIME PER POINT switch to the required position before executing the final measurement.

IMPORTANT: Always press the HOLD LAST button after the sweep has been triggered. This will help guard against an accidental loss of data upon the completion of the sweep.

The approximate sweep times are tabulated in Table 8-4, page 8-17 under the *Plug-ins* tab.

TERMINATING SLOW SWEEPS

To terminate a slow sweep, momentarily press the LIVE button while, at the same time, holding in the HOLD LAST button. The Plug-in will enter into the Hold mode, indicating that the sweep has been successfully terminated.

NOTE: Do not select a faster time per point to expedite sweep completion. This may cause the oscilloscope to record the wrong normalization and the time numerics will be in error.

CAPTURING SINGLE EVENTS

A single event can be captured by pressing the LIVE button and then the HOLD NEXT button (before a valid trigger is generated), This action will allow only one sweep to be triggered. The Plug-in will enter the Hold mode upon the completion of the single sweep, retaining the collected data in the memory.

When possible, simulate the expected signal and execute several practice measurements to ensure the controls have been properly positioned.

➤ IMPORTANT: Always press the HOLD NEXT button - BEFORE - a valid trigger is received. Otherwise, a second sweep will replace the data collected during the first sweep.

MULTIPLE TRIGGER MODES

The Normal, Cursor and Delayed trigger modes can be mixed or matched when multiple channels are acquiring data. See *Plug-ins* tab, page 8-38 for detailed descriptions.

● SINGLE PLUG-IN OPERATION

A single trigger applied to either channel A or B, or the EXT input BNC will initiate a sweep for both channels. However, the only time that both channels will simultaneously acquire data for display is when:

#1. Both channels are operating in the Normal trigger mode, or

#2. Both channels are operating in the Cursor (or Delayed) trigger modes and identical delays have been selected.

Therefore, when viewing displays acquired with <u>different</u> trigger modes (or identical trigger modes with <u>different</u> delays), it is important to remember that the displayed data groups are, with respect to each other, displaced in time.

Figures 15-1 thru 15-6 illustrate the relationships of the displayed data groups for each one of the possible combinations of trigger modes.

NOTE: The term (T_0), in the following figures, represents the position of the Plug-in's trigger cursor, or "Time Zero." Placing the Mainframe's vertical cursor at the extreme left-hand edge of the screen and selecting channel A or B by consecutive taps on the left/right cursor buttons will result in a numerical display of the repsective channel delay indicated in the figures.

In addition, assume that the following examples of signals were acquired while in the External trigger mode.

••Matching Trigger Modes

NORMAL/NORMAL

Extreme left of screen always corresponds to the (T_0) origin for both channels. The (T_0) origin corresponds to the time at which acquisition began on each channel.

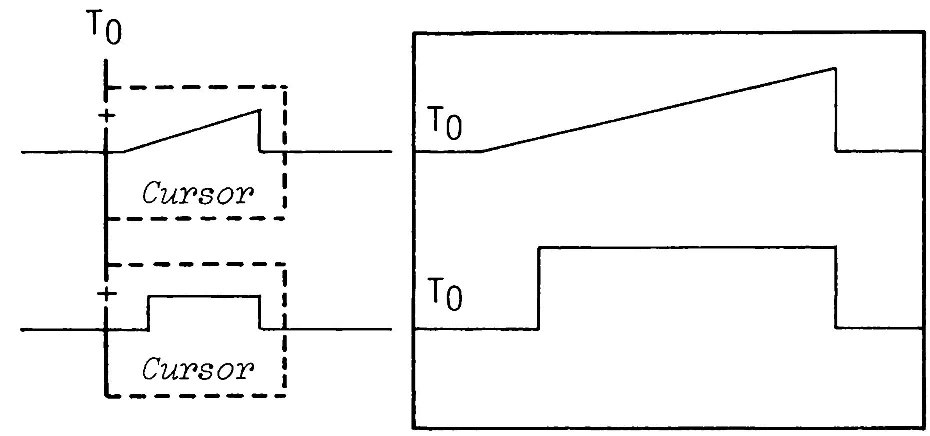


Figure 15-1

CURSOR/CURSOR

Extreme left of screen corresponds to each individual (T-) time origin for both channels. The (T-) origins correspond to the time at which acquisition began on each channel. Identical (T-) origins will only occur when identical delays have been selected.

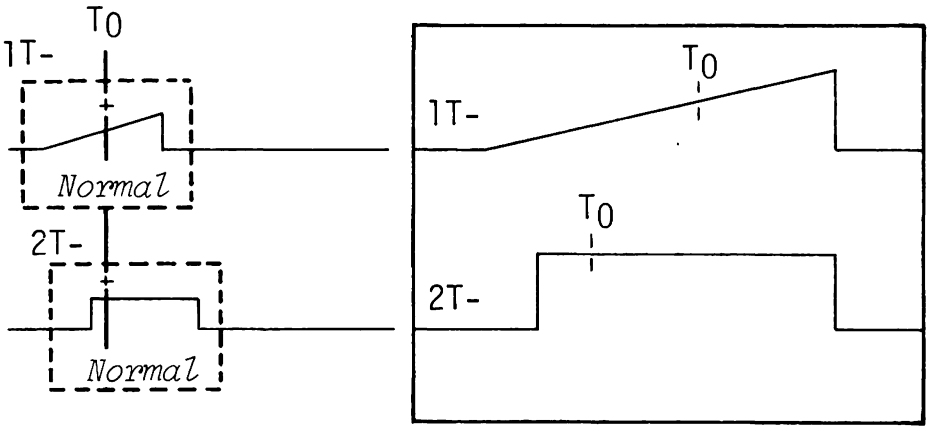


Figure 15-2

DELAYED/DELAYED

Extreme left of screen corresponds to each individual (T+) time origin for both channels. The (T+) origins correspond to the time at which acquisition began on each channel. Identical (T+) origins will only occur when identical delays have been selected.

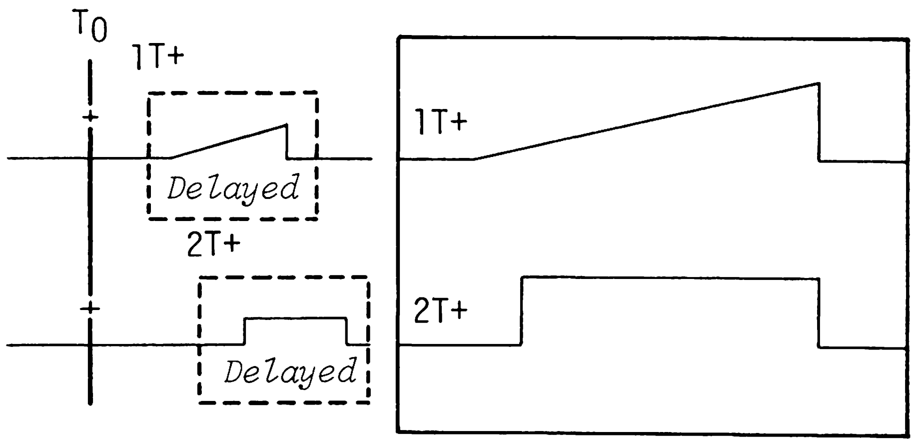
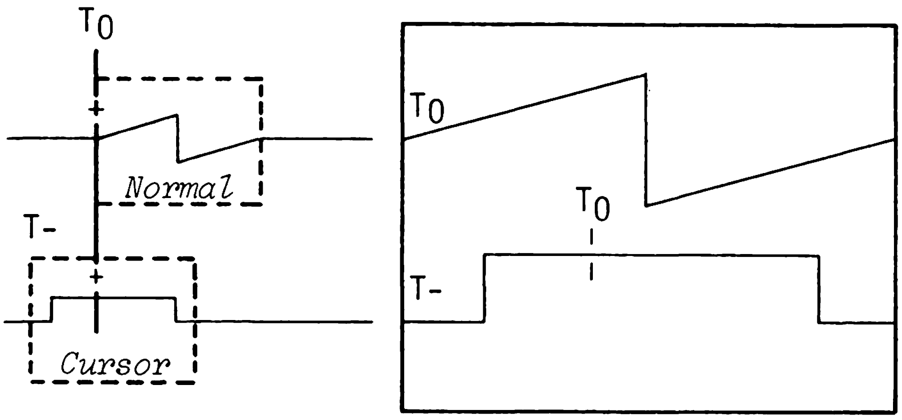
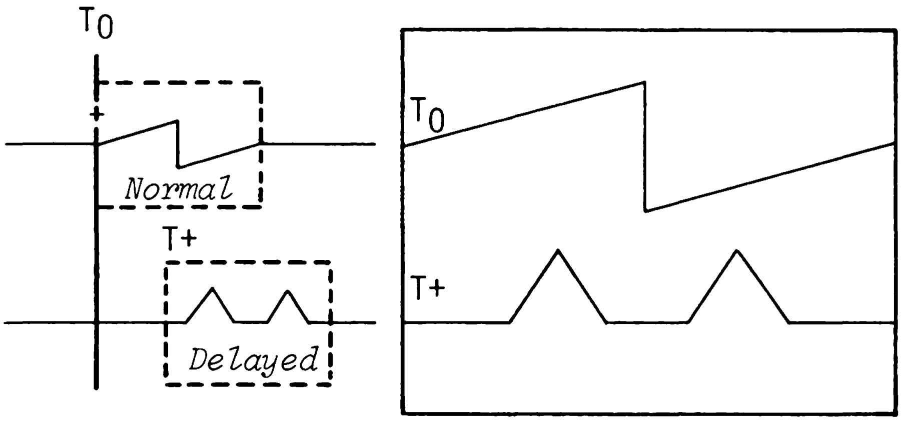
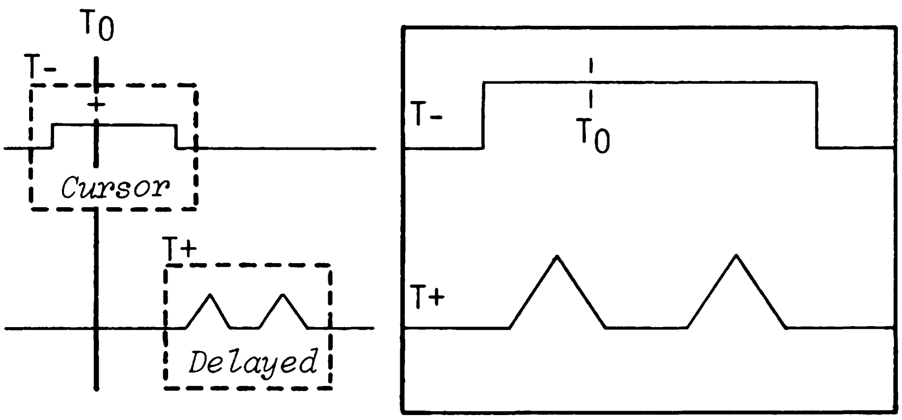


Figure 15-3

••Mixing Trigger Modes

NORMAL/CURSOR	
Extreme left of screen corresponds to the (T_0) time origin for the *Normal* trigger signal and (T-) for the *Cursor* trigger signal. The (T_0) and (T-) origins correspond to the time at which acquisition began on each channel.	 *Figure 15-4*
NORMAL/DELAYED	
Extreme left of screen corresponds to the (T_0) time origin for the *Normal* trigger signal and (T+) for the *Delayed* trigger signal. The (T_0) and (T+) origins correspond to the time at which acquisition began on each channel.	 *Figure 15-5*
CURSOR/DELAYED	
Extreme left of screen corresponds to the (T-) time origin for the *Cursor* trigger signal and (T+) for the *Delayed* trigger signal. The (T-) and (T+) origins correspond to the time at which acquisition began on each channel.	 *Figure 15-6*

● TWO PLUG-IN OPERATION

When employing two Plug-ins to acquire data, the operator can elect to trigger both Plug-ins simultaneously with a common trigger, or trigger each Plug-in individually with two separate triggers. See *Plug-ins* tab, page 8-38 for detailed descriptions.

Regardless of which manner of triggering is selected, the overall effects previously described for a single Plug-in (two channel) display remains the same.

Figure 15-7 illustrates the effect of triggering a sweep from a common trigger applied to the "master" Plug-in when the "slave" Plug-in's trigger SOURCE switch is in the "S" position.

Figure 15-8 illustrates the effect of triggering sweeps on each Plug-in with a different trigger.

NOTE: The term (T_0), in the following figures, represents the position of the Plug-in's trigger cursor, or "Time Zero." Placing the Mainframe's vertical cursor at the extreme left-hand edge of the screen and selecting channel A or B by consecutive taps on the left/right cursor buttons will result in a numerical display of the respective channel delay indicated in the figures.

In addition, assume that the following examples of signals were acquired while in the External trigger mode.

COMMON TRIGGER

Illustrates the effect of applying a common trigger to the "master" Plug-in when the "slave" Plug-in's trigger SOURCE switch is in the "S" position. The extreme left of screen corresponds to the time at which acquisition began on each individual channel.

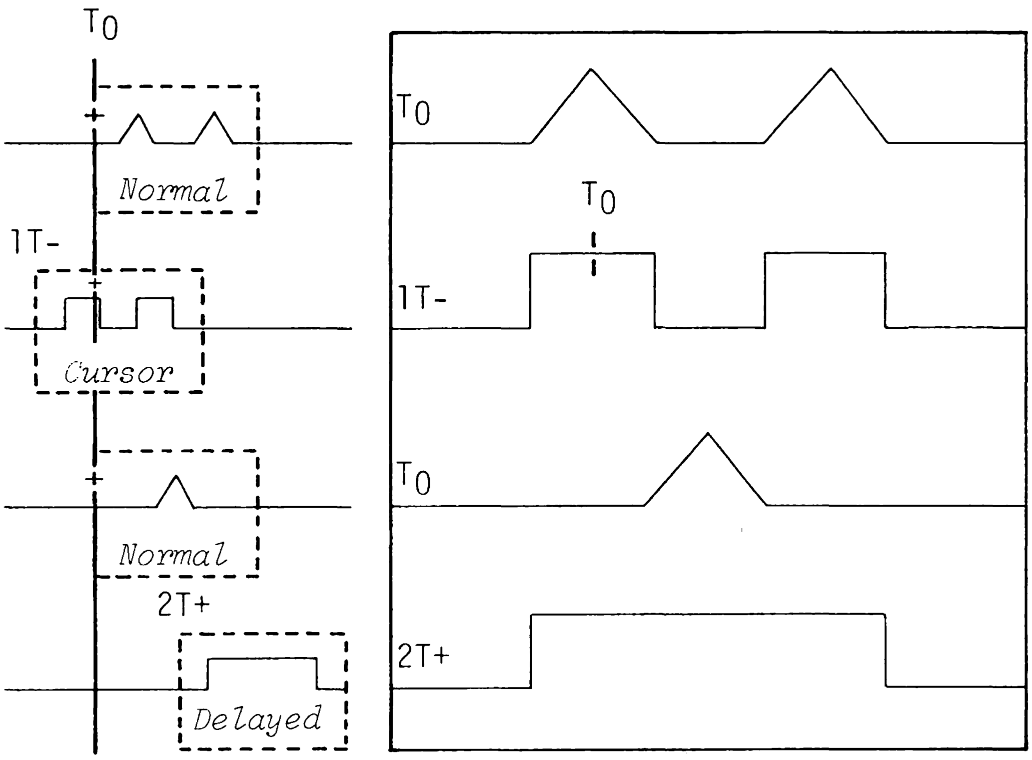


Figure 15-7

SEPARATE TRIGGERS

Illustrates the effect of applying separate triggers to each Plug-in, providing each Plug-in with a different trigger time (T_0) origin. The extreme left of screen corresponds to the time at which acquisition began on each individual channel.

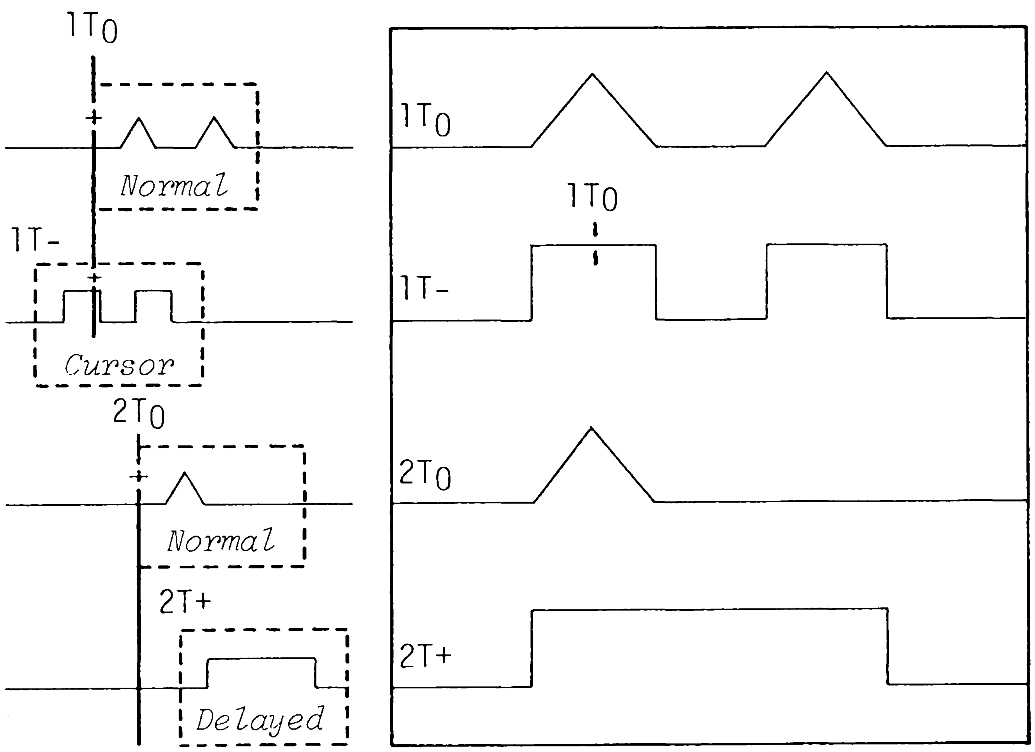


Figure 15-8

SETTING A D.C. TRIGGER LEVEL

The trigger View function (Plug-ins tab, page 8-30) is provided as a convenience feature and is not intended for absolute settings of the trigger level. The relative positions of the waveform, trigger level and sensitivity are visually accurate when performing the "Adjusting the Trigger" procedure, (Plug-ins tab, page 8-36). However, the voltage values read by the cursor are only accurate to within approximately 5%.

There are two alternative methods (Continuous Signals and One-Shot Signals) which may be used to set an internal D.C. trigger level.

The Continuous Signals procedure (page 15-11) will provide an exact D.C. trigger level. The accuracy of the One-Shot Signals procedure (page 15-12) depends on how carefully Step #17 is executed.

● CONTINUOUS SIGNALS

#1. Apply the input signal to either channel A or B and place the adjacent input BNC switch to the "DC" position. (Ground the unused input BNCs by placing the adjacent input BNC switches to the "GND" position.

#2. Turn the selected channel on and the unused channel off.

#3. LIVE button: Press.

#4. AUTO/NORM switch: Auto

#5. COUPLING switch: DC

#6. SLOPE switch: (+ or -)

#7. SOURCE switch: A or B (Whichever is being used)

#8. AUTOCENTER switch: On

#9. FUNCTION switch: Any position but "Numerics Reset."

#10. VIEW switch: On

#11. SENSITIVITY control: Adjust as required for trigger sensitivity.

#12. VIEW switch: Off

#13. TRIGGER POSITION control: Adjust delay until trigger cursor is visible.

#14. Position the vertical cursor over the trigger cursor. The Time Numerics should read zero.

#15. LEVEL control: Adjust the trigger level until the voltage numerics decode the required voltage level.

#16. TRIGGER POSITION control: Adjust delay to required value.

- ONE SHOT SIGNALS

#1. Turn on the channel to be used and place both input BNC switches to the "GND" position. Turn off the unused channel.

#2. LIVE button: Press.

#3. AUTO/NORM switch: Auto

#4. COUPLING switch: DC

#5. SLOPE switch: (+ or -)

#6. SOURCE switch: A or B (Whichever is being used)

#7. AUTOCENTER switch: On

#8. FUNCTION switch: Any position but "Numerics Reset" and "Grid."

#9. VIEW switch: On

#10. SENSITIVITY control: Adjust as required for trigger sensitivity.

#11. VIEW switch: Off

#12. TRIGGER POSITION control: Adjust delay until the trigger cursor is visible.

#13. Position the vertical cursor over the trigger cursor. The Time Numerics should read zero.

#14. LEVEL control: Fully clockwise for positive (+) slope triggering, fully counterclockwise for negative (-) slope triggering.

#15. POSITION control: Adjust the channel's POSITION control until the trace is vertically positioned at the screen level where triggers are to occur.

#16. AUTO/NORM switch: Norm

#17. LEVEL control: Very slowly adjust the LEVEL control until the TRIGG'D LED flashes. (If no flash occurs, return to Step #15 and readjust the trace a little closer to screen vertical center.)

#18. FUNCTION switch: Reset Numerics

#19. EXECUTE button: Press.

#20. AUTO/NORM switch: Auto

#21. POSITION control: Adjust the channel's POSITION control until the voltage numerics decode the opposite sign and voltage value required:

a. For example, if a trigger level of (+500 mV) is desired, adjust the POSITION control until the voltage numerics decode (-500 mV).

#22. FUNCTION switch: Any position but Reset Numerics.

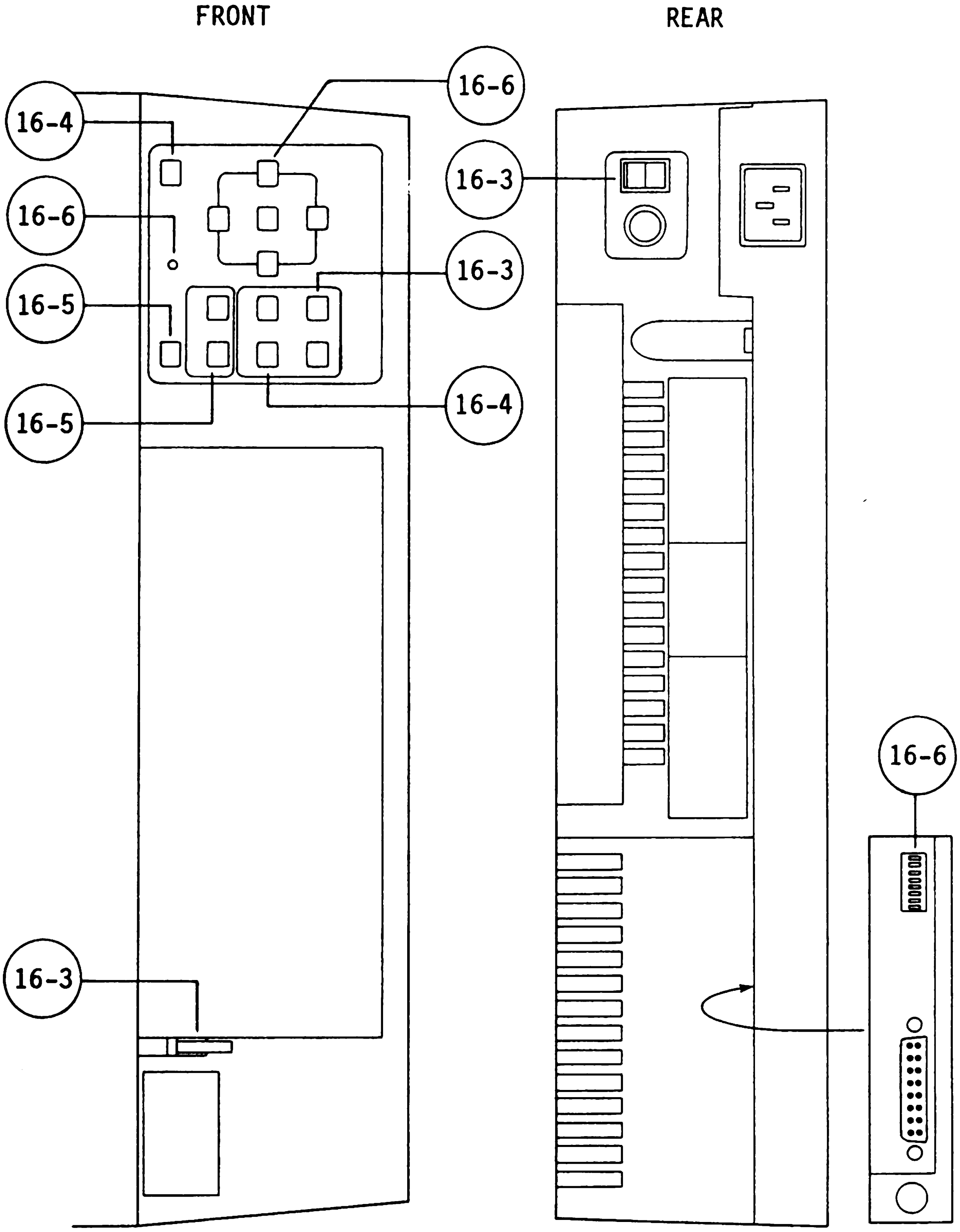
#23. TRIGGER POSITION control: Adjust delay to required value.

#24. AUTO/NORM switch: Norm

#25. Apply the input signal and place the adjacent input BNC switch to the "DC" position.

#26. Wait for trigger and resulting waveform display.

Digital Plotter – HP 7470A



INTRODUCTION

The operating instructions contained in this section of the manual are summarized from the HP 7470A Digital Plotter Manual.

➤ IMPORTANT: Refer to the HP 7470A Plotter manual and verify the proper line voltage setting before applying power to the plotter.

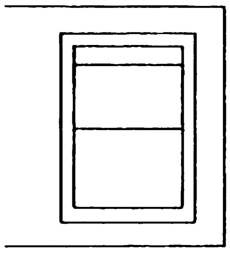
- IMPORTANT: The 7470A Interface Cable furnished by Nicolet should be used to interface the 4094 and 7470A. If a different cable is used, it must be modified as described in Figure #1 or erroneous plots will occur.

PLOTTER Pin #		4094 Pin # (Plotter Port)
2	-------------------	2
3	-------------------	3
7	-------------------	7
5	------------------	20
20	-------------------	4

Figure #1

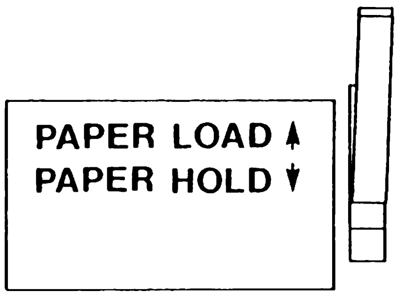
The Digital Plotter's features include the ability to:

- Plot up to four plots on a single sheet of paper.
- Provide two plotting modes -
  a. Standard - Maximum of 1024 points, (40 Secs - 2.5 Minutes).
  b. High Resolution - All points plotted, (up to 7 minutes).
- Plot different line types (e.g., dashed, dot-dashed, etc.) for each of the four plots when high resolution is not selected.
- Pause between plots, allowing different colored pens to be used.
- Provide scale information: volts/div. and time/div., etc.
- Scale plot to accomodate various graph paper dimensions.
- Plot only the waveform indicated by the Plug-in/Channel Identifier.
- Plot YT and/or XY waveform displays.
- Plot vertical and/or horizontal expanded waveforms.
- Plot a title displayed on the display screen's Status Line.



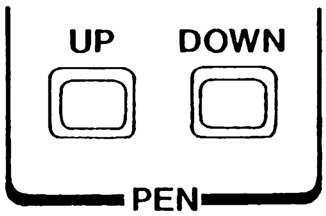
LINE ON/OFF SWITCH - Rear Panel

Applies power to the plotter.



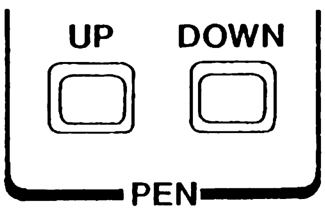
PAPER LOAD LEVER

Activates/deactivates the pinch-roll-ers paper hold-down feature.



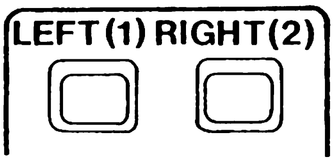
PEN UP BUTTON

Raises the pen when pressed. Over-rides the program pen controls when pressed and held down.



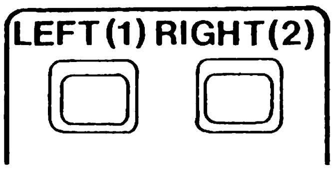
PEN DOWN BUTTON

Lowers the pen when pressed. Over-rides the program pen controls when pressed and held down.



LEFT (1) BUTTON

Selects the pen located in the left pen stall. Pressing the LEFT (1) and ENTER buttons simultaneously stores the pen into the left pen stall, if possible.



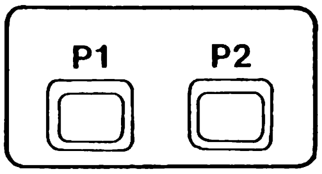
RIGHT (2) BUTTON

Selects the pen located in the right pen stall. Pressing the RIGHT (2) and ENTER buttons simultaneously stores the pen into the right pen stall, if possible.

VIEW BUTTON

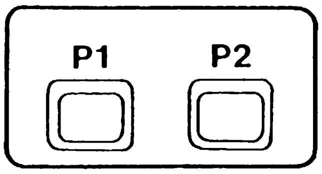
Pressing and locking in the VIEW button turns on the ERROR light, suspends plotting, raises the pen, and extends the paper to enable the pens to be changed or view the entire plotting area.

Pressing the VIEW button again turns off the ERROR light, returns the pen to its previous coordinates and status (up or down), and plotting resumes.



P1 BUTTON

Repositions the pen to the preset, or manually selected lower left plotting limit.

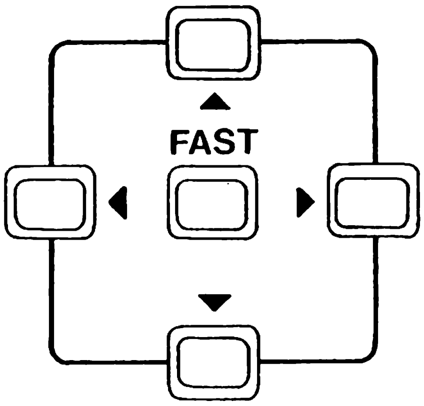


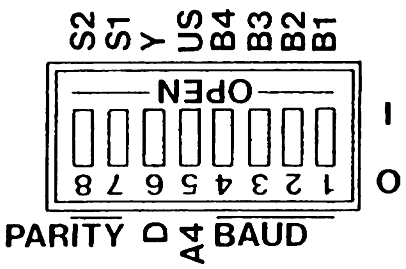
P2 BUTTON

Repositions the pen to the preset, or manually selected upper right plotting limit.

ENTER BUTTON

Used in conjunction with the P1 and P2 buttons when manually selecting new plotting limits.





FAST & DIRECTION BUTTONS

The direction buttons fine tune the pen in the direction selected at a slow rate of movement. Simultaneously pressing two adjacent direction buttons (e.g., up/left) fine tunes the pen diagonally in the direction of the two arrows.

Pressing the FAST button while pressing the direction button(s) coarse tunes the pen in the direction selected at a fast rate of movement.

ERROR INDICATOR

Illuminates if power is applied to the plotter before applying power to the 4094, or if power is removed from the 4094 while power remains applied to the plotter.

DIP SWITCH - Rear Panel

Selects the parity (set to NONE) and baud rate (set to 2400). It also selects either programmed "on" or programmed "off" operation and the maximum plotting limits.

Refer to the HP 7470A Graphics Plotter Operator's Manual for setting instructions.

PLOT ELEMENTS IDENTIFICATIONS

Figure #16-1 illustrates a typical plotting format, the dimensions of which are determined by the lower left and upper right plotting limits.

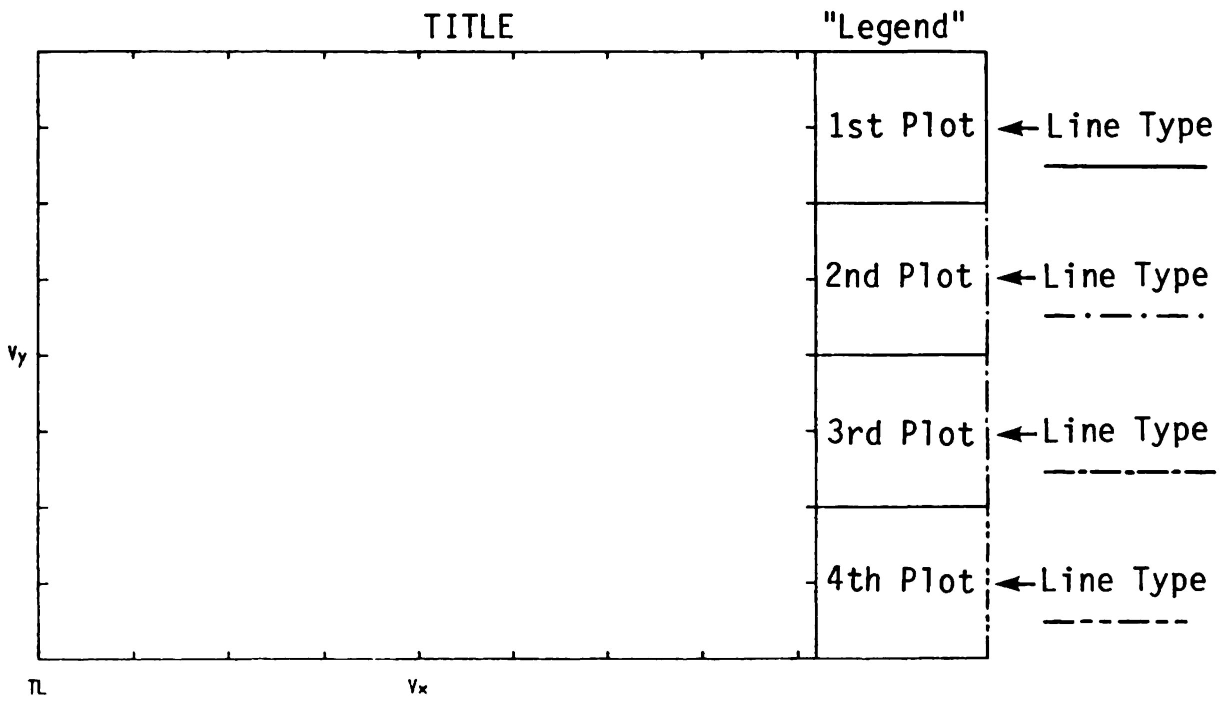


Figure 16-1

● LEGEND

The legend is divided into four boxes. Each box identifies the time and voltage references for the associated

- V/D - Volts/Division
- Vy - Y-axis' reference voltage.
- Vx - X-axis' reference voltage.
- T/D - Time/Division.
- TL - Time reference at left edge.

● LINE TYPES

The right edge of each legend box illustrates the line type used to plot the corresponding waveform. NOTE: High resolution plots (all data points plotted) are plotted with a solid line.

● TITLE

The title, if any, that is displayed on the screen's Status Line will also be printed.

GRAPH PAPER SELECTION

The plotter is programmed to automatically divide the graph paper into nine vertical divisions by ten horizontal divisions when the lower left and upper right plotting limits coincide with the lower left and upper right margins of the graph paper.

NOTE: The actual "waveform" plots are plotted in eight horizontal by eight vertical divisions.

It is recommended that "millimeter" graph paper be used, (e.g., DIETZGEN Millimeter Graph Paper No. 341-M or equivalent). This will allow the major divisions selected by the plotter to coincide with the divisions on the graph paper.

The graph paper should be equivalent to the dimensions illustrated in Figure #16-2.

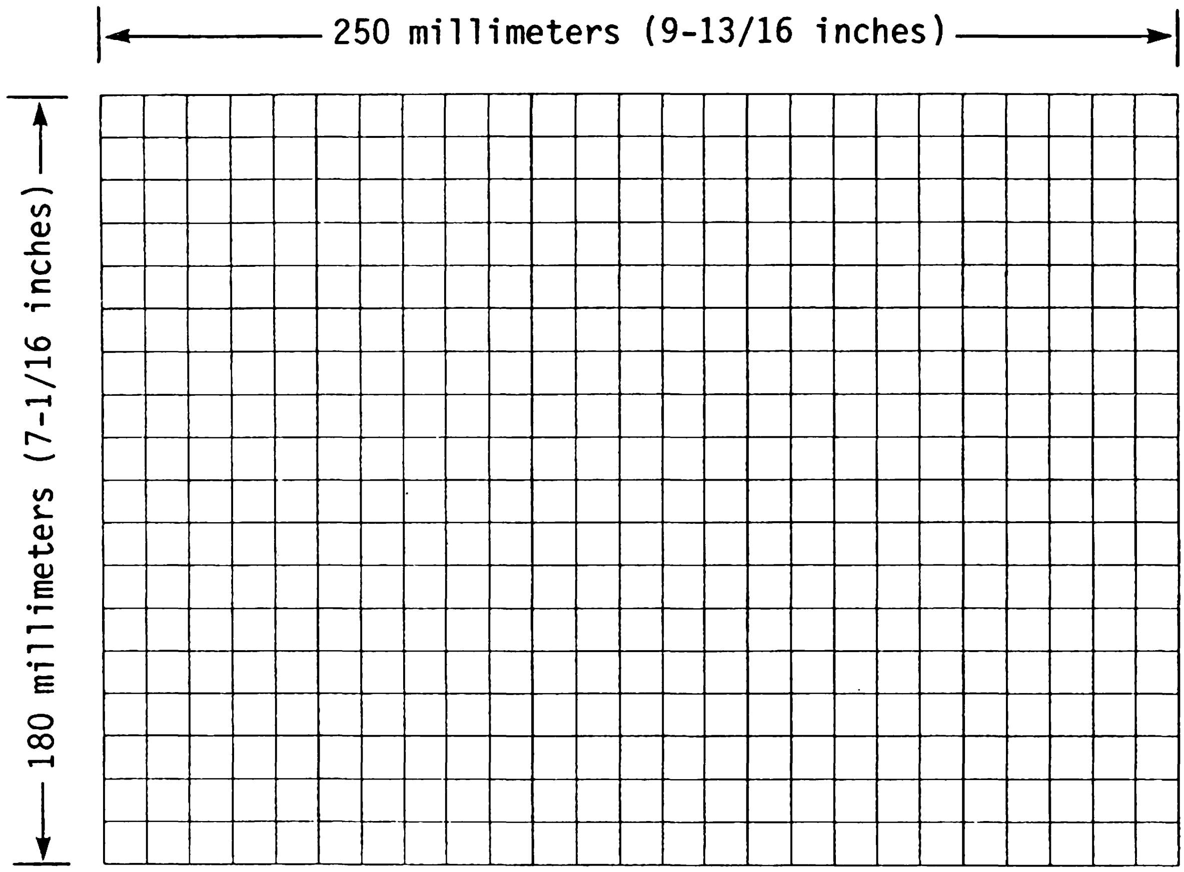


Figure 16-2

LOADING THE PEN

When inserting the pen into the plotter's pen holder, hold the pen holder at point A (Figure #16-3) to ensure that the pen is securely "locked" into position.

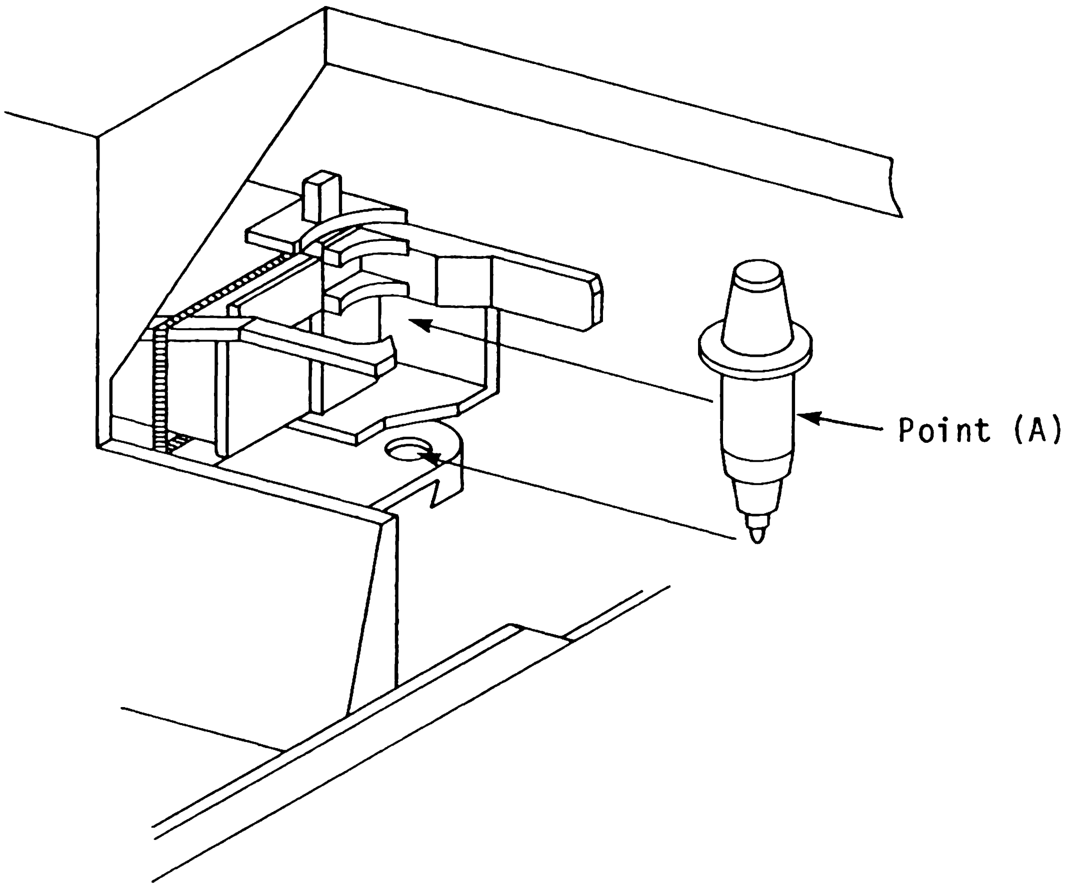


Figure 16-3

ABORTING THE PLOTTER PROGRAM

The Plotter Program can be be aborted at any time by turning the 4094's FUNCTION switch away from the PEN position. However, the plotter will complete any commands it has already received before stopping.

To guard against unwanted lines when aborting a plot:

#1. Press and hold the plotter's PEN UP button,

#2. Switch the 4094's FUNCTION switch away from the PEN position.

#3. After the plotter has stopped, release the plotter's PEN UP button.

#4. Replace the graph paper before executing another plot.

PLOTTER ERRORS

A plotter error is identified by an illuminated ERROR light on the plotter. To clear an error:

#1. Cycle the plotter's POWER switch off and then on again.

#2. Change the graph paper, if applicable, and execute a new plot.

If a command attempts to position the pen out of the plotting limits, the pen will automatically be lifted.

STANDARD RESOLUTION PLOTS

A maximum of 1024 data points are plotted, requiring 40 seconds to 2.5 minutes.

Which of the waveform's data points will be plotted is tabulated in Table 16-1. If, for example, MEMORY = ALL, DATA POINTS PER WAVEFORM = 7,936, and EXPANSION = X2, then every fourth data point will be plotted from the selected waveform.

HIGH RESOLUTION PLOTS

All of the selected waveform's displayed data points are plotted, requiring up to 7 minutes for a 16K record.

High resolution plots are selected by pressing and holding in the EXECUTE button and then placing the AUTOCENTER switch to the "ZERO" position. Each high resolution plot is drawn with a solid line.

INCREMENTAL SELECTION OF STANDARD PLOT DATA POINTS								
MEMORY SWITCH	DATA POINTS PER WAVEFORM	HORIZONTAL EXPANSION SWITCH						
		OFF	X2	X4	X8	X16	X32	X64
ALL	15,872	16	8	4	2	*	*	*
	7,936	8	4	2	*	*	*	*
	3,968	4	2	*	*	*	*	*
	1,984	2	*	*	*	*	*	*
H1/H2	7,936	8	4	2	*	*	*	*
	3,968	4	2	*	*	*	*	*
	1,984	2	*	*	*	*	*	*
	992	*	*	*	*	*	*	*
Q1/Q2/Q3/Q4	3,968	4	2	*	*	*	*	*
	1,984	2	*	*	*	*	*	*
	992	*	*	*	*	*	*	*
	496	*	*	*	*	*	*	*

Table 16-1

(*) All of the selected waveform's displayed data points are plotted.

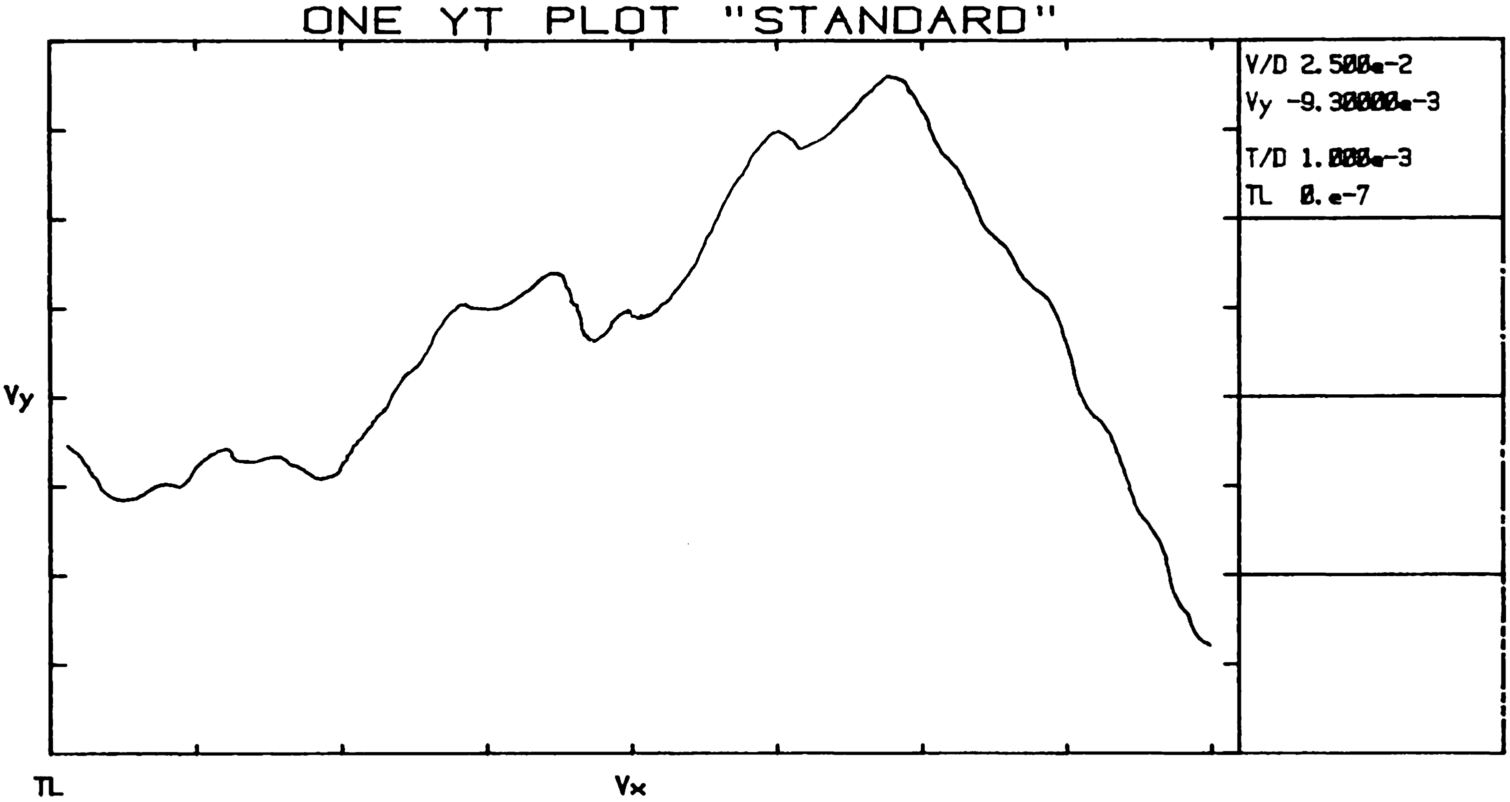


Figure 16-4

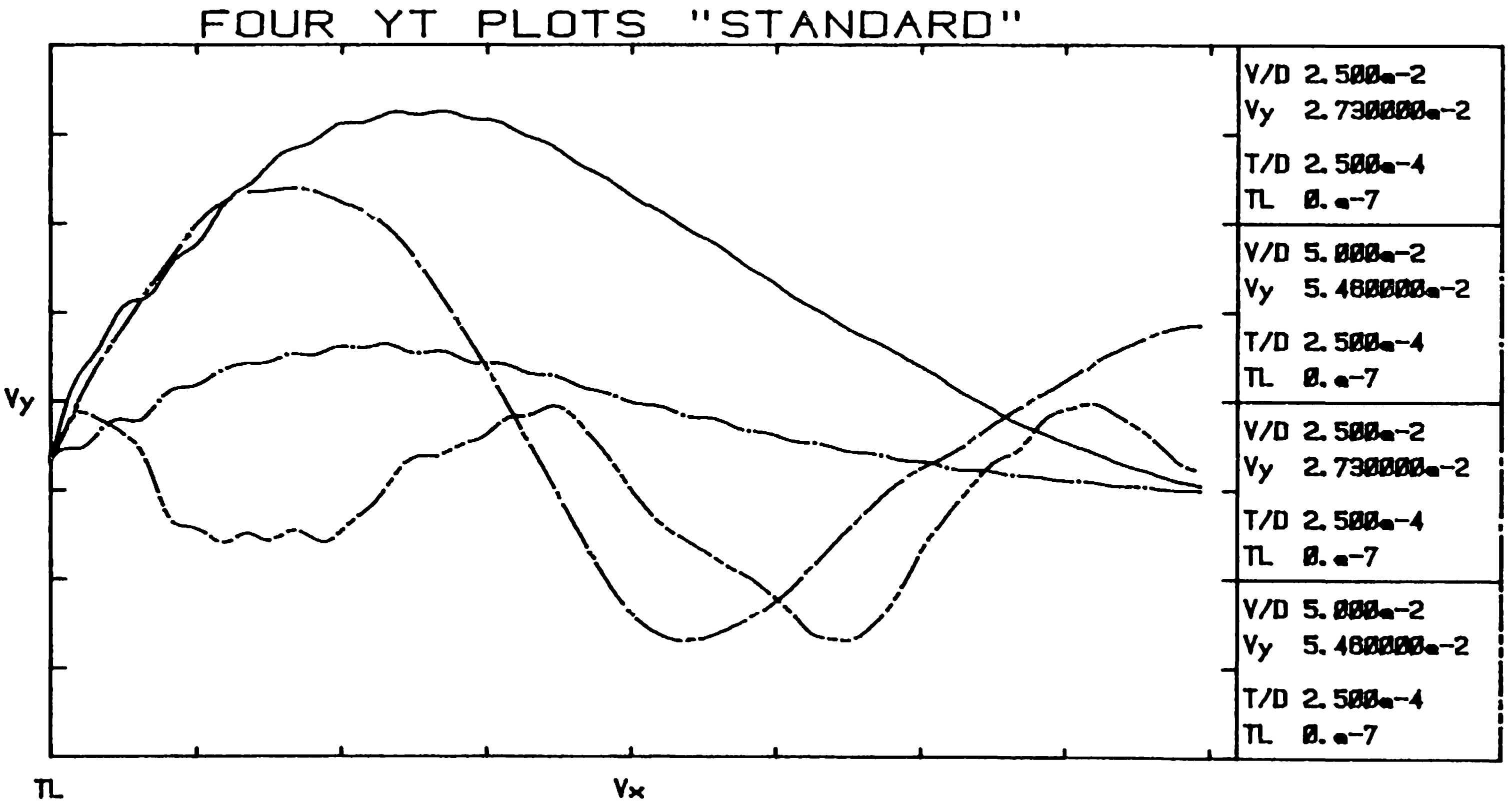


Figure 16-5

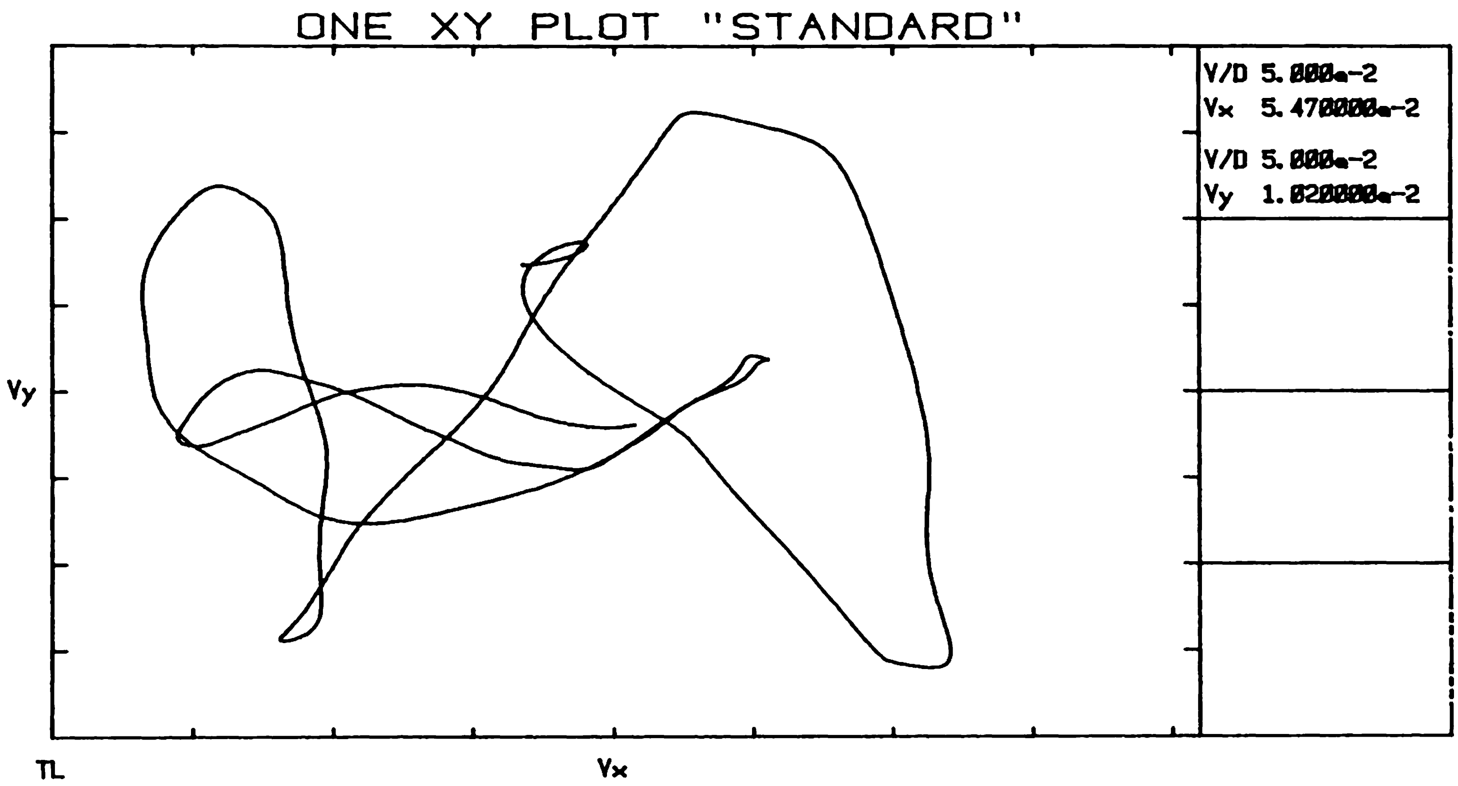


Figure 16-6

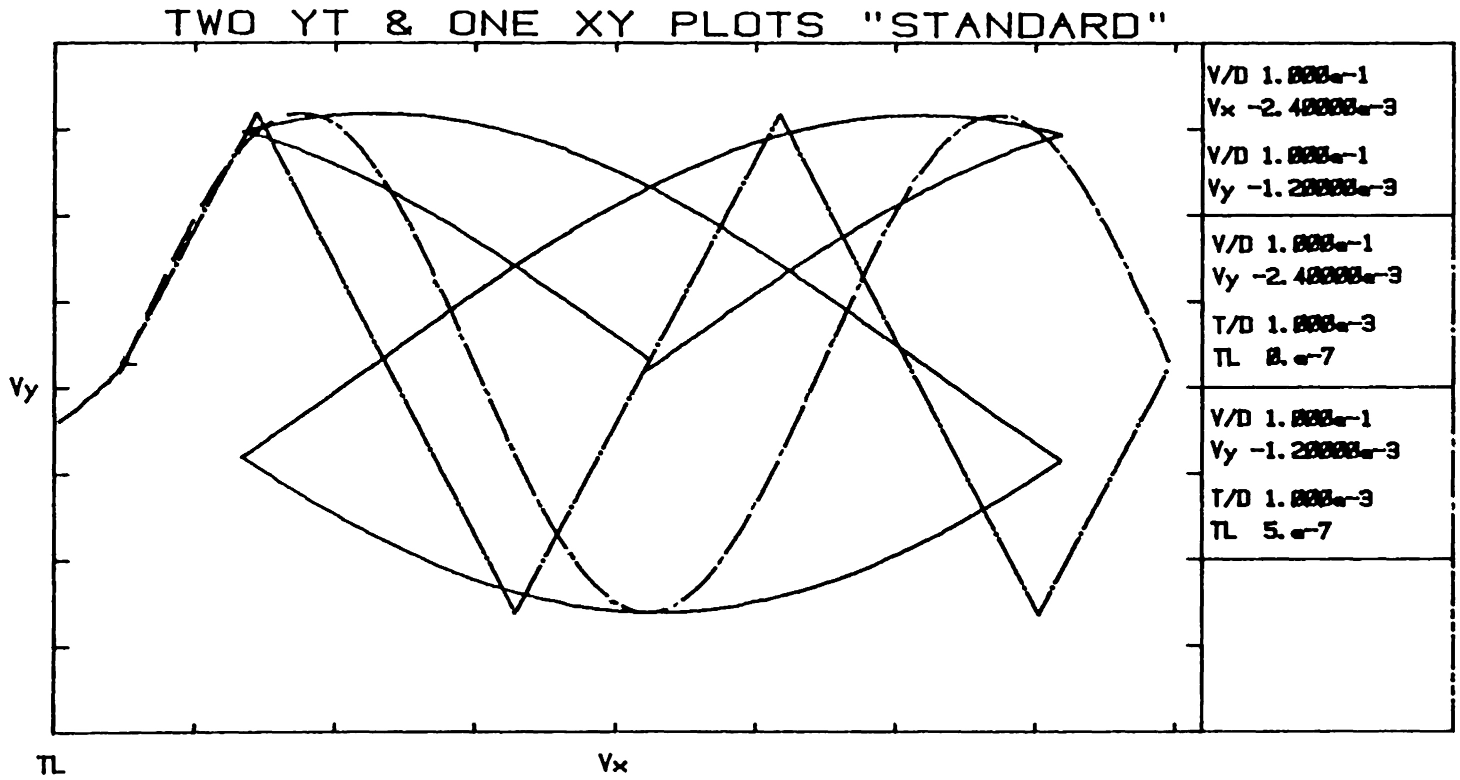


Figure 16-7

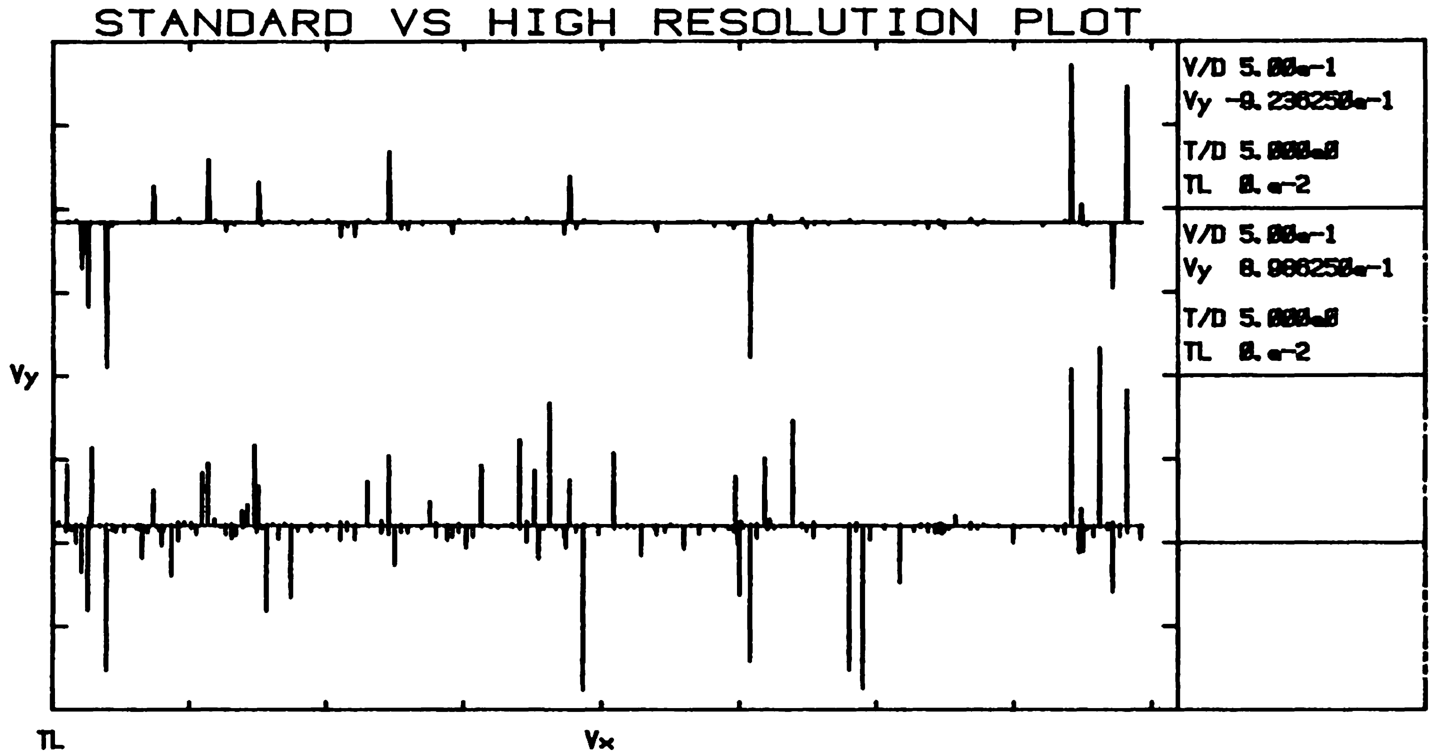


Figure 16-8

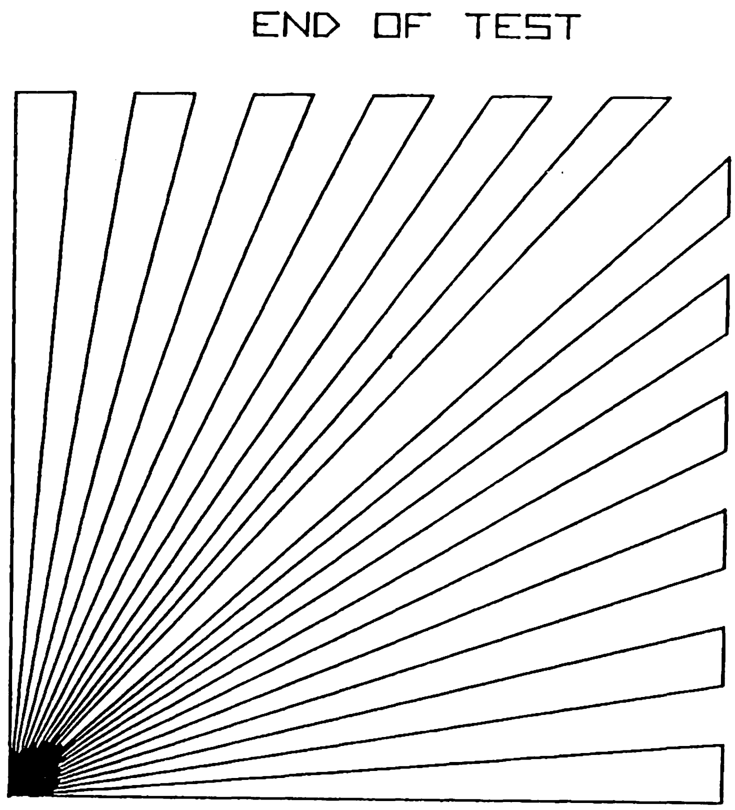


Figure 16-9

PLOTTING PROCEDURE

#1. If the data that is to be plotted is not already stored in the 4094's display memory (data displayed on screen), record the data in the memory.

#2. Select which title, if any, is to be plotted by positioning the MEMORY switch until the desired title is displayed on the display screen's Status Line.

If no title is present and one is desired, refer to the Disk Programs tab in the 4094 Operating Manual for instructions on the use of the Standard Pak program diskette. Then, under the same tab, refer to the Standard Pak program description labeled "TITLE."

#3. Connect the plotter to the 4094 with the cable provided. The cable ends are marked SCOPE and PLOTTER.

CAUTION: High voltages exists within the 4094. Use care while performing Step #4.

#4. The 4094's plotter baud rate is factory preset to 2400 baud. This can be verified by removing the third bay side cover and inspecting the #5 position selector on the RS232 dip switch located at the top of the I/O board. The #5 position selector should be in the closed (down) position, (Figure 16-10).

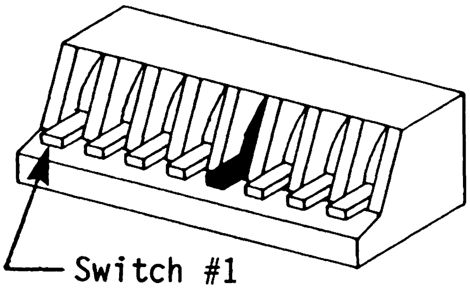


Figure 16-10

#5. Set the plotter's PARITY switch (at rear of plotter) to "NONE," (S1 = Ø).

#6. Set the plotters BAUD RATE switch (at rear of plotter) to "2400," (B4 = 1; B3 = B2 = B1 = Ø).

► IMPORTANT - Verify the plotter's line voltage selection before applying power to the plotter. Refer to the HP 7470A Plotter manual.

#7. Load the paper.

#8. Place the Mainframe's FUNCTION switch to the PEN position.

NOTE: Lower left and upper right plotting limits may be set to match the graph paper, (usually 9 divisions vertical by 10 divisions horizontal). This operation is optional if plain paper is used. If Steps #9 through #14 are not performed, the lower left and upper right plotting limits previously selected will be used unless power has been removed.

➤ IMPORTANT: Removing power from the plotter erases manually selected plotting limits, in which case, the lower left and upper right plotting limits will be equal to the preset limits automatically selected by the plotter.

#9. Press the plotter's P1 button.

a. The pen moves to current, lower left plotting limit.

#10. If the lower left limit is correct, proceed with Step #11. If the lower left limit is NOT correct:

a. Reposition the pen to the desired lower left limit by pressing the PEN POSITIONING buttons.

b. Press the plotter's ENTER and P1 buttons simultaneously to set the lower left limit.

#11. Press the plotter's P2 button.

a. The pen moves to current, upper right plotting limit.

#12. If the upper right limit is correct, proceed with Step #13. If the upper right limit is NOT correct:

a. Reposition the pen to the desired upper right plotting limit by pressing the PEN POSITIONING buttons.

b. Press the plotter's ENTER and P2 buttons simultaneously to set the upper right limit.

#13. Press the Mainframe's EXECUTE button.

a. The border, Vy, Vx, TL, and Title are plotted when the button is released.

b. The command (SELECT A WAVE-

FORM "EXECUTE") appears on the display screen's Status Line.

#14. If only one waveform is being displayed on the screen, proceed with Step #15. If more than one waveform is being displayed:

a. Position the vertical cursor over a prominent feature of the waveform that is to be plotted first.

b. Place the Mainframe's HORIZONTAL EXPANSION switch to the X256 position.

c. Position the vertical cursor so that it passes through one of the selected waveform's data points.

d. Place the Mainframe's HORIZONTAL EXPANSION switch to the "OFF" position.

#15. Position the selected waveform on the screen as necessary. This includes vertical/horizontal expansion, cursor position, YT or XY display, etc.

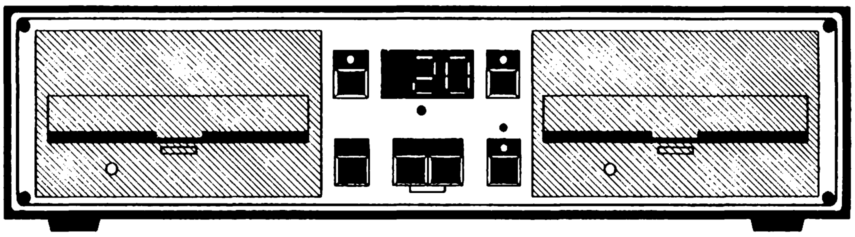
#16. If a high resolution plot is desired (every data point is plotted with a solid line), press and hold in the Mainframe's EXECUTE button while placing the AUTOCENTER switch to the "ZERO" position. If a high resolution plot is NOT required, momentarily press the Mainframe's EXECUTE button.

a. The display screen's Status Line clears and the operation of the 4094's front panel controls are inhibited.

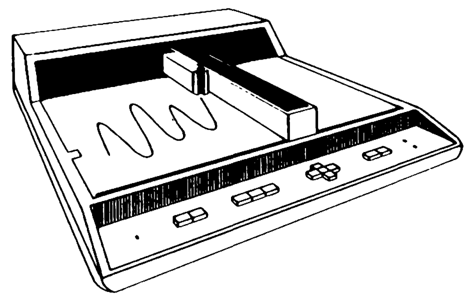
b. The selected waveform is plotted.

#17. The command (SELECT A WAVEFORM "EXECUTE") reappears on the display screen's Status Line after the plot is completed.

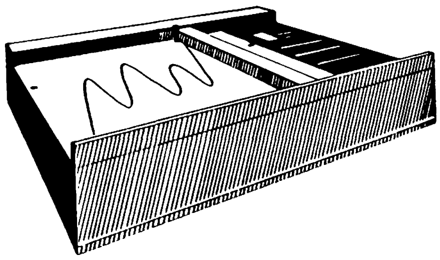
#18. Repeat Steps #14 through #18 until up to four plots have been competed, if desired. A plot can be aborted at any time by turning the 4094's FUNCTION switch away from the PEN position.



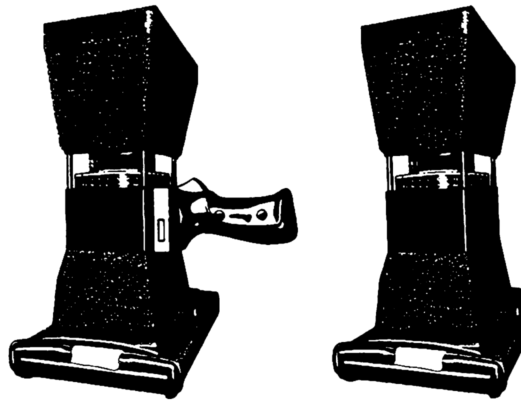
DUAL DISK DRIVE - *The XF-44/1 (single drive) and XF-44/2 (dual drive) disk recorders provide a simple means by which signals can be permanently recorded for later recall. The XF-44 provides all of the features of the F-43 Disk Recorder. The XF-44/2 configuration provides the additional "diskette copy" feature.*



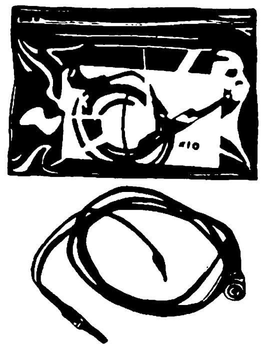
H.P. DIGITAL PLOTTER - *Plots on standard 8-1/2" x 11" paper. Permits multiple plots with 7 selectable dashed-line fonts and includes alphanumeric labeling.*



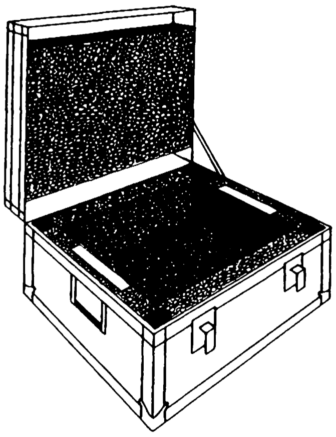
XY PLOTTER - *Available in either 8-1/2" x 11" or 11" x 17" plotter configurations with rackmount brackets and BNC inputs.*



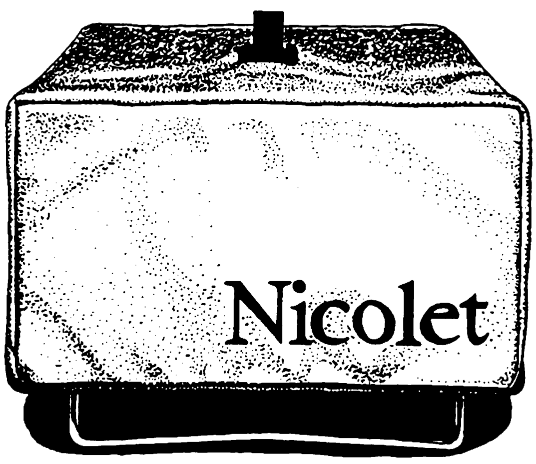
SCOPE CAMERA - *Polaroid* CU-5 or Shackman lightweight, pack film cameras using Polaroid 3-1/4" x 4-1/4" (8.3 x 10.8 cm) self-developing film.*



10X PROBE - *10 Megohm input resistance when used with scopes with 1 Megohm input. 100 MHz bandwidth, 600 volts DC working voltage, 59" (1.5 m) cable length.*



CARRYING CASE - *Sturdy 1/8" polyethylene plastic with steel-reinforced corners, four latches and two recessed handles. Protective inserts of Ethafoam ** plastic. Approximate dimensions: 23-1/4" (59 cm) wide by 22" (55.9 cm) deep by 13" (33 cm) high. Weight is 35 lb (15.75 kg).*



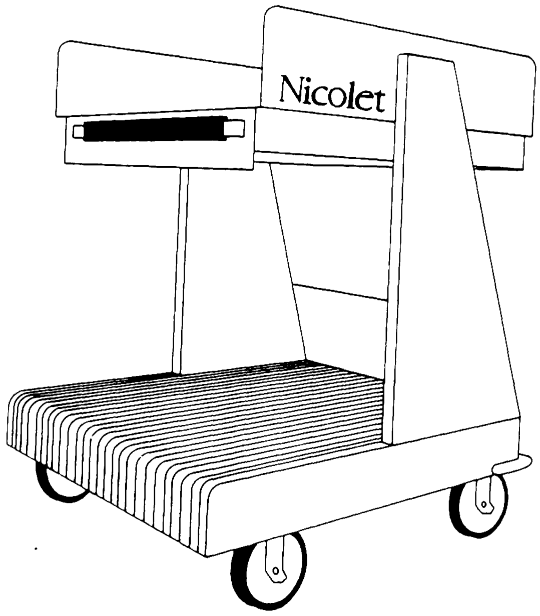
DUST COVER - *Heavy duty, leather grained vinyl material reinforced on the front panel, edges and corners for added protection. Includes quick seal Velcro*** strips for fast access, detachable pouch for accessories and a slotted top for access to the carrying handle.*

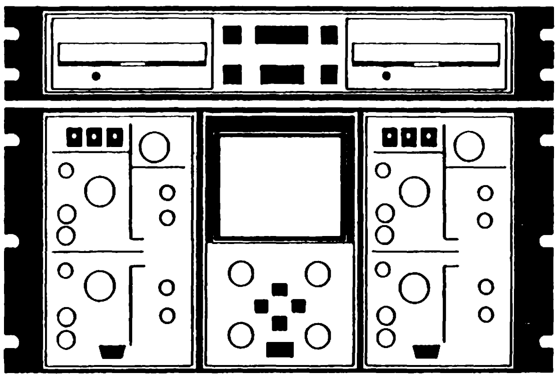
* *Reg. tm. Polaroid Corp., Cambridge, MA*
** *Reg. tm. Dow Chemical Co., Midland, MI*
*** *Reg. tm. Velcro USA Inc., New York, NY*

SCOPE CART - *Versatile, enamel finished oscilloscope cart on easy rolling 2-1/2" casters. Includes 3 power outlets, self-contained storage drawer, front mounted castor brakes, and tray which can be angled up to 35°.*

Approximate dimensions: Top surface is 17-1/2" (44.5 cm) deep and 18" (45.72 cm) wide. Overall dimensions, including casters and rear bumper guards, are 35-1/4" (87 cm) high by 21-1/4" (54 cm) wide by 24-3/4" (63 cm) deep.

Approximate weight is 80 lbs (36 kg).





RACK MOUNTS - *Separate rack mounts for the 4094 oscilloscope and XF-44 Disk Recorder are manufactured from 1/8" angle aluminum drilled to fit a standard 19" (48.26 cm) rack or cabinet.*

PARTS LIST

The Parts List will be immediately forwarded upon completion.

NICOLET
INSTRUMENT
CORPORATION
OSCILLOSCOPE DIVISION