Nicolet Model 4094 Digital Oscilloscope

Operation Manual

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IMPORTANT

The Standard Program Package shipped with the 4094C mainframe can be used with any model Nicolet 4094 oscilloscope.

Specialized Program Packages used with your 4094, 4094A, and 4094B mainframes must be updated for use with the 4094C mainframe.

Please call your local salesperson, or the Nicolet Applications Department 608/273-5008 or 800-NICOLET (642-6538) to request a free update.

CAUTIONS

The following WARNING note 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:** The 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 or 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 be required to correct the interference.

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

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

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

5-1

CAUTION: Do not allow the input signal to exceed the maximum, allowable input voltage (with respect to ground) listed in the Specifications.

8-9

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

a. Power is off.
b. Power is being applied or removed.
c. The drive is not being used.
d. The instrument is being moved.

9-9, 11-1

CAUTION: Ensure that the position of the XF-44's POWER selector matches that of the 4094's rear panel voltage selector before applying power to either unit.

11-1

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

11-1

WARNING: Before applying power to the instrument, refer to the Receiving and Power Requirements tab.

12-3

GLOSSARY

Analog Zero: Identified by the position of the plug-in's trigger (small) crosshair.

Bit: Synonym for a binary digit which can be either a logic level one (1, or mark), or a logic level zero (0, or space).

BNC: Connector used to input/output signals.

Data Group: The displayed input signal.

Data Points: The small dots displayed on the screen which represent 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 displayed by small dots (data points).

Disk Recorder: Optional F-43 and XF-4 conversions used to permanently record input signals on a floppy diskette.

Hold Mode: The status of the plug-in when the Hold Last LED is on and the Live LED is off.

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

Live: The status that the plug-in must be in (Live LED on) to capture input signals.

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

Menu: Selection of various functions that can be performed on stored data.

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 section of the 4094 that contains the digitizing and buffer memory circuitries, and the controls used to capture the input signal(s).

Recall: The process of taking data stored on the floppy diskette and placing it into the display memory for display on the screen.

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 of the MEMORY switch.

Store: The process of taking data from the display memory and storing it on the floppy diskette.

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

NOTE: The plug-in specifications are located in the rear pocket of the binder.

IMPORTANT: Analog specifications must be checked after the 4094 has had power applied to it for at least one (1) hour.

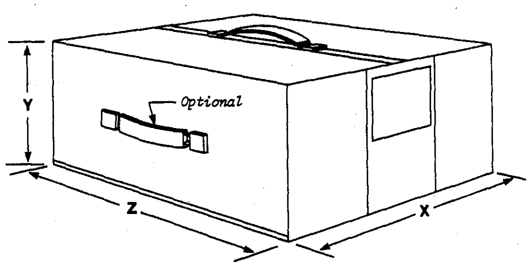
Specifications contained in this manual are subject to change without notice.

Specifications Covered in this Section

4094 MAINFRAME	
MEMORY SIZE:	16K words, 16 bits.
ADDRESSABLE SUBGROUPS:	Halves (8K), Quarters (4K).
STORAGE CAPACITY:	Up to 32 Waveforms.
DISPLAY:	5-inch, high definition.
EXPANSION:	Up to X256, both axes, cursor-interactive.
ARITHMETIC FUNCTIONS:	Subtract (4094A & B), Invert (4094A & B), Data Move (4094A, B, & C).
PEN (4094A and B):	Output to an XY, Strip Chart Recorder, or digital plotter.
PLOT (4094C):	Output to digital plotter.
OPTIONAL FUNCTIONS:	Variety of mathematical routines available on diskettes.
DATA MEMORY:	15,872 words, 16 bits.
NUMERICS	
a. YT Display Mode:	Time and voltage plus channel identifier
b. XY Display Mode:	X-volts and Y-volts plus channel identifier
NUMERIC DISPLAYS (XY/YT)	
a. Normal:	Absolute numerics.
b. Reset Numerics:	Relative numerics.
c. Grid:	Numeric scale per grid mark.
AUTOCENTER	
a. Unexpanded Display:	Automatic lock of cursor to waveform.
b. Expanded Display:	Automatic waveform centering.
c. Zero (Spring-loaded):	Automatic check of analog zero.
DISK RECORDER	
Disk Recorder Type:	5-1/4" Floppy, double sided, double density, soft sectored, 96 TPI.
Storage Capacity:	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, and 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.
Min Transfer Times (16K):	GPIB Binary, 1.5 seconds. RS-232C Binary, 18 seconds.
POWER	
Line Voltage:	120/240 VAC, +8% to -20%, 1 Ph, 50-60 Hz (+5%)
Power:	465 volt-amperes (approximate)

Specifications are subject to change without notice.

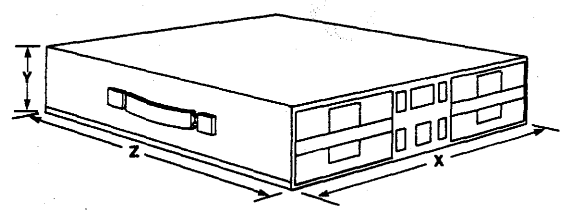
4094 Mainframe



DIMENSIONS (Approximate)

X	Basic Frame Width:	43.1 cm
	Side Carrying Handle:	Add 1.3 cm
	Side Bumpers:	Add 0.5 cm
Y	Basic Frame Height:	22.2 cm
	Top Handle:	Add 1.3 cm
	Bottom Feet:	Add 1.6 cm
Z	Basic Frame Length:	46.4 cm
	Front Panel Knobs:	Add 0.8 cm

XF-44 Disk Recorder



DIMENSIONS (Approximate)

X	Basic Frame Width:	43.1 cm
	Side Carrying Handle:	Add 0.8 cm
	Side Bumpers:	Add 0.2 cm
Y	Basic Frame Height:	10.5 cm
	Bottom Feet:	Add 1.6 cm
Z	Basic Frame Length:	46.4 cm
	Front Panel Knobs:	Add 0.8 cm
	Rear Panel Knobs:	Add 0.9 cm

WEIGHTS (Approximate)

Mainframe only:	30 pounds
4175 Plug-in:	10 pounds
4180 Plug-in:	12 pounds
4562 Plug-in:	7 pounds
4570 Plug-in:	12 pounds
4851 Plug-in:	7 pounds
F-43/1 right hand bay Disk Recorder with one disk drive:	3 pounds
F-43/2 right hand bay Disk Recorder with two disk drives:	4 pounds
XF-44/1 external disk recorder with one disk drive:	17 pounds
XF-44/2 external disk recorder with one disk drive:	20 pounds

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.

If damaged, call NICOLET, Test Instruments Division, Shipping Department, at (608) 271-3333 for instructions.

POWER ON/OFF SWITCH

> **WARNING:** Inspect the voltage selection switch (Figure 5-2 or 5-3) at the rear of this instrument for the correct setting BEFORE applying power. Use Table 5-1 to verify the correct setting.

The 4094A and 4094B Power On/Off switch is located on the front panel directly below the display screen. Push the Power knob in to apply power to the instrument.

The 4094C Power On/Off switch is located on the left hand plug-in bay rear panel.

POWER REQUIREMENTS

The Model 4094 Digital Oscilloscope 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.

#2. A separate safety ground at ground potential.

#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.

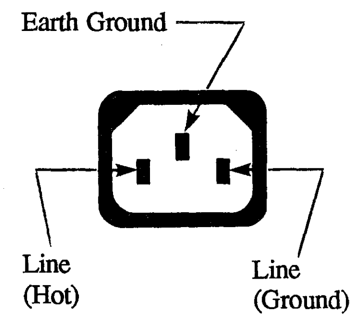


Figure 5-1

4094A & 4094B

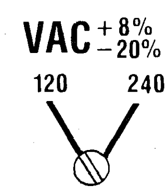


Figure 5-2

4094C

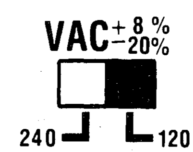


Figure 5-3

Switch Position	Range
120	96V - 129V
240	192V - 259V

Table 5-1

START-UP

The Start-up section provides the user 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 mainframe and plug-in operations are covered here. Detailed explanations of specific controls are found in the appropriate specialized sections of the manual.

Part I does not require a signal source.

Part II assumes that either a function generator or other signal source is available to provide input signals. The reader is urged to locate a signal source in order to gain experience under realistic conditions. Part I must be read before proceeding to Part II.

WARNING: Before applying power to the instrument, refer to the Receiving and Power Requirements tab.

PART I

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

Initial Setup

#1. Remove any diskettes from the disk recorders and leave the disk recorder door(s) open.

#2. Turn the oscilloscope power OFF. The power switch is located on the rear panel of the instrument.

#3. Turn all front panel control knobs fully counterclockwise.

#4. Place all lever switches to the down position.

Figure 6-1 illustrates the initial setup positions for the mainframe controls and Figure 6-2 illustrates the plug-in controls.

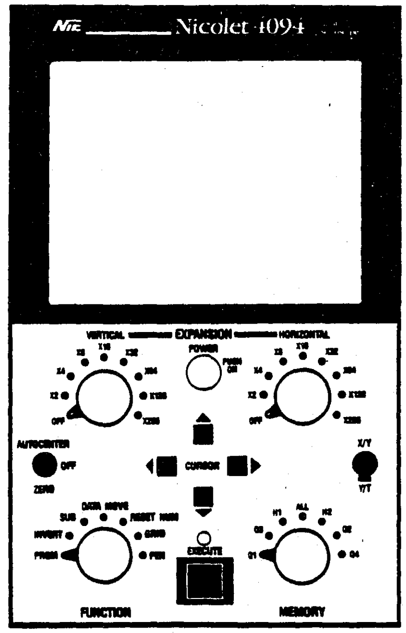


Figure 6-1

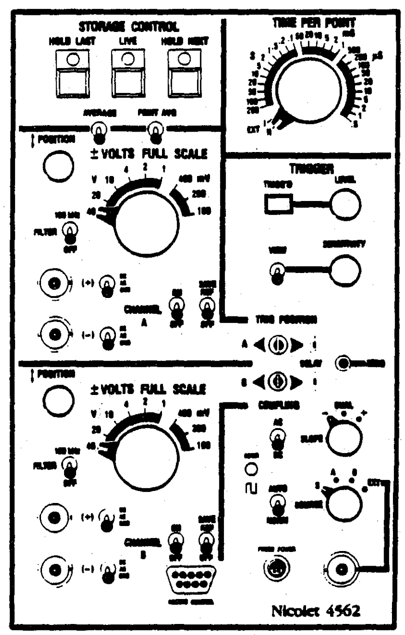


Figure 6-2

Overview of Controls

If the 4094 has two plug-ins, use only the left hand plug-in for this section (Part I). Place the right hand plug-in's CHANNEL A and B "ON/OFF" switches to the "OFF" positions.

#1. Turn the Power ON/OFF switch at the rear of the 4094 to ON.

#2. Make the following settings (Figure 6-3).
   a. Time Per Point: 10 µS
   b. Channel A: ON
   c. Trigger: AUTO
   d. Trigger Source: A
   e. Press the right hand plug-in's LIVE button (if applicable) and then the left hand plug-in's LIVE button.

After the left hand plug-in's LIVE button has been pressed, the screen will display a vertical and horizontal cursor, a trace, and a small trigger crosshair associated with channel A (Figure 6-4).

NOTE: Since the channel A inputs are 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 TRIGG'D LED is flashing, indicating that sweeps are occurring across the display screen. These sweeps are initiated by the AUTO trigger mode.

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 6-4) 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) is associated with the channel A input and is always located at zero time, zero voltage (0,0). Movement of the horizontal cursor beyond the upper/lower points 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. Releasing the CURSOR button and then pressing it again allows the cursor to "wrap-around" to the opposite side of the screen. This feature can be used to quickly move the cursor 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 the Autocenter mode.

#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.

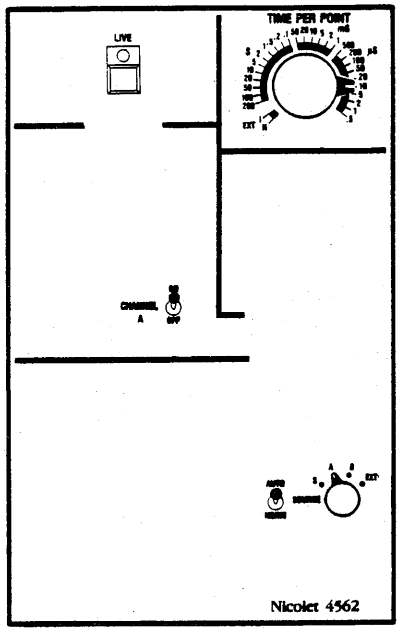


Figure 6-3

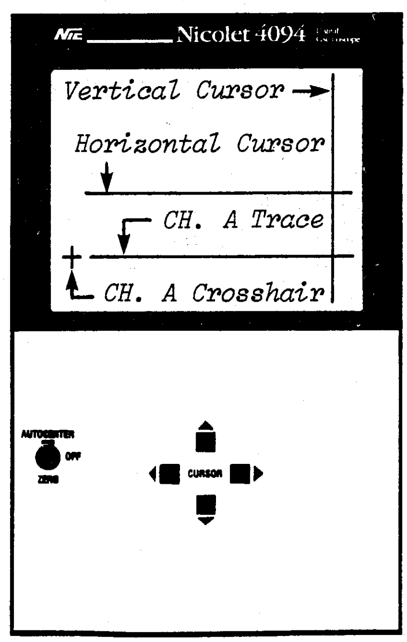


Figure 6-4

The UP/DOWN cursor controls are inoperative, but the RIGHT/LEFT cursor controls remain operational when Autocenter is turned on. The horizontal cursor always remains located at the intersection of the input waveform and the vertical cursor.

#5. Adjust the Channel A POSITION control (Figure 6-5) until the trigger cursor, trace, and horizontal cursor move to approximately the center of the screen.

Note that the voltage numerics remain unchanged during step #5. The POSITION knob affects the display position only, not the time or voltage values.

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

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

#7. Tap the LEFT or RIGHT cursor controls several times.

The crosshair and horizontal cursor alternates between the Channel A and Channel B traces.

To gain a clearer understanding of what is occurring as the cursor control is tapped:

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

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

#9. Tap the LEFT or RIGHT cursor buttons again (Figure 6-6).

The vertical cursor moves to the next, closest data point. The input traces appear to move because the display remains centered about the vertical cursor. The horizontal cursor moves to the intersection of the waveform and vertical cursor because the Autocenter mode is still switched on.

The "1A" or "1B" notations indicate whether channel A or channel B data is being inspected. The time and voltage numerics indicate the values associated with each data point coordinate.

Channel A and Channel B data points are captured 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 appear to be displayed in an alternating fashion as though they were taken at different times.

#10. Tap the LEFT/RIGHT cursor control several times (Figure 6-6).

The time numerics readout the same time value for each pair of data points (one from Channel A, one from Channel B) because the "paired" data points were captured at the same time.

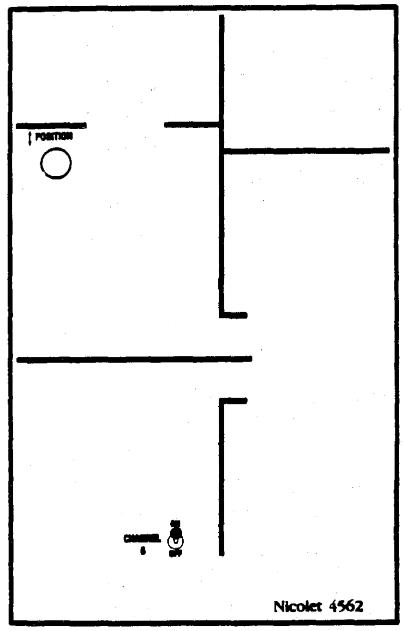


Figure 6-5

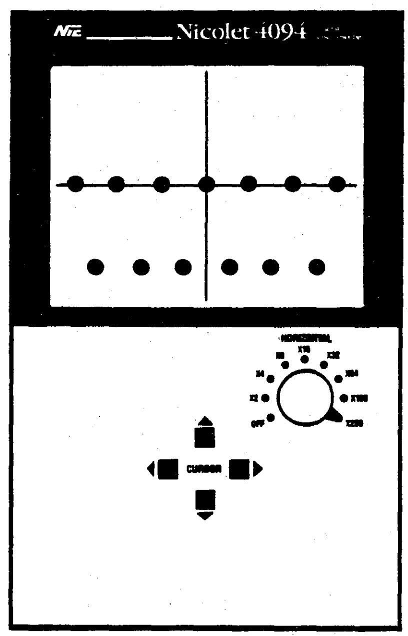


Figure 6-6

Note that the voltage numerics are approximately the same for both channels (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 judgments made when using analog oscilloscopes are not necessarily valid with digital oscilloscopes.

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 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:

#11. Place the HORIZONTAL EXPANSION switch to the OFF position (Figure 6-7).

#12. Place the TIME PER POINT switch to the 5 mS position (Figure 6-8).

#13. Press the LIVE button and observe the sweep speed as the trace moves across the screen (Figure 6-8).

#14. Switch the TIME PER POINT switch (Figure 6-8) back and forth between the 10 mS and 2 mS positions. Note the difference in sweep speed.

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 follow.

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

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

Note: Front panel settings are only acknowledged by the 4094 between sweeps. If a change is made to any front panel control which must be acknowledged immediately by the 4094, press the LIVE button. Pressing the LIVE button stops sweeps in progress, erases the display, and forces the 4094 to review all front panel settings before continuing. The LIVE button is a very powerful front panel control.

HOLD NEXT - Holds data points captured during the next sweep in the 4094 internal (display) memory. The most common situation is to press LIVE and then HOLD NEXT before a new sweep is started. Once the sweep is completed, only the HOLD LAST LED will be illuminated and the captured data will be stored in memory.

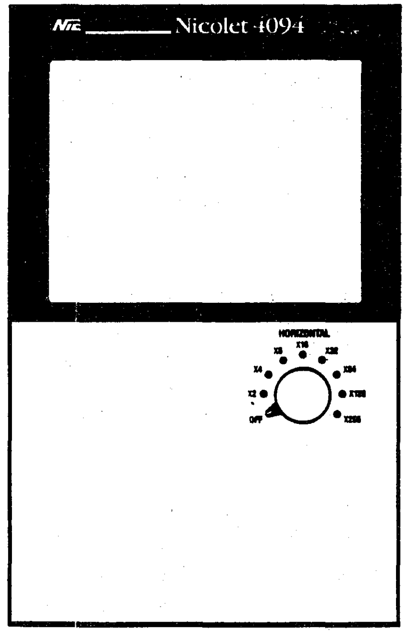


Figure 6-7

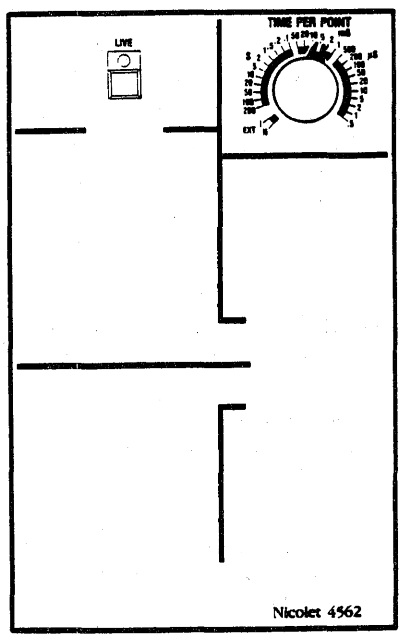


Figure 6-8

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

#16. Press the LIVE button.

#17. 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, only the HOLD LAST button will remain illuminated, the sweep stops (trigger light stops flashing), and all of the data captured during the last sweep is saved.

#18. Press the LIVE button.

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

Note that both the LIVE and HOLD NEXT LEDs are illuminated. Also note that the current sweep is not held, but the next sweep is held in 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 at the end of the next sweep.

#20. Press the LIVE button.

Sweeps resume across the screen.

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.

The five possible reasons for the above condition are listed below in the order of probability:

#1. The 4094 is not in LIVE and, therefore, will not allow new signals to enter the scope.

#2. Valid triggers are not present. 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! Select a faster Time-Per-Point setting and press the LIVE button.

#4. If 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.

#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.

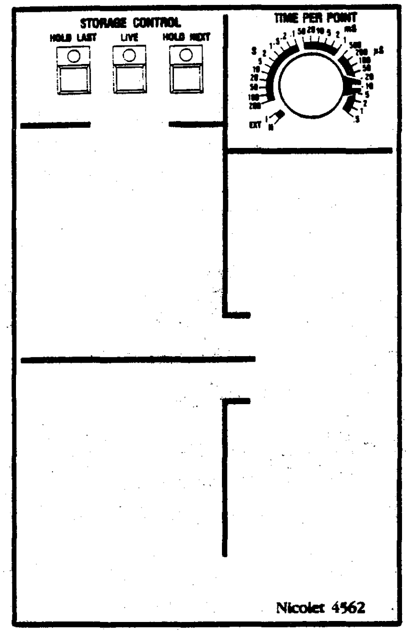


Figure 6-9

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.

Initial Setup

#1. All knobs on the front panels should be in the extreme counterclockwise positions, except -
  a. TIME PER POINT: 5 mS
  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

Figures 6-10 and 6-11 illustrates the initial setup positions for the mainframe and plug-in controls.

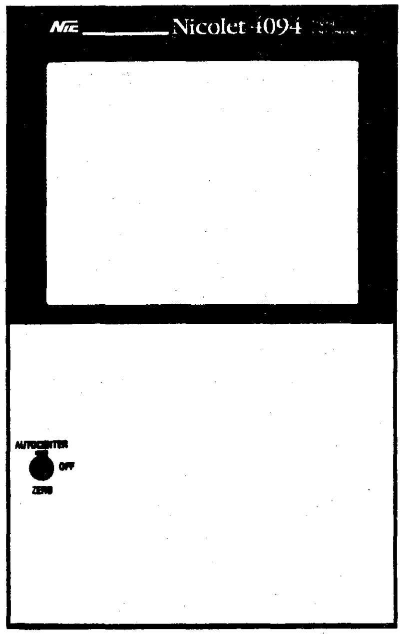


Figure 6-10

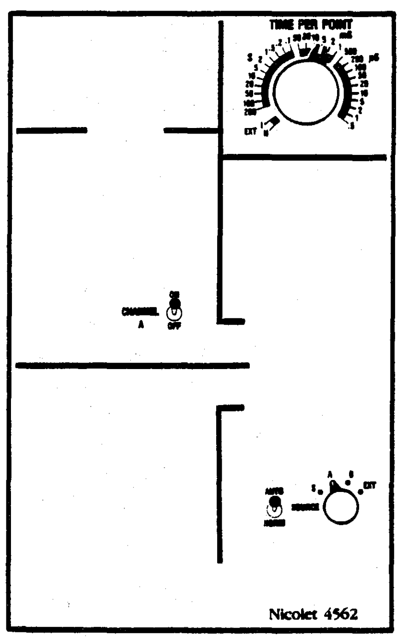


Figure 6-11

Overview of Controls

NOTE: The following figures identify the controls that 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. Position the Channel A (+) input BNC switch to DC.

The"DC" position allows both changing (AC) voltages and nonchanging (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).

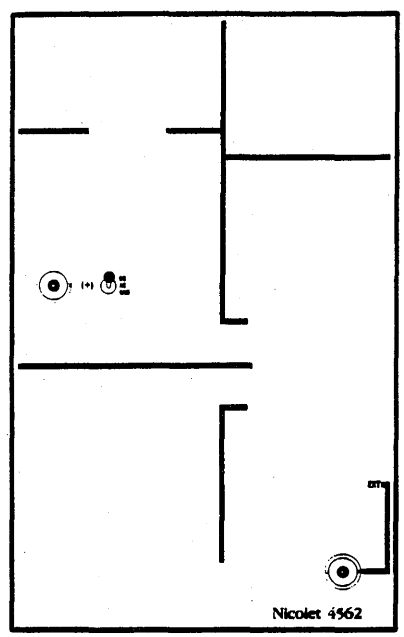


Figure 6-12

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

If necessary, adjust the Channel A POSITION control (Figure 6-12) 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 that can be viewed without being too large for the display area.

#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.

NOTE: Press the LIVE button after each new time-per-point setting is made, thus forcing the 4094 to acknowledge each new setting. It is not necessary, however, to press the LIVE button if rapid sweeps are occuring due to a <u>fast</u> time-per-point setting 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 (.5 µS) position while observing the display (Figure 6-13).

Shorter times between sample points make the waveform to appear stretched out.

#6. Move the TIME PER POINT switch (Figure 6-13) one step at a time in the counterclockwise direction.

The longer the times between sample points, the more compressed the waveform appears. When the waveform becomes so compressed that the actual waveshape 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 that 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 cannot 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.

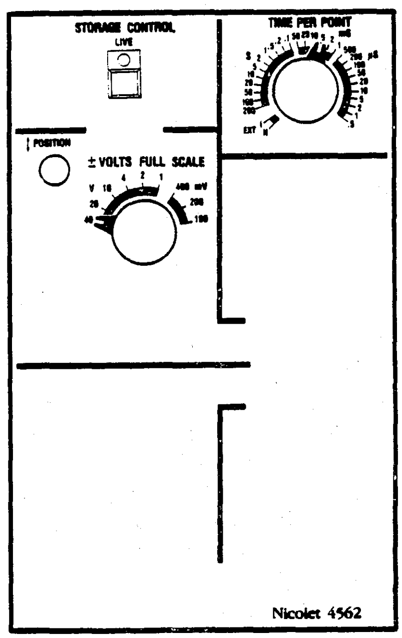


Figure 6-13

#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 counterclockwise 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:

Period = 1/frequency (in Hertz)

A quick mental approximation is usually sufficent to avoid undesirable 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 triggering with the input signal.

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

#12. Make sure that the trigger SOURCE switch (Figure 16-14) is still set at "A".

#13. Press the LIVE button (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.

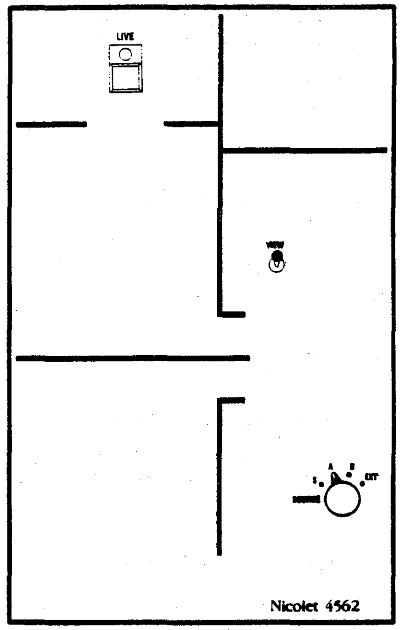


Figure 6-14

#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 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 trigger 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 horizontal lines intersect the waveform, triggers will be synchronized with the input.

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 means the input signal needs 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).

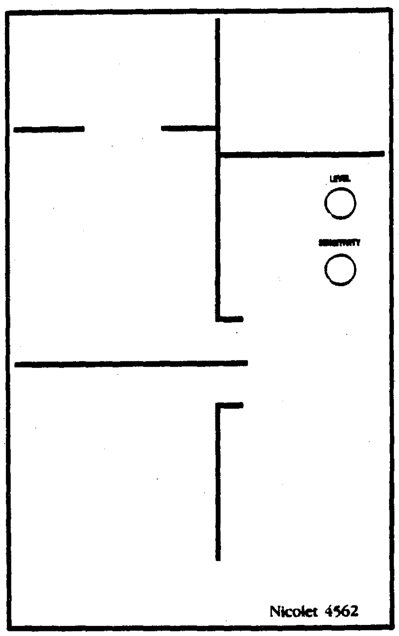


Figure 6-15

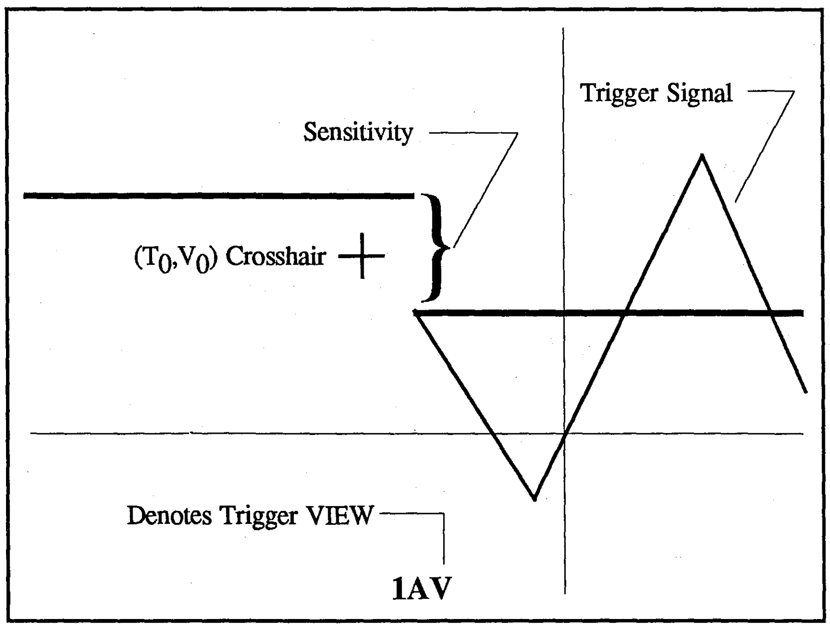


Figure 6-16

#17. Place the trigger SLOPE switch to the "DUAL" and then "+" positions while observing the display.

The trigger SLOPE switch determines whether the triggers take place on either rising (+) 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 because only one sweep is required.

#19. Turn trigger VIEW off (Figure 6-17).

The input signal is now easily viewed.

SUMMARY

Parts I and II have covered the essential 4094 front panel controls which are necessary for virtually any standard measurement. Many contols 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.

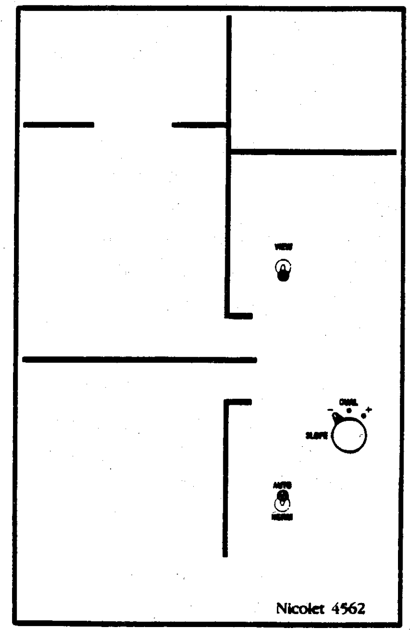
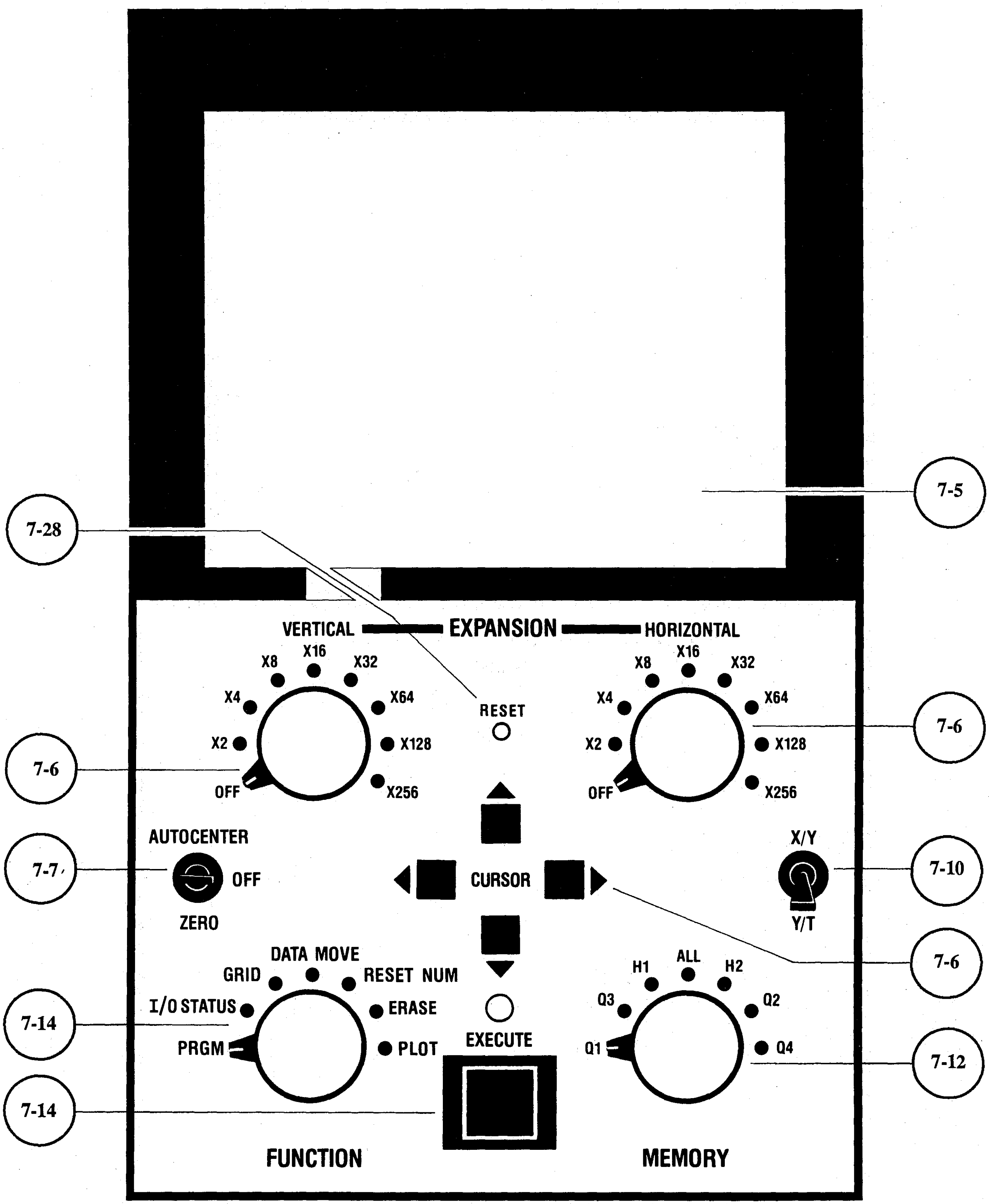


Figure 6-17

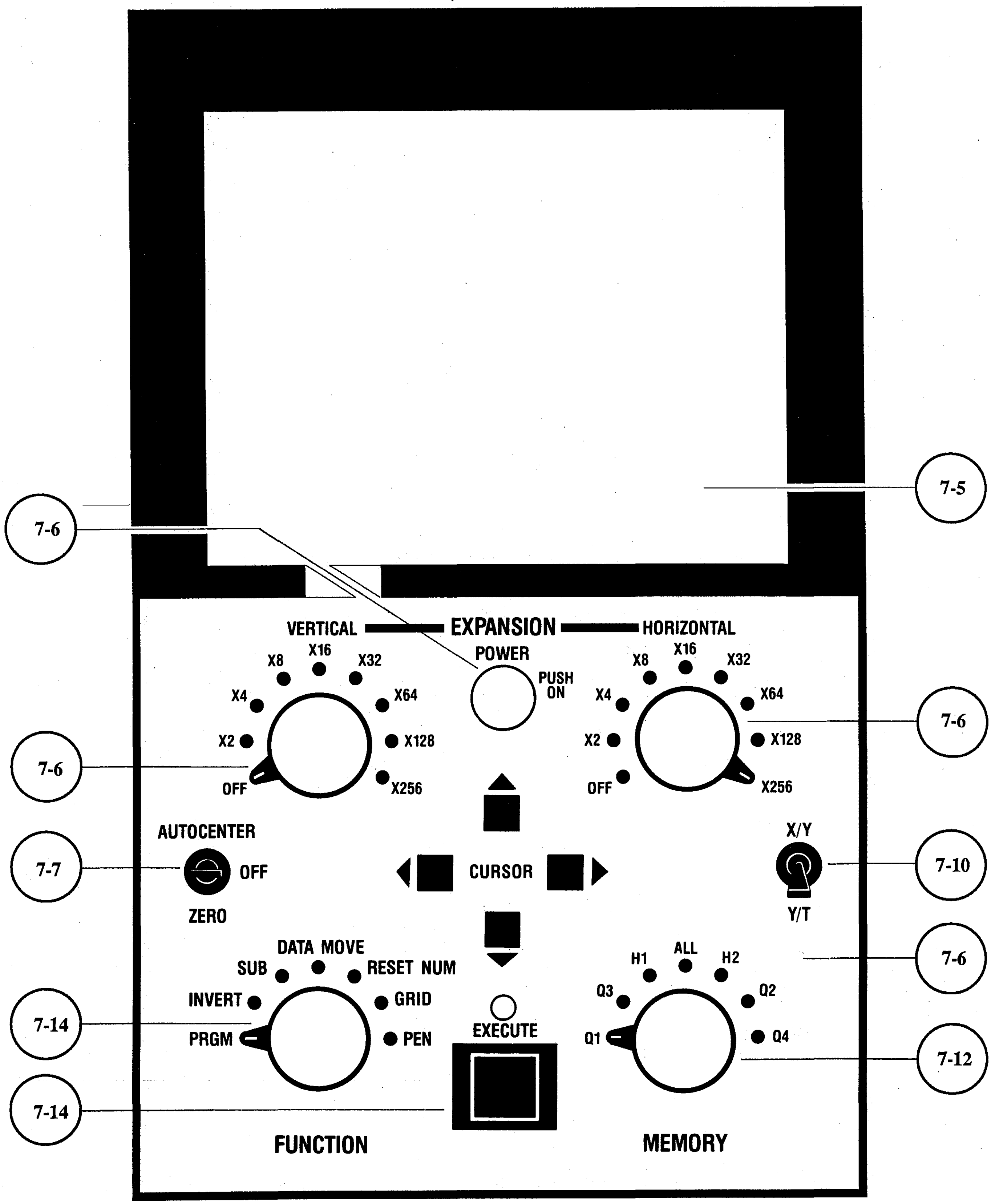
MAINFRAME (4094C)



Refer to the reverse of this page for the 4094A and 4094B.

06-01-87

MAINFRAME (4094A & 4094B)



INTRODUCTION

> **IMPORTANT:** This section includes descriptions for the Model 4094A, 4094B, and 4094C oscilloscopes. Unless otherwise noted, the following descriptions pertain to all three models.

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

Features include -

Horizontal expansion up to x256.

Vertical expansion 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 either halves or quarters.

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 (LIVE and HOLD NEXT LEDs off, HOLD LAST LED on).

IMPORTANT: Every third data point is displayed when the Function switch is in the **ALL** position. All of the data points are displayed when the display is either expanded or the Function switch is in either the **H1** or **H2** positions.

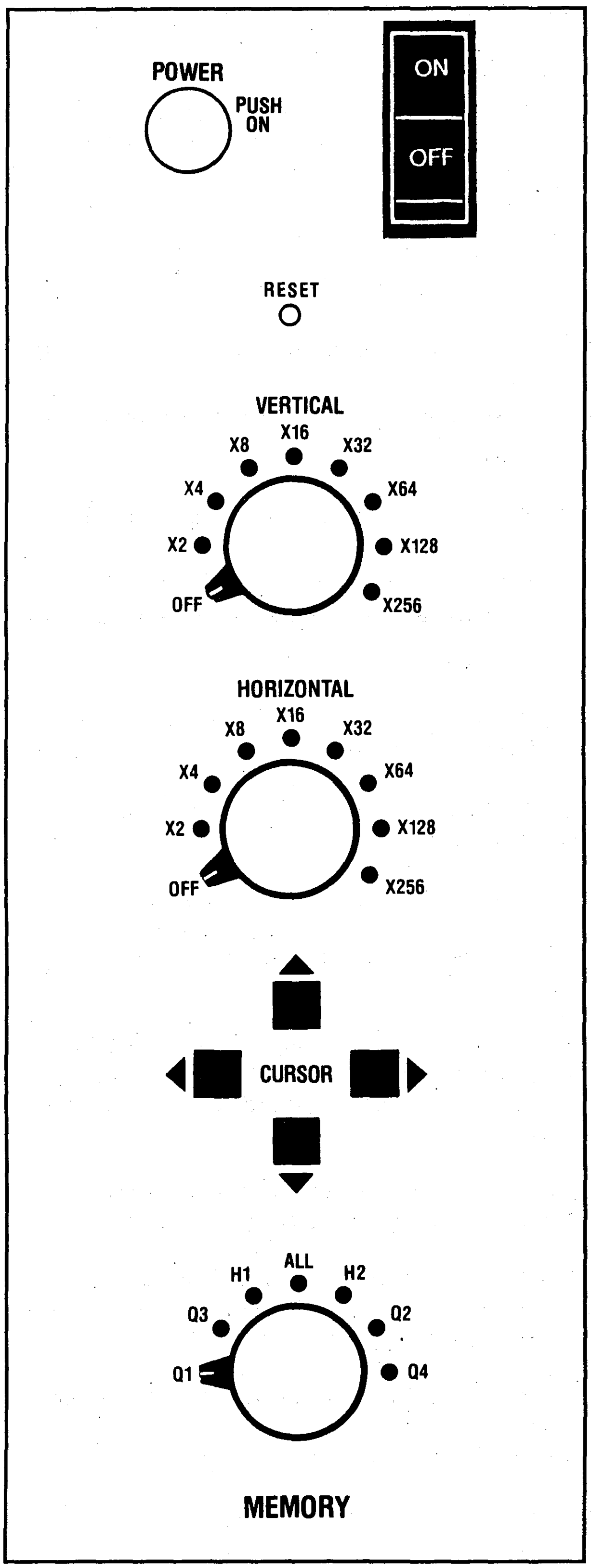
NUMERICS SYMBOLOGY

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}
? = Note 1	10^{21}
! = Note 1	10^{24}

Table 7-1

NOTE 1: 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 ON/OFF OPERATOR

Push the knob in to apply power to the 4094A and 4094B. The power operator for the 4094C is on the rear panel.

RESET

Resets 4094C memories. See page 7-28.

VERTICAL EXPANSION SWITCH

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

HORIZONTAL EXPANSION SWITCH

Horizontally expands the display data group by up to 256 times.

CURSOR BUTTONS

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

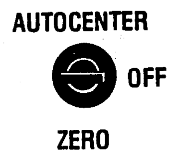
MEMORY SWITCH

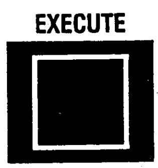
Determines the length of record for the data group to be acquired. Also determines where a waveform will be stored, or which data group(s) will be displayed.

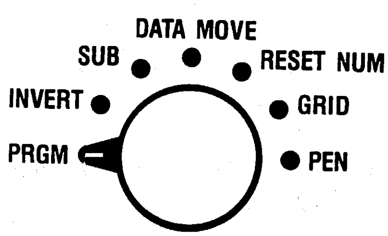
ALL: 15,872 (16K) words.

H1 & H2: 7,936 (8K) words, each.

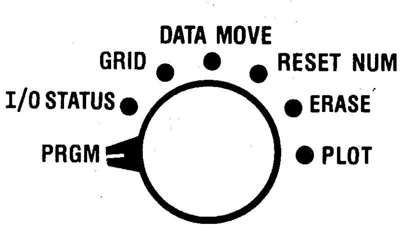
Q1 - Q4: 3,968 (4K) words, each.







Models 4094A & 4094B only.



Model 4094C only.

AUTOCENTER SWITCH

AUTOCENTER - Data group passes through screen center when vertical and horizontal expansions are turned on. When the Expansion switches are turned off, the horizontal cursor intersects the vertical cursor at the coordinate decoded by the numerics display.

OFF - Turns Autocenter off.

ZERO - Repositions the mainframe's horizontal cursor to the zero volts coordinate.

XY/YT SWITCH

XY - Displays 1 data group as a function of another.

YT - Displays data as voltage functions of time.

FUNCTION SWITCH

The **EXECUTE** button must be pressed (except for GRID) before the selected function will be performed.

PRGM - Activates functions recalled from the Program diskettes.

I/O STATUS (**) - Displays I/O status on screen.

GRID - Allows an electronic graticule to appear on the screen.

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.

SUB (*) - Subtracts one data group from another. Adds two data groups if one group is inverted first.

RESET NUM - Resets the voltage-time origins (0,0) to any point on the screen selected by the intersection of the vertical and horizontal cursors.

ERASE (**) - Erases displayed data from the screen.

PEN (*) - Initiates a pen recording output.

PLOT (**) - Initiates a plot output.

* Models 4094A and 4094B only.
** Model 4094C only.

DISPLAY COMPONENTS

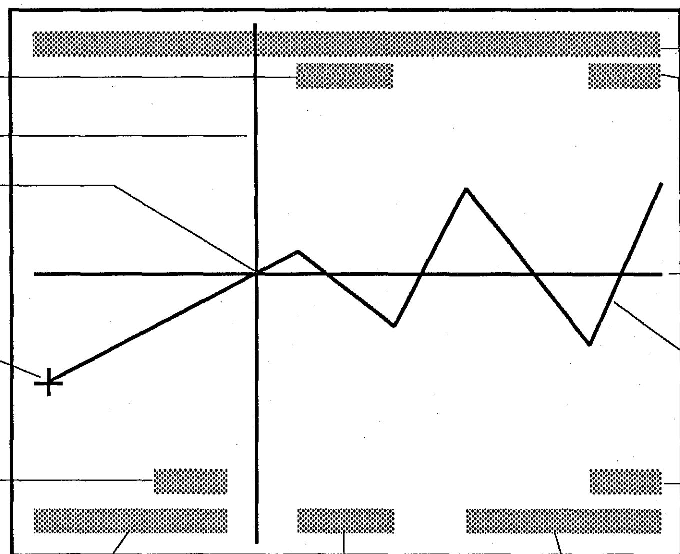


Figure 7-1

Status Line
Function of the Disk Programs. See Disk Programs tab.

Reset Numerics Indicator
Indicates new (0,0) origins have been selected.

Data Group
The displayed input signal.

Trigger Cursor
Identifies the time and voltage (0,0) origins. See Plug-ins tab.

X-Axis & Y-Axis Identifiers
Identify which Plug-in/Channel captured the displayed voltage values. (Appear in the XY mode only.)

Computer Control Indicator
Indicates the front panel controls are inhibited. See the Input/Output tab and the Disk Programs tab.

Left Numerics

YT Mode - Time coordinates.

XY Mode - X-axis voltage.

Right Numerics

YT Mode - Voltage coordinates.

XY Mode - Y-axis voltage.

Trigger View - Upper/lower threshold voltages. See Plug-ins tab.

Plug-in/Channel Identifier
Identifies which Plug-in/Channel captured the signal. In addition:

1AR = Plug-in 1/Channel A; Save Reference mode selected.

1AV = Plug-in1/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.

CURSOR BUTTONS

The CURSOR buttons manipulate the mainframe's vertical and horizontal cursor. They also manipulate the display data group, depending upon whether or not the Autocenter and/or display Expansion modes are being used. Refer to the Plug-ins tab, Auto-center switch description.

NOTE: The 4094 includes cursor "wrap-around" features which allow the cursor to quickly reposition from one side of the screen to the opposite side without having to recross the entire screen (see Figure 7-2).

Systems shipped before May, 1982 "wrap-around" automatically when the screen's displaying limit is reached.

Systems shipped after May, 1982 stop the vertical cursor after reaching the screen's left or right display limits. This prevents the cursor from "overshooting" the first or last data point of the trace.

To "wrap-around" the vertical cursor, momentarily release the left/right cursor button and then press the button again.

The horizontal cursor "wraps-around" automatically upon reaching the upper/lower screen's displaying limit.

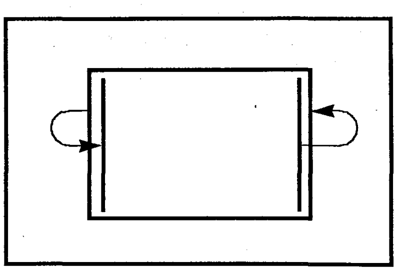


Figure 7-2

EXPANSION SWITCHES

The displayed data group can be symmetrically expanded by 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 and data point it is intersecting reposition to screen center. All other data points reposition by the same amount, symmetrically expanding about the horizontal cursor.

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

Example 7-1

Figure 7-3: An unexpanded display.

Figure 7-4: After horizontally expanding the display by a factor of X4.

Figure 7-5: After vertically expanding the display by a factor of X4.

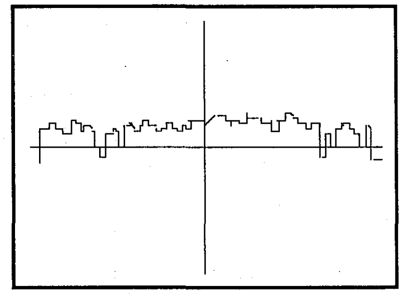


Figure 7-3

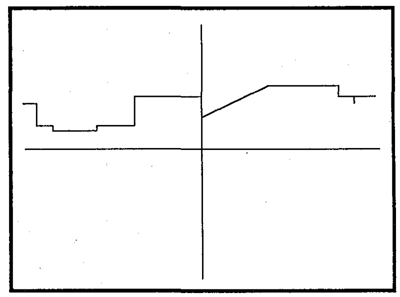


Figure 7-4

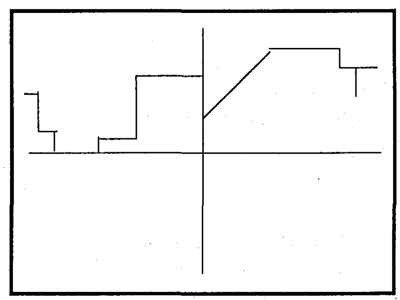


Figure 7-5

AUTOCENTER SWITCH

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

ZERO - The mainframe horizontal cursor repositions to the zero volts location. This position is spring-loaded, automatically returning to the OFF position when released.

OFF - Turns Autocenter off, enabling individual display elements to be manipulated via the Cursor buttons. Which element(s) will be affected depends upon the positions of the Expansion switches (see Table 7-2).

AUTOCENTER - The mainframe crosshair superimposes over the data point intersected by the vertical cursor.

With horizontal expansion applied, 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 captured the displayed data point being inspected. (e.g., 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).

HORIZONTAL EXPANSION TURNED -	VERTICAL EXPANSION TURNED -	CURSOR BUTTONS PRESSED	
		LEFT or RIGHT	UP or DOWN
OFF	OFF	Vertical Cursor moves.	Horizontal Cursor moves.
OFF	ON	Vertical Cursor moves.	Data Group moves.
ON	OFF	Data Group moves.	Horizontal Cursor moves.
ON	ON	Data Group moves.	Data Group moves.

Table 7-2 - Autocenter Turned OFF

HORIZONTAL EXPANSION TURNED -	VERTICAL EXPANSION TURNED -	PRESSING THE LEFT OR RIGHT CURSOR BUTTONS AFFECTS THESE ELEMENTS -
OFF	OFF	Horizontal and Vertical Cursors move.
OFF	ON	Vertical Cursor moves.
ON	OFF	Horizontal Cursor and Data Group move.
ON	ON	Data Group moves.

Table 7-3 - (Autocenter Turned ON)

Autocenter & Expansion Combined

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

This method of viewing data allows a specific area of interest to be repositioned to screen center for closer 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. Turn on Autocenter.
   a. The mainframe crosshair superimposes over the data point intersected by the vertical cursor.

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

#4. Press the left or right Cursor button.
   a. The data group passes through screen center.

Example 7-2

Figure 7-6: An unexpanded display. The vertical cursor is positioned over the area of interest.

Figure 7-7: The Autocenter mode was switched on. The mainframe crosshair superimposes over the data point intersected by the vertical cursor.

Figure 7-8: With 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.

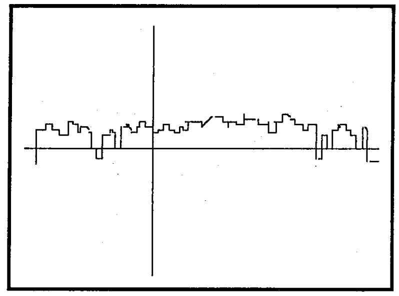


Figure 7-6

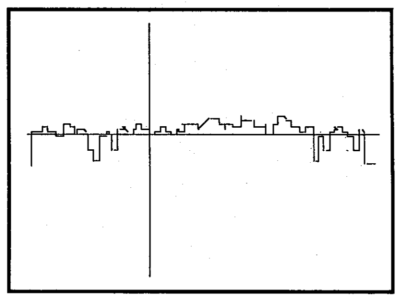


Figure 7-7

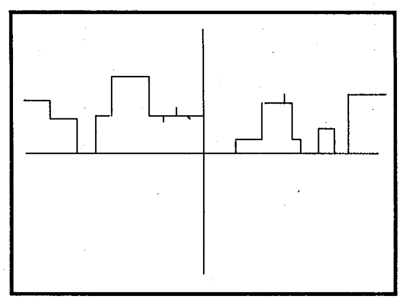


Figure 7-8

Multiple Data Group Displays

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

Turning Autocenter on superimposes the mainframe crosshair over the data point being inspected. The crosshair alternates between the data groups with either the left or right Cursor button is pressed.

Example 7-3

Figure 7-9: 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 7-10: The same display, but with Autocenter switched on. The mainframe crosshair superimposes over the data point being inspected. The Plug-in/Channel numerics indicate which Plug-in/Channel captured the data point being inspected.

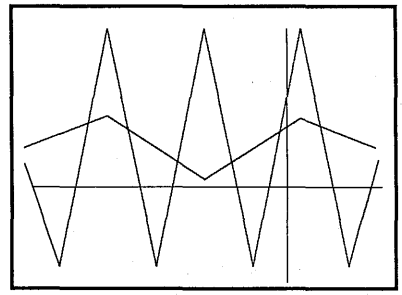


Figure 7-9

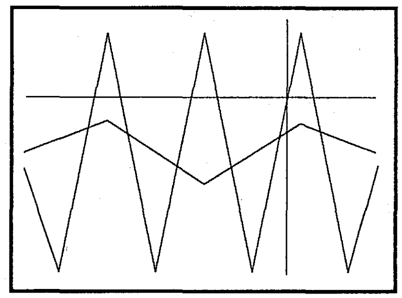


Figure 7-10

XY/YT SWITCH

The YT Position

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 Auto-center switched on, this intersection will coincide with a specific data point.

The XY Position

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 Auto-center switched 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 is displayed over the Right Numerics.

Store the X-axis data group in the Q1, Q2, or H2 subsections of the display memory. The Y-axis data group must be stored in the corresponding subsections of 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 into which subsections the respective data groups must be stored, and the Memory switch position required for the XY display.

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 mode of operation when capturing signals with two channels. Input the X-axis signal to channel A and the Y-axis signal to channel B.

Example 7-4

Figure 7-11: Two data groups displayed in the YT mode.

Figure 7-12: The same two data groups displayed in the XY mode.

Memory Switch Position Required for XY Displays	AXIS and corresponding SUBSECTIONS	
	X-axis	Y-axis
ALL	H1	H2
H1	Q1	Q3
H2	Q2	Q4

Table 7-4

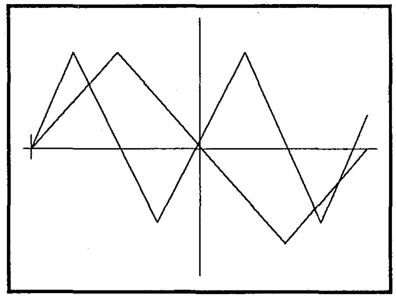


Figure 7-11

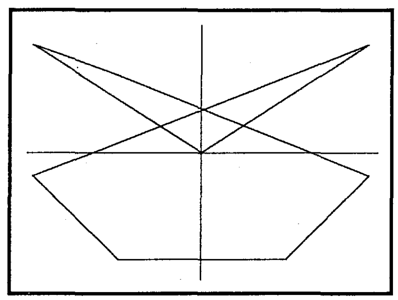


Figure 7-12

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. Turn on Autocenter.

#6. Apply both vertical and horizontal expansion if the XY display is to pass through screen center. If the 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.
Left Numerics = X-axis volts
Right Numerics = Y-axis volts

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

Table 7-5 summarizes into which subsections the respective signals will be routed 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

Rotating an XY Display

4094A & 4094B Only

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 recapturing the signals, by following the appropriate procedure.

A. Rotating Q1 and Q3

#1.	XY/YT:	YT
#2.	MEMORY:	Q1
#3.	Execute	SUB
#4.	MEMORY:	Q3
#5.	Execute	SUB
#6.	MEMORY:	Q1
#7.	Execute	SUB
#8.	MEMORY:	H1
#9.	Execute	INVERT
#10.	XY/YT:	XY

B. Rotating H1 and H2

#1.	XY/YT:	YT
#2.	MEMORY:	H1
#3.	Execute	SUB
#4.	MEMORY:	H2
#5.	Execute	SUB
#6.	MEMORY:	H1
#7.	Execute	SUB
#8.	MEMORY:	ALL
#9.	Execute	INVERT
#10.	XY/YT:	XY

C. Rotating Q2 and Q4

#1.	XY/YT:	YT
#2.	MEMORY:	Q2
#3.	Execute	SUB
#4.	MEMORY:	Q4
#5.	Execute	SUB
#6.	MEMORY:	Q2
#7.	Execute	SUB
#8.	MEMORY:	H2
#9.	Execute	INVERT
#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.

The display memory is typically left intact, allowing it to record a single input signal with all (16K) words of memory. This provides the highest detailed reproduction of the input signal.

Dividing the memory into subsections (halves or quarters) allows multiple data groups to be compared or arithmetically manipulated.

Example 7-5

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

Figure 7-13: Intact memory of (16K) words. All data points are displayed.

Figure 14: Memory divided into two (8K) subsections. Alternate data points are displayed.

Figure 15: Memory divided into four (4K) subsections. Every fourth data point is displayed.

Storing Data Groups

The position selected on the MEMORY switch at the time of signal 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 when the memory is divided.

Example 7-6

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

Figure 7-17: The input signal will be recorded with (8K) words of memory and stored in subsection H1 or H2 as determined by the position of the MEMORY switch.

Figure 7-18: The input signal will be recorded with (4K) words of memory and stored in subsection Q1, Q3, Q2, or Q4 as determined by the position of the MEMORY switch.

16K	ALL (0,1,2,3,.... etc)

Figure 7-13

8K	H1 (0,2,4,6,...... etc)
8K	H2 (1,3,5,7,...... etc)

Figure 7-14

4K	Q1 (0,4,8,12,.... etc)
4K	Q3 (2,6,10,14,... etc)
4K	Q2 (1,5,9,13,..... etc)
4K	Q4 (3,7,11,15,... etc)

Figure 7-15

ALL =	**16K**

Figure 7-16

H1 =	**8K**
H2 =	**8K**

Figure 7-17

Q1 =	**4K**
Q3 =	**4K**
Q2 =	**4K**
Q4 =	**4K**

Figure 7-18

Viewing Stored Data Groups

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

NOTE: The plug-in must be in the Hold Mode.

Example 7-7

Figure 7-19: Either one (16K), two (8K), or four (4K) data groups will be displayed when the "ALL" position is selected.

Figure 7-20: Either a single (8K) or up to two (4K) data groups will be displayed when the "H1" or "H2" positions are selected.

Figure 7-21: A single (4K) data group will be displayed when the MEMORY switch is placed to either the "Q1, Q3, Q2, or Q4" positions.

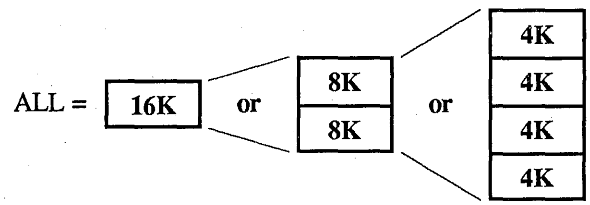


Figure 7-19

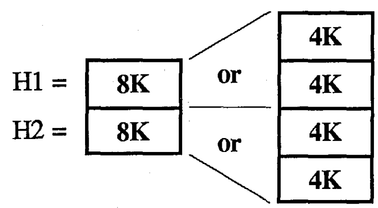


Figure 7-20

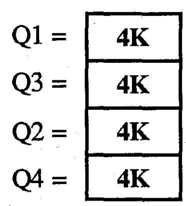


Figure 7-21

FUNCTION & EXECUTE

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

NOTE: The plug-in should be in the HOLD MODE before executing a function, or a valid trigger will replace the data stored in memory with new data collected during the next sweep.

4094A & 4094B

FUNCTION	PAGE
PRGM	7-14
INVERT	7-15
SUB	7-16
DATA MOVE	7-18
RESET NUMERICS	7-19
GRID	7-24
PEN	7-25

4094C Only

FUNCTION	PAGE
PRGM	7-14
I/O STATUS	7-27
GRID	7-24
DATA MOVE	7-18
RESET NUMERICS	7-20
ERASE	7-22
PLOT	*

* Refer to Section 15 "Digital Plotter".

PRGM (Program)

The PRGM position (when Executed) activates the one-button functions recalled from the Program diskettes.

Refer to the Standard Program Package manual for operating instructions.

INVERT

4094A & 4094B Only

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 capturing the signal.

To invert a data group:

#1. Store the data group.

#2. Place the plug-in into the Hold Mode.

#3. XY/YT switch: YT

#4. Turn off Horizontal expansion.

#5. Using the Memory switch, display the data group that is to be inverted.

#6. Function switch: INVERT

#7. Press the Execute button.

Example 7-8

Figure 7-22: Memory switch is in "ALL".

The upper data group A (analog and digital zeros not superimposed) was stored in **H1**.

The lower data group B (analog and digital zeros are superimposed) was stored in H2.

Figure 7-23: Memory switch is in "H1". Data group A after being inverted.

Figure 7-24: Memory switch is in "H2". Data group B after being inverted.

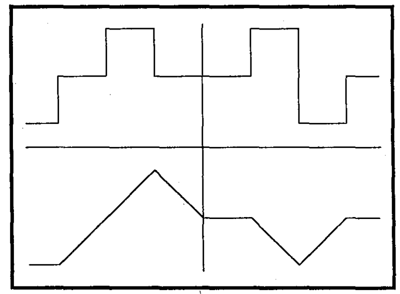


Figure 7-22

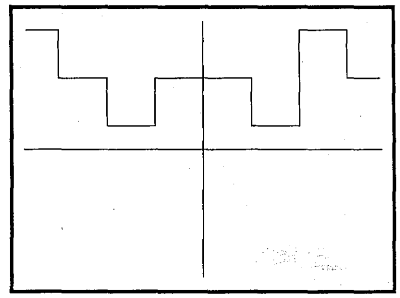


Figure 7-23

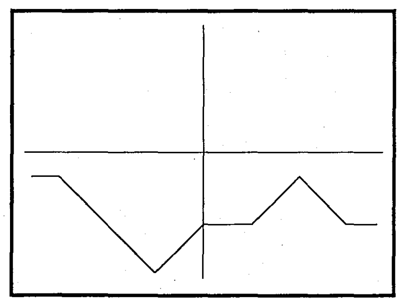


Figure 7-24

SUB (Subtract)

4094A & 4094B Only

Subtracts one data group from another. Data groups can also be added if the subtrahend is inverted before executing the SUB function.

NOTE: The 4094 must be in the YT display mode.

Subtracting data groups from each other is basically the process of storing two data groups in associated memory subsections (e.g., Q1 & Q3, Q2 & Q4, or H1 & H2), selecting which data group will be the subtrahend, and then executing the SUB function.

IMPORTANT: The SUB function is performed with reference to digital zero (screen center), rather than analog zero (crosshair position). Therefore, although the resulting signal amplitude is correct, the numerics will be offset unless the channel's analog zeros are set to screen center during acquisition. (A simple way to do this is with the GRID function.) If numeric results are important, use the Disk Program SUBTRACTION routine (see Disk Programs tab).

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 state) 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 to too large to be fully displayed on the screen, either recapture the signals using a larger ±Volts Full Scale setting, or use the SUBTRACTION program available on the Program Diskettes.

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

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

Memory Switch Position	EQUATIONS	
	Subtract	Add
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

Subtracting Data Groups

4094A & 4094B Only

To subtract a data group from another:

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

#2. Place the plug-in to the Hold Mode.

#3. XY/YT switch: YT

#4. Turn off Horizontal Expansion.

#5. Function switch: SUB

#6. Memory switch: Select which subsection will be the subtrahend.

#7. Press the Execute button.

To return the data groups to their original states, press the Execute button again.

Example 7-9

Figure 7-26 illustrates the effect of subtracting one of the data groups in Figure 7-25 from the other.

Adding Data Groups

4094A & 4094B Only

To add two data groups:

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

#2. Place the plug-in to the Hold Mode.

#3. XY/YT switch: YT

#4. Turn off Horizontal Expansion.

#5. Memory switch: Select which subsection will be the subtrahend.

#6. Function switch: INVERT

#7. Press the Execute button.

#8. Function switch: SUB

#9. Press the Execute button.

To return the data groups to their original states, execute a second SUB function and then an INVERT function.

Example 7-10

Figure 7-28 illustrates the effect of adding the two data groups in Figure 7-27.

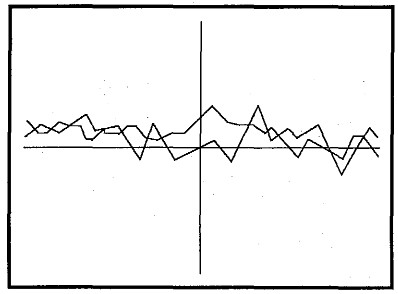


Figure 7-25

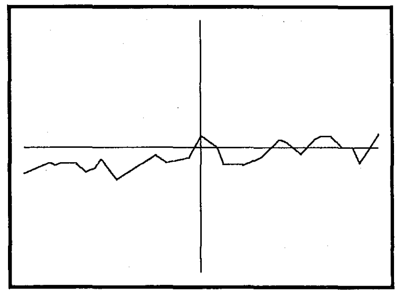


Figure 7-26

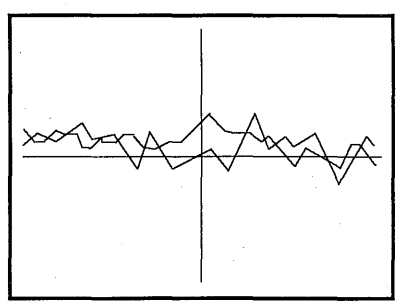


Figure 7-27

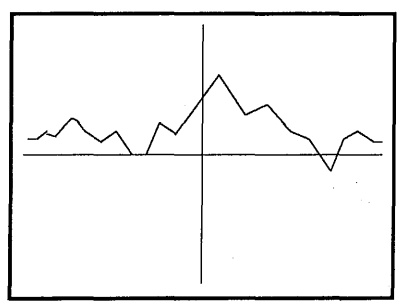


Figure 7-28

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.

NOTE: The 4094 must be in the YT display mode.

Data Moving One Data Group for Comparison with Another

#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. Position the Memory switch until both data groups are displayed.

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

#5. Position the Memory switch until only the data group that is to be moved is displayed.

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

#7. Function switch: DATA MOVE

#8. Press the Execute button.

#9. Position the Memory switch until both data groups are displayed.

Example 7-11

Figure 7-30 illustrates the effect of data moving one of the data groups in Figure 7-29.

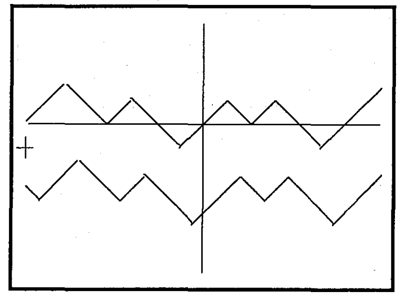


Figure 7-29

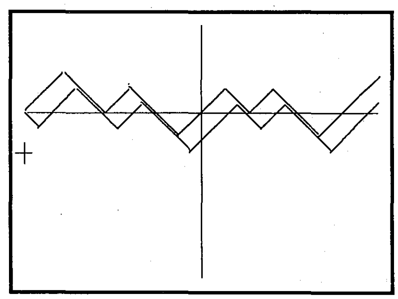


Figure 7-30

RESET NUMERICS

> **4094A, B & C**
> Also see page 7-20 for special 4094C procedure.

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 Turned On

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

The new (t=0, v=0) origin can be at any point on the screen as 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 (t=0, v=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 with Autocenter switched on, then that data point will become the new (t=0, v=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 (t=0, v=0) origin.

With Autocenter and XY Modes Turned On

The left numerics (X-axis' voltage) and right numerics (Y-axis' voltage) reset to (0,0) when Autocenter is switched on and the RESET NUMERICS function is executed. This corresponds to the data point coordinate intersected by the mainframe crosshair.

Example 7-12

Figure 7-31: Typical YT mode display with Autocenter switched on.

Figure 7-32: The same display after executing the RESET NUMERICS function. The plug-in's trigger crosshair has repositioned to the mainframe crosshair and both numerics have reset to zero.

Figure 7-33: The crosshair has been repositioned and the numerics reflect the selected data point's values relative to the new origin.

With Autocenter Turned Off

The left and right numerics always reset to zero when the RESET NUMERICS is executed. However, the left (time) numerics will change only when the vertical cursor is moved. Likewise, the right (voltage) numerics will change only when the horizontal cursor is moved.

NOTE: Autocenter must be switched on when inspecting data in the XY display mode.

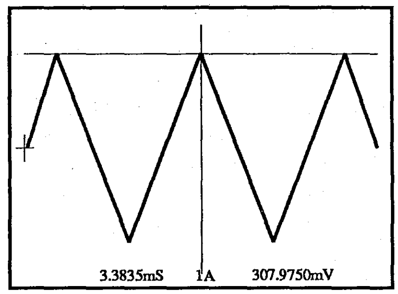


Figure 7-31

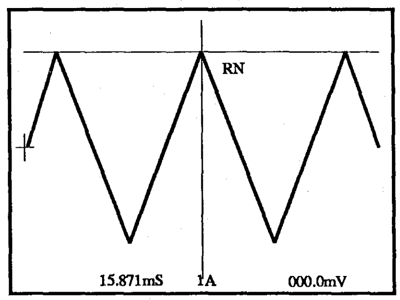


Figure 7-32

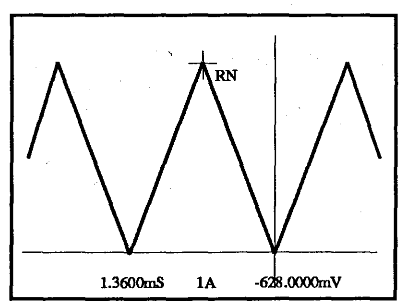


Figure 7-33

RESET NUMERICS

4094C Only
Also see page 7-19 for standard operation

The letters "RNA" or "RN" will appear below the status line depending upon whether or not Autocenter is turned on when RESET NUMERICS is executed.

NOTE: RNA mode is not available for the XY display mode.

With Autocenter and YT Modes Turned On

#1. Place the Function switch to RESET NUMERICS.

#2. Turn Autocenter ON.

#3. Depress and hold both the UP and DOWN Cursor buttons.

#4. Press EXECUTE and release the UP and DOWN Cursor buttons.

To Exit the Special Reset Numerics Function -

#1. Press EXECUTE.

Executing RESET NUMERICS with Autocenter turned on allows peak-to-peak voltages to be measured while in the LIVE mode. The small trigger crosshair moves to the current position of the main cursor intersection. If in the LIVE mode, the trigger cursor will follow the voltage level of the input signal.

The new (t=0, v=0) origins can be at any point on the screen as determined by the position of the main cursor intersection 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 (t=0, v=0) origins.

The data at the horizontal 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 with Autocenter switched on, then that data point will become the new (t=0, v=0) origin when the RESET NUMERICS function is executed.

The small trigger crosshair will immediately "jump" to the position of the main cursor intersection and the RNA indicator will be displayed as soon as the Execute button is pressed. The operator can use the main cursor intersection to inspect other points of interest without losing track of the new (t=0, v=0) origin.

Example 7-13a

Figure 7-34: Typical YT mode display with Autocenter switched on.

Figure 7-35: The same display after moving the main cursor to the positive peak and then executing the RESET NUMERICS function. The small trigger crosshair has repositioned to the main cursor intersection and both numerics have reset to zero.

Figure 7-36: The main cursor has been repositioned and the numerics reflect the selected data point's value with respect to the new origin.

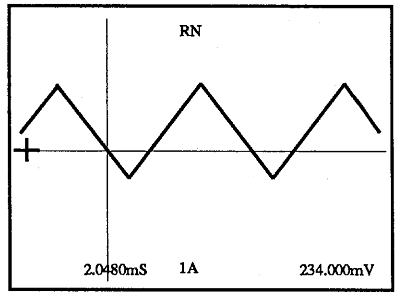


Figure 7-34

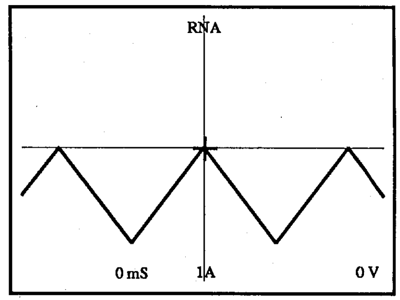


Figure 7-35

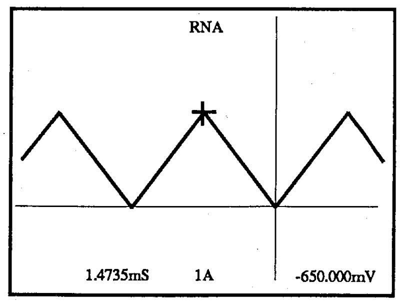


Figure 7-36

With Autocenter Turned Off

Pressing the Execute button when Autocenter is turned off will turn the RNA mode off. If the RNA mode is already off when the Execute button is pressed, the small trigger crosshair will move to the current main cursor intersection.

In other words, pressing the Execute button twice from an "RNA-mode-on-condition" leaves the unit in the same state as pressing the Execute button once from an "RNA-mode-off-condition".

See Example 7-13b on page 7-21

4094C Only

Example 7-13b

Figure 7-37: Typical RNA mode display after switching Autocenter off.

Figure 7-38: The same display after executing the RESET NUMERICS function. RNA mode is turned off and the small trigger crosshair is left in its current position.

Figure 7-39: The same display after once again executing the RESET NUMERICS function. The small trigger crosshair has repositioned to the main cursor intersection and both numerics have reset to zero.

Figure 7-40: The horizontal cursor has moved. The right numerics reflect the selected data point's voltage with respect to the new origin.

Figure 7-41: The vertical cursor has moved. The left numerics reflect the selected data point's time measurement with respect to the new origin.

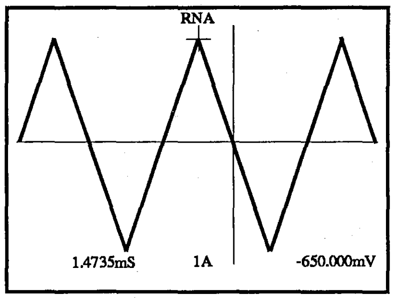


Figure 7-37

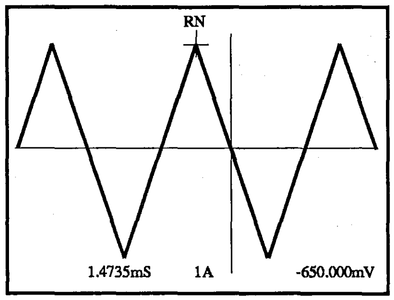


Figure 7-38

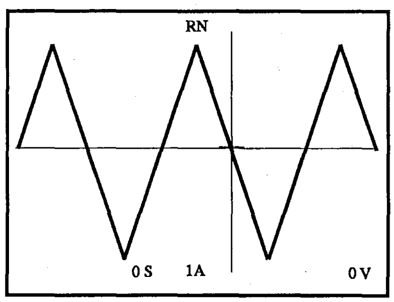


Figure 7-39

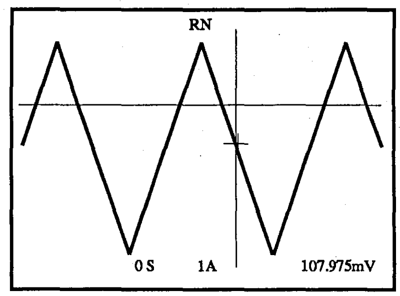


Figure 7-40

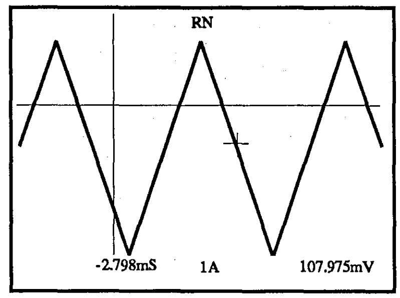


Figure 7-41

ERASE

4094C Only

Executing the ERASE function erases all of the waveforms currently displayed on the screen. The memory sections used to store the displayed data is also erased.

CAUTION: Backup important waveforms on a diskette before executing the ERASE function.

Erasing an Expanded Display

Only the portion of the waveform visible on the screen is erased when Horizontal Expansion is applied and the ERASE function is executed.

Example 7-14

Figure 7-43: Typical waveform display.

Figure 7-44: The same display after applying Horizontal Expansion.

Figure 7-45: The same display after executing ERASE and then turning Horizontal Expansion off.

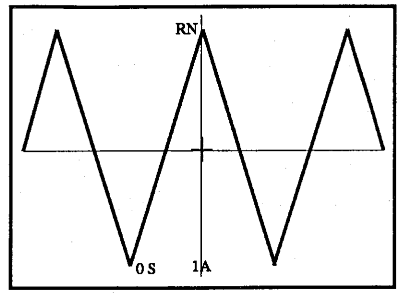


Figure 7-43

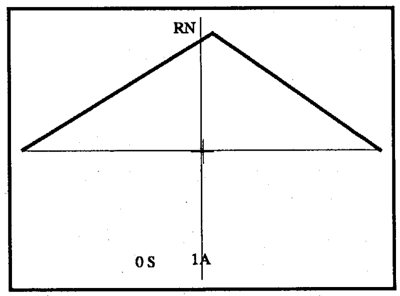


Figure 7-44

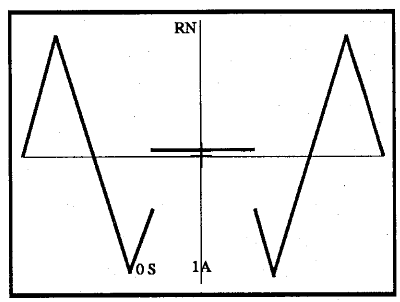


Figure 7-45

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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, but the mainframe's vertical and horizontal cursors disappear.

The left (time) numerics reflects the time per vertical line and the right (voltage) numerics reflects the volts per horizontal line.

NOTE: The grid expands to the horizontal limits of the display screen when Horizontal expansion is switched on. This occurs because all (16K) words of memory are used during expansion. 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 displayed data.

Example 7-15

Figure 7-46: Typical display of an input signal. The Time Per Point was set at 10 µS and the Volts Full Scale was set at ±2 volts.

Figure 7-47: The same display after selecting the GRID position.

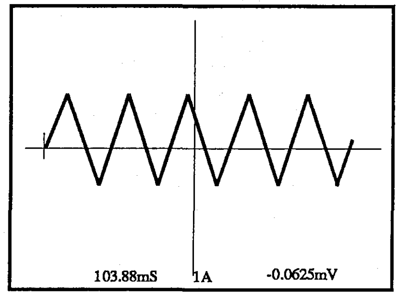


Figure 7-46

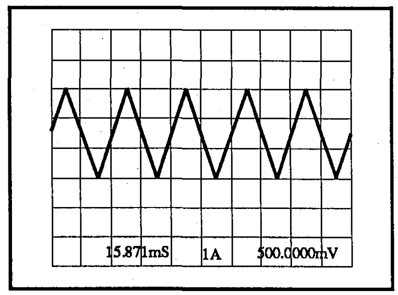


Figure 7-47

PEN

4094A & 4094B Only

The PEN controls (Figure 7-48) are located on the rear panel. These permit the recording of displayed data groups on either an XY or Strip Chart (YT) pen recorder.

NOTE: Refer to the tab labeled Digital Plotter for information on the digital plotter.

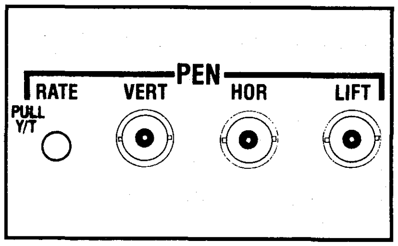


Figure 7-36

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 knob. For a strip chart (YT) recording, pull out the control knob.

- **XY Mode**

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 for very slow or faster pen recorders.

- **YT Mode**

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

Vertical & Horizontal BNCs

The VERT and HOR output BNCs are at approximately zero volts before the pen readout is executed. This corresponds to a vertical, negative full scale position on the paper, and the leftmost part of the waveform when using an XY recorder.

The VERT and HOR output BNC voltages will range up to approximately 5 volts while data is being recorded, and return to approximately 0 volts when the recording is completed.

Lift BNC

4094A & 4094B Only

The LIFT BNC's output voltage, before the pen readout is executed, depends upon the version of Mainframe installed.

a. Version 1.0 through 1.9
   The output is approximately 5 volts.

b. Version 2.0 and above
   The output is rated up to a maximum of 30 V at 200 mA.

To determine which version 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.

#3. Press and hold the Execute button while still holding in the left and right Cursor buttons. The Mainframe's version number appears 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, raising the pen nib.

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

Border Confirmation

4094A & 4094B Only

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

#1. Place the Function switch to PEN.

#2. Place the Autocenter switch to ZERO and hold.

#3. Press the Execute button.

#4. Release the Autocenter switch.

The pen moves from the lower left border limit to the upper right border limit, and then back again; delaying up to approximately 6 seconds at each limit before moving again.

NOTE: The vertical full scale limit will equal 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, repeat the above procedure for each confirmation.

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

Reproducing Waveforms

4094A & 4094B Only

After confirming the border limits, press the EXECUTE button to initiate the recording.

NOTE: The Autocenter switch must be in the OFF position and the Function switch in the PEN position.

If display expansion is turned on, only the displayed portion of the waveform will be reproduced by the pen recorder.

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

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

Aborting a Recording

Move the Function switch to a different position to abort a pen recording

I/O STATUS

4094C Only

Placing the Function switch to I/O STATUS and pressing the Execute button causes the Input/Output Status display to appear on the screen.

The operator can select I/O parameters directly from the screen (Figure 7-49), rather than using DIP switches as required with the 4094A and 4094B oscilloscopes.

NOTE: If the EPROM fails, a message indicating a failure has occurred will appear on the screen when the I/O STATUS function is exited (Execute button pressed). The oscilloscope will still operate properly with the newly selected parameters, but these will reset to their defaults if power is removed from the oscilloscope and then reapplied.

Procedure

#1. Place the Function switch to I/O STATUS and press Execute. The I/O Status display appears (Figure 7-49) and the plug-in(s) go into the Hold Last mode if not already in that mode. The disk and I/O ports will also be disabled.

#2. Using the UP/DOWN cursor buttons, position the small pointer at the right of the screen until it is aligned with the desired parameter. The pointer wraps-around automatically when the upper/lower screen limits have been reached.

#3. To make selections, press the LEFT/RIGHT cursor button until the desired value appears. The values wrap-around automatically when the maximum/minimum range has been reached.

#4. Press Execute after all of the desired settings have been made.

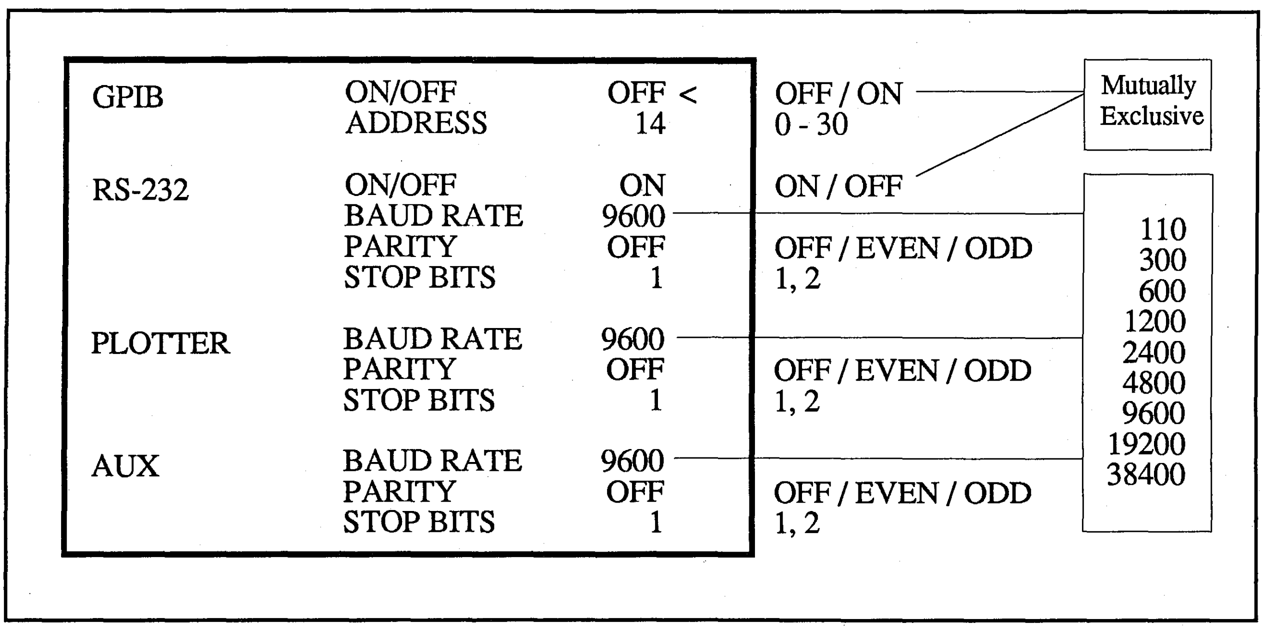


Figure 7-49

RESET BUTTON

The RESET button is mounted behind the Mainframe front panel and is operated by inserting a pointed object into the small access hole directly below the display screen.

The front panel LEDs will flash on and off when either of the following two methods of reset is used.

Method #1

Method #1 clears all data stored in memory and resets the I/O. The I/O STATUS screen parameter selections are not affected.

Procedure
Press the RESET button to clear all data stored in memory.

Method #2

NOTE: This method is applicable only when the 4094C is interfaced with the Disk Recorder accessory.

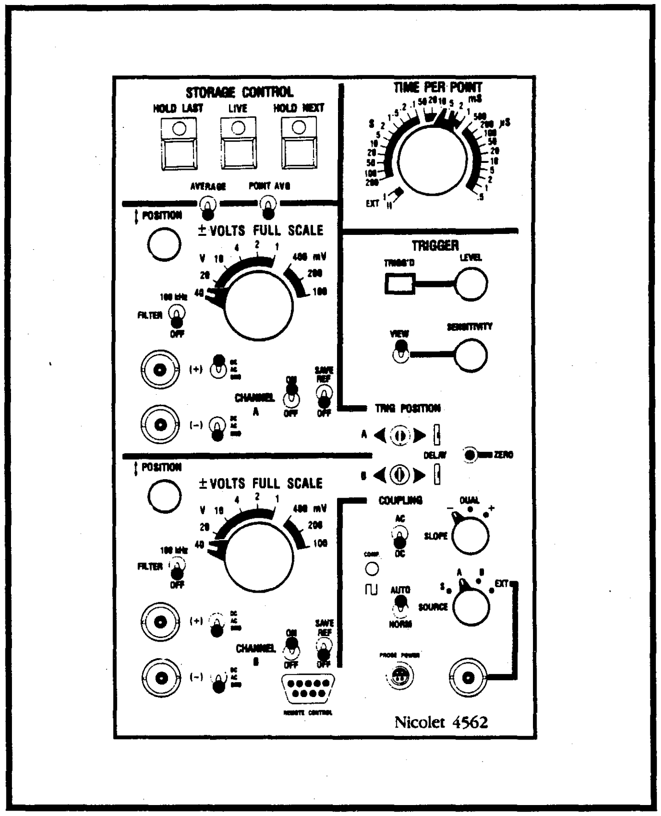
Method #2 resets the I/O only. Data stored in memory and I/O STATUS parameter selections are not affected.

Procedure
#1. Press and hold in either of the Disk Recorder UP or DOWN buttons.

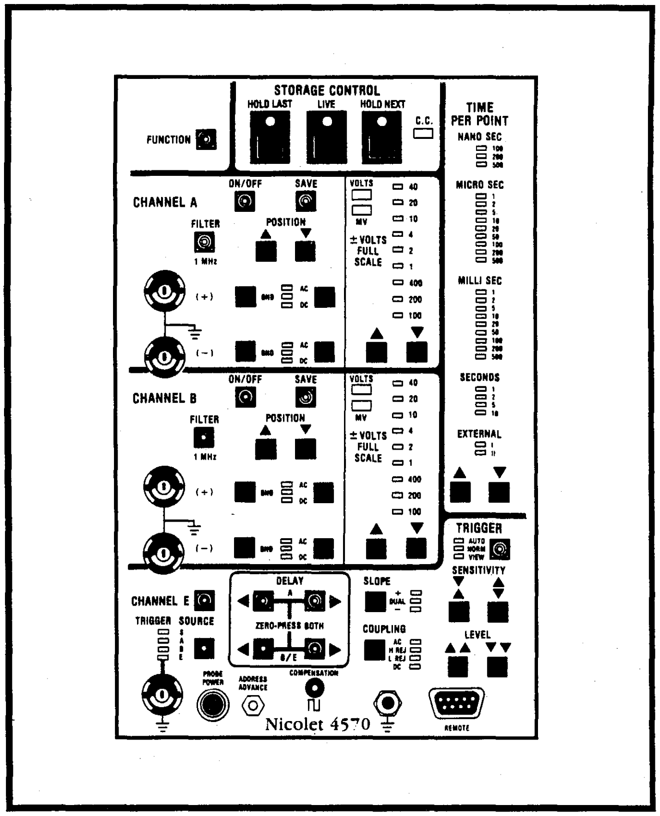
#2. Press the RESET button.

#3. Relese the UP/DOWN button.

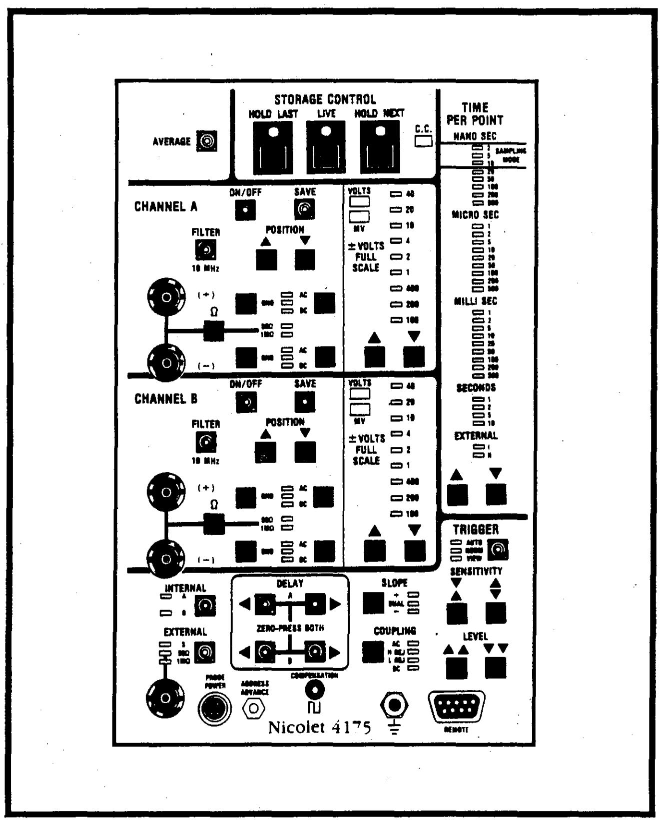
PLUG-INS



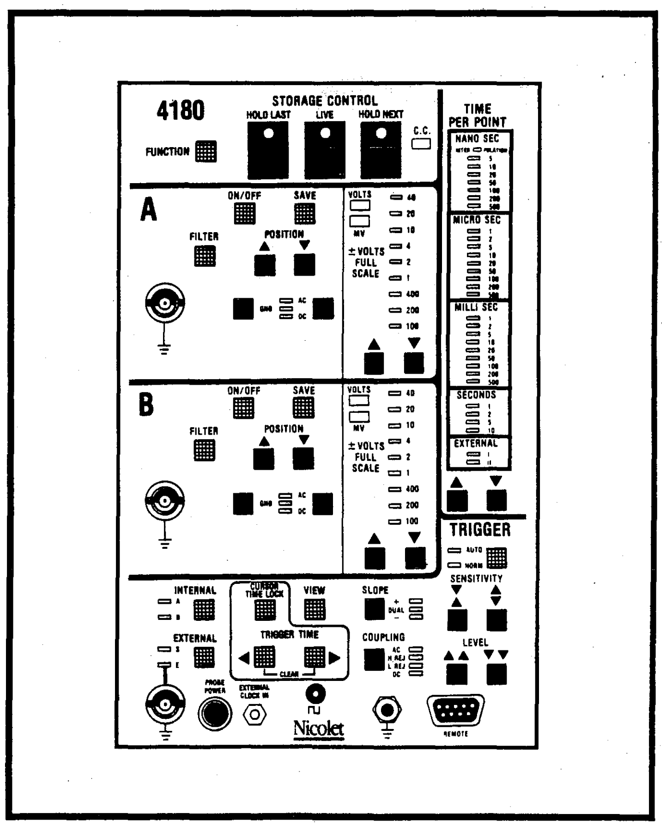
4562 & 4851 Plug-ins
(4562 shown)



4570 Plug-in



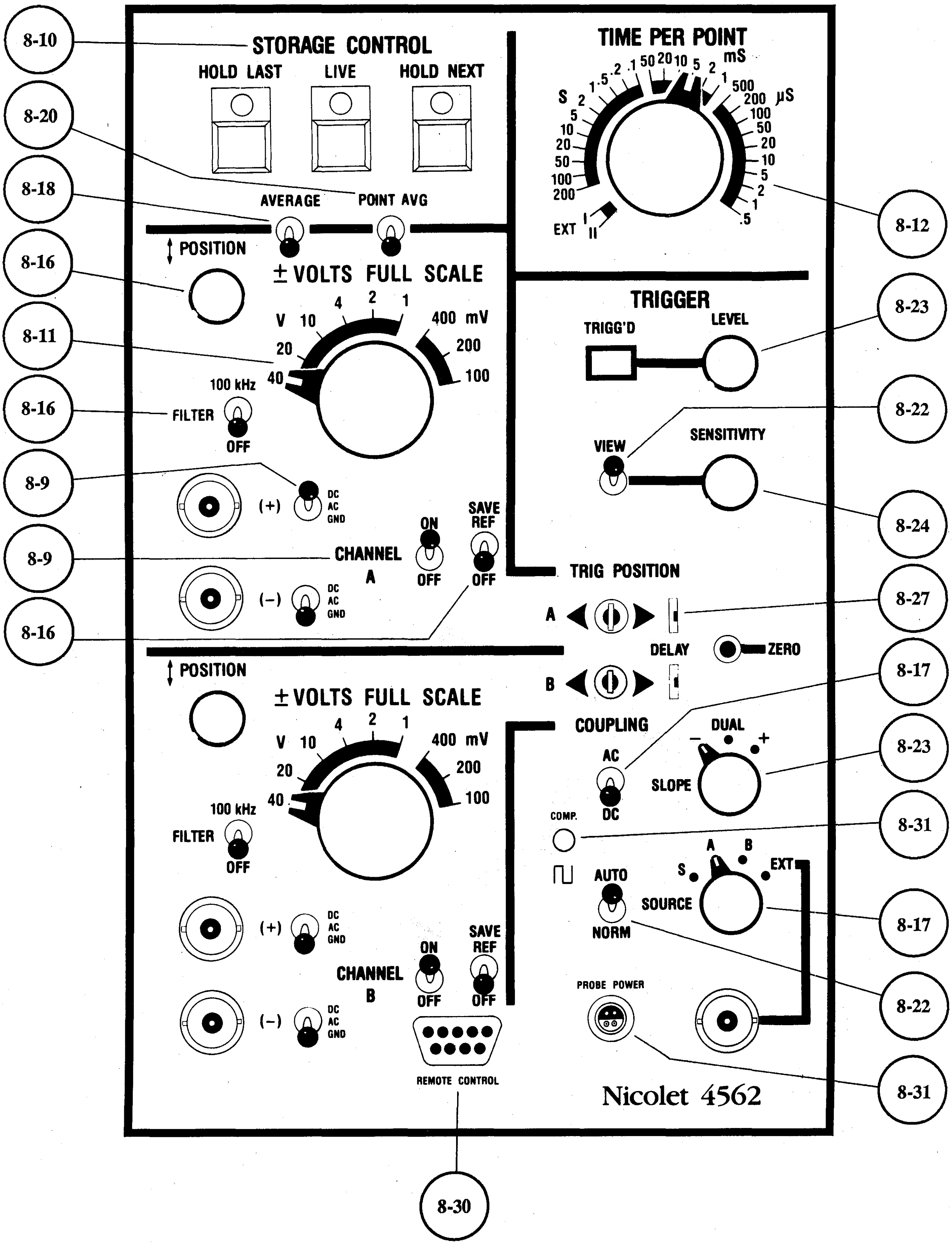
4175 Plug-in



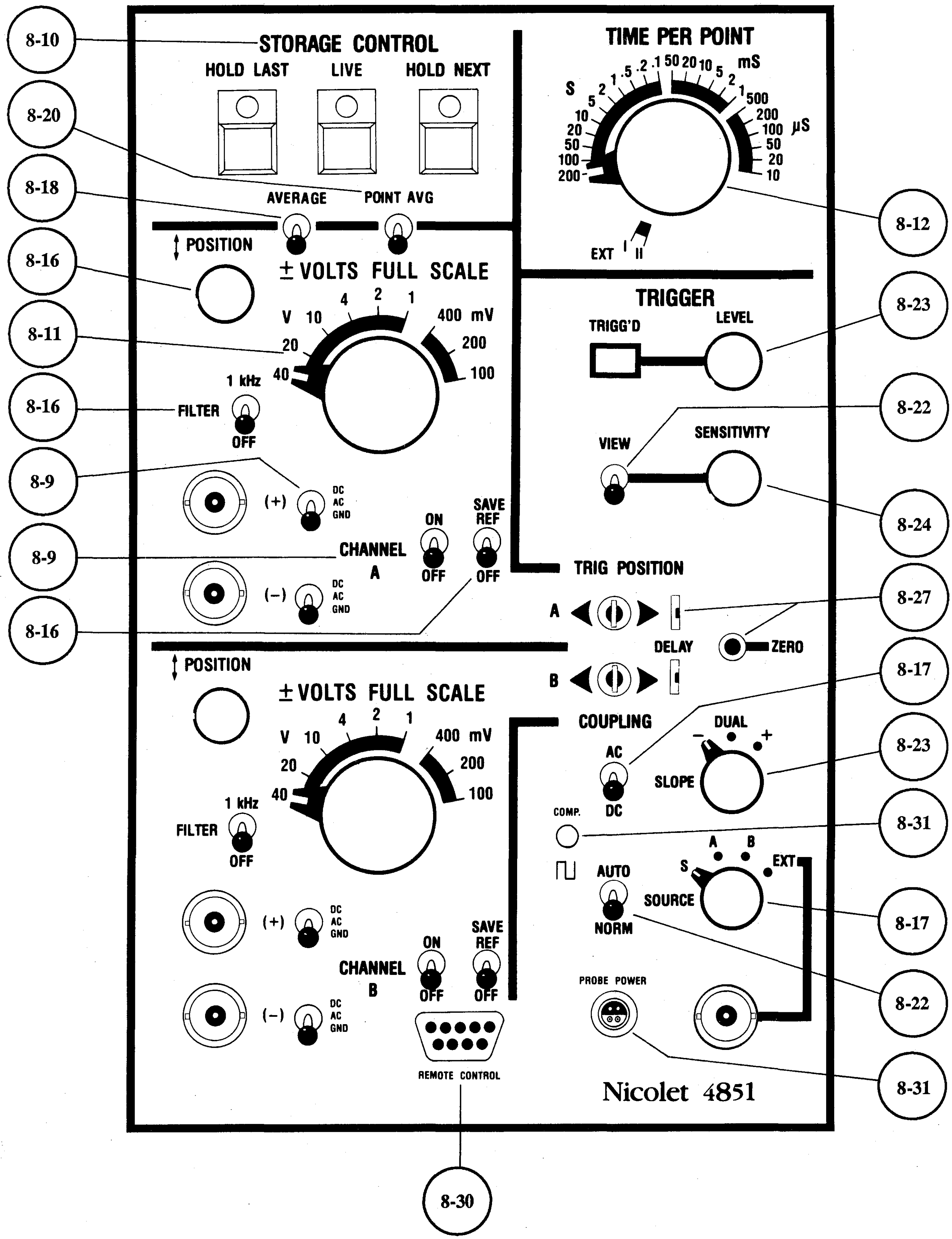
4180 Plug-in

06-01-87

4562 PLUG-IN


8-10
STORAGE CONTROL
HOLD LAST
LIVE
HOLD NEXT
8-20
8-18
AVERAGE
POINT AVG
8-16
POSITION
± VOLTS FULL SCALE
V 10 4 2 1
400 mV
20
200
40
100
8-11
100 kHz
8-16
FILTER
OFF
8-9
(+)
DC
AC
GND
8-9
CHANNEL
A
ON
OFF
SAVE
REF
OFF
(−)
8-16
POSITION
± VOLTS FULL SCALE
FILTER
100 kHz
OFF
CHANNEL
B
REMOTE CONTROL
8-30
TIME PER POINT
mS
S
µS
EXT
8-12
TRIGGER
TRIGG'D
LEVEL
8-23
8-22
VIEW
SENSITIVITY
8-24
TRIG POSITION
A
B
DELAY
ZERO
8-27
8-17
COUPLING
AC
DC
DUAL
SLOPE
8-23
COMP.
8-31
AUTO
NORM
SOURCE
S
A
B
EXT
8-17
8-22
PROBE POWER
8-31
Nicolet 4562

4851 PLUG-IN



STORAGE CONTROL
HOLD LAST
LIVE
HOLD NEXT
AVERAGE
POINT AVG
POSITION
± VOLTS FULL SCALE
V 10 4 2 1 400 mV
20 200
40 100
1 kHz
FILTER
OFF
(+) DC AC GND
(−) DC AC GND
ON
SAVE REF
CHANNEL A
OFF
OFF
CHANNEL B
REMOTE CONTROL
TIME PER POINT
S
mS
μS
EXT I II
TRIGGER
TRIGG'D
LEVEL
VIEW
SENSITIVITY
TRIG POSITION
A
B
DELAY
ZERO
COUPLING
AC
DC
DUAL
SLOPE
COMP.
AUTO
NORM
SOURCE
S A B EXT
PROBE POWER
Nicolet 4851
8-10
8-20
8-18
8-16
8-11
8-16
8-9
8-9
8-16
8-12
8-23
8-22
8-24
8-27
8-17
8-23
8-31
8-17
8-22
8-31
8-30

INTRODUCTION

The Model 4562 Plug-in uses two 12-bit, 500 nanosecond digitizers.

The Model 4851 Plug-in uses two 15-bit, 100 kHz digitizers.

Other Plug-in features include -

Single-ended or Differential amplifier operation.

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, Point Averaging, and 100 kHz Filter (4562) or 1 kHz Filter (4851) to reduce the effects of "noise" on the signals.

A Save Reference mode to compare "live" and saved signals.

Remote Control capabilities.

Test point compensation.

A plus/minus probe power output.

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.

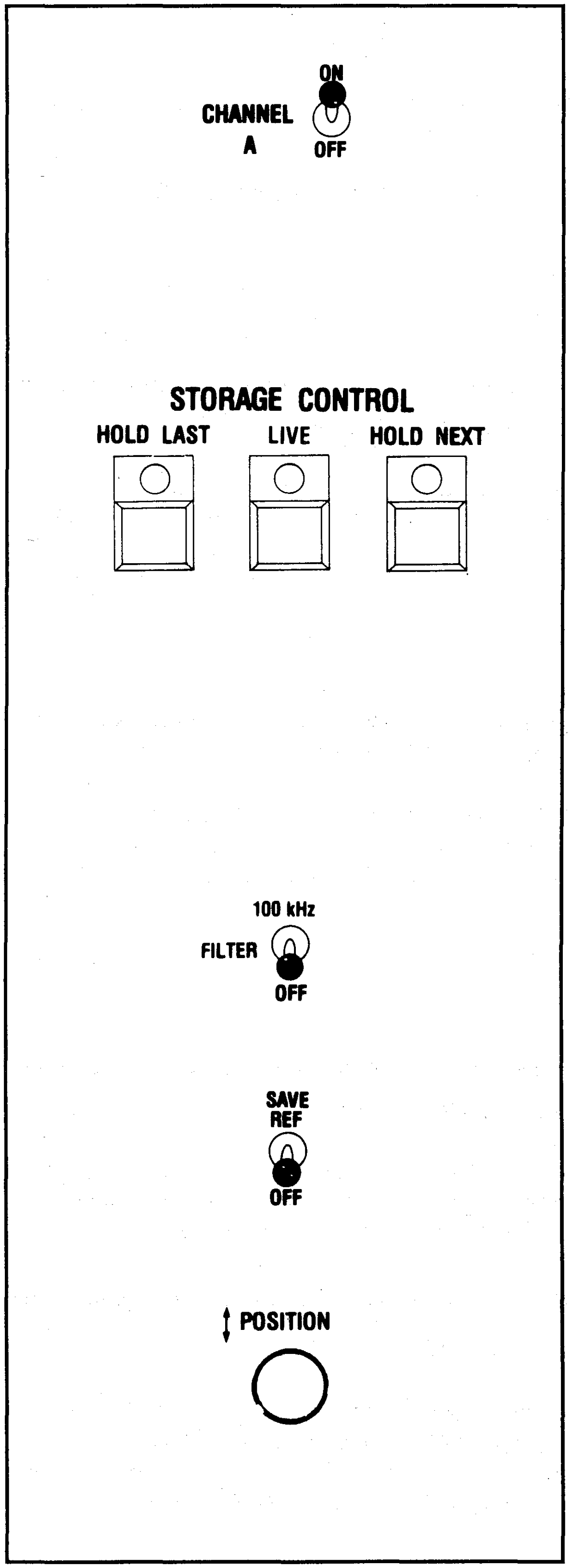
The plug-in should be in the Hold mode whenever a plug-in parameter is changed. Otherwise, the operator must either press the LIVE button to reset the plug-in, or wait until after the next sweep is completed before the 4094 will acknowledge parameter change(s).

Selecting the Hold Mode

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, use the following procedure to select the Hold mode.

#1. Press and hold the HOLD LAST button.
#2. Momentarily press the LIVE button.
#3. Release the HOLD LAST button.

NOTE: This section describes single plug-in operation. Refer to the Multiple Plug-ins tab when more than one plug-in is being used.



CHANNEL ON/OFF SWITCHES

The channel On/Off switch turns the channel on, enabling it to capture data for display.

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.

FILTER SWITCH

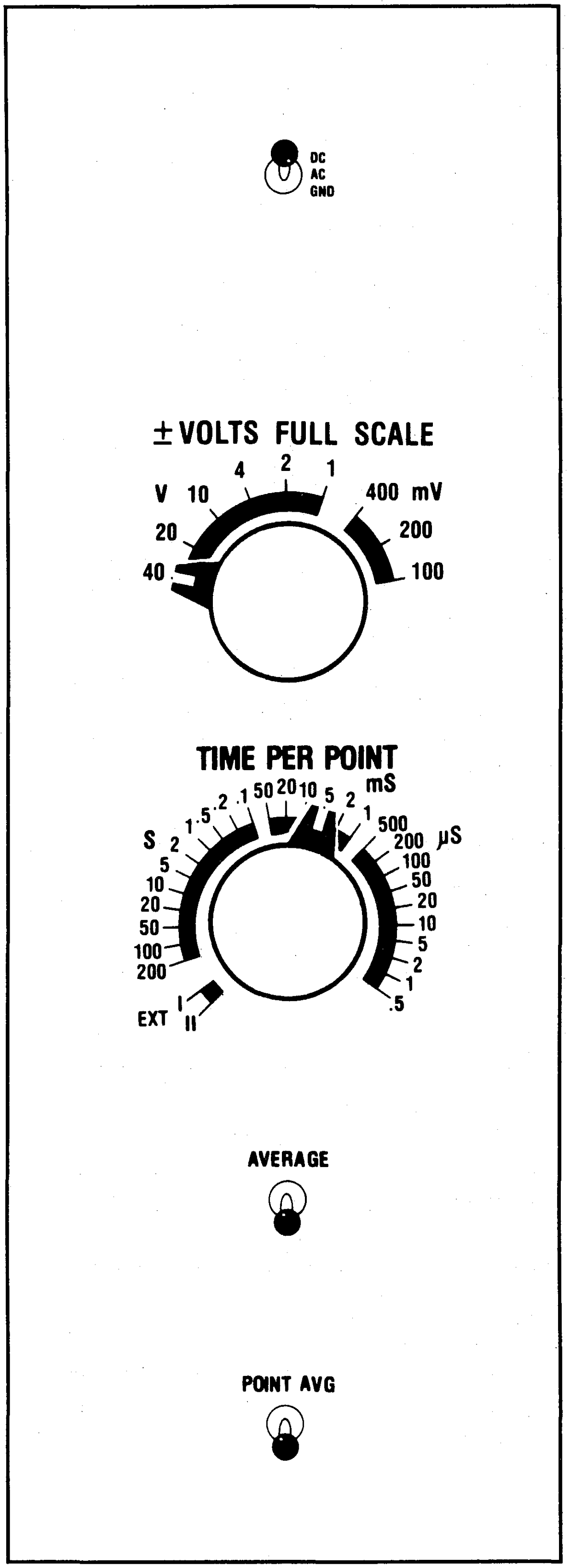
Turn on to filter high frequency "noise" from a low frequency input signal.

SAVE REFERENCE SWITCH

Turn on to compare "live" and saved signals (the channel must be turned on).

POSITION CONTROL

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



DC/ACGND SWITCH

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 - Grounds the amplifier's positive or negative input.

VOLTS FULL SCALE SWITCH

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

TIME PER POINT SWITCH

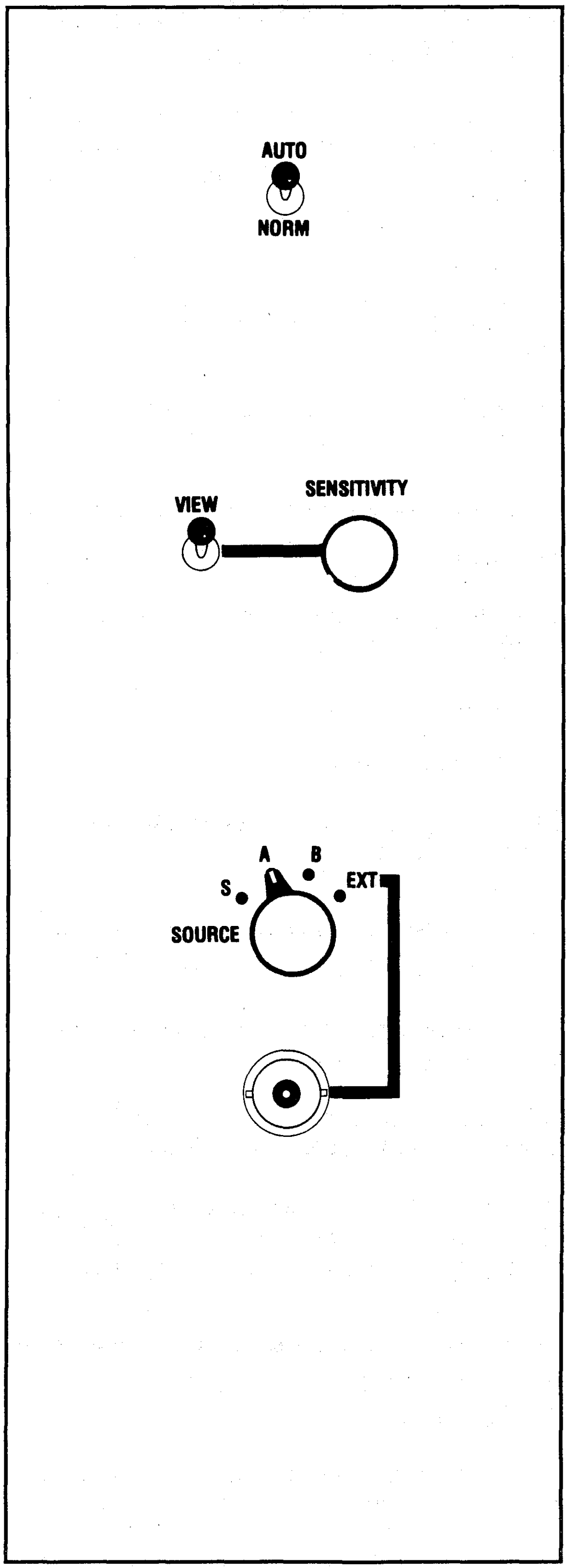
Selects the time resolution of the signal to be captured. Sweep speeds are expressed as time-per-point rather than time-per-centimeter.

AVERAGE SWITCH

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

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 (4562) or 500 µS/point (4851).



TRIGGER AUTO/NORMAL SWITCH

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.

TRIGGER VIEW & SENSITIVITY CONTROLS

The View mode (when turned on) is used to select specific characteristics that will qualify the signal as a valid trigger.

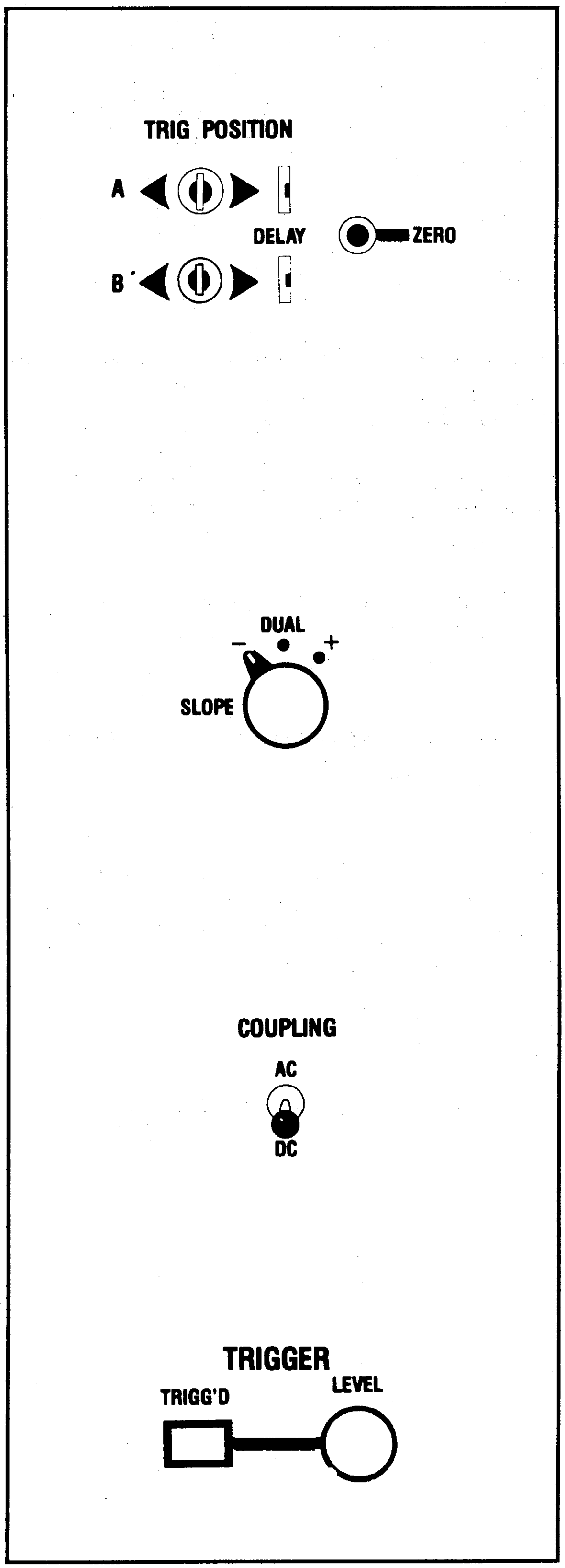
The Trigger Sensitivity control adjusts the "window" (voltage span) that the signal must pass through before it will qualify as a valid trigger.

TRIGGER SOURCE

(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. The master plug-in's Trigger Source switch must be in the A, B, or EXT position.

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

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



TRIGGER POSITION CONTROLS

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 Zero button.

Cursor Trigger - Press the paddle switch to the right.

Delayed Trigger - Press the paddle switch to the left.

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 SWITCH

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

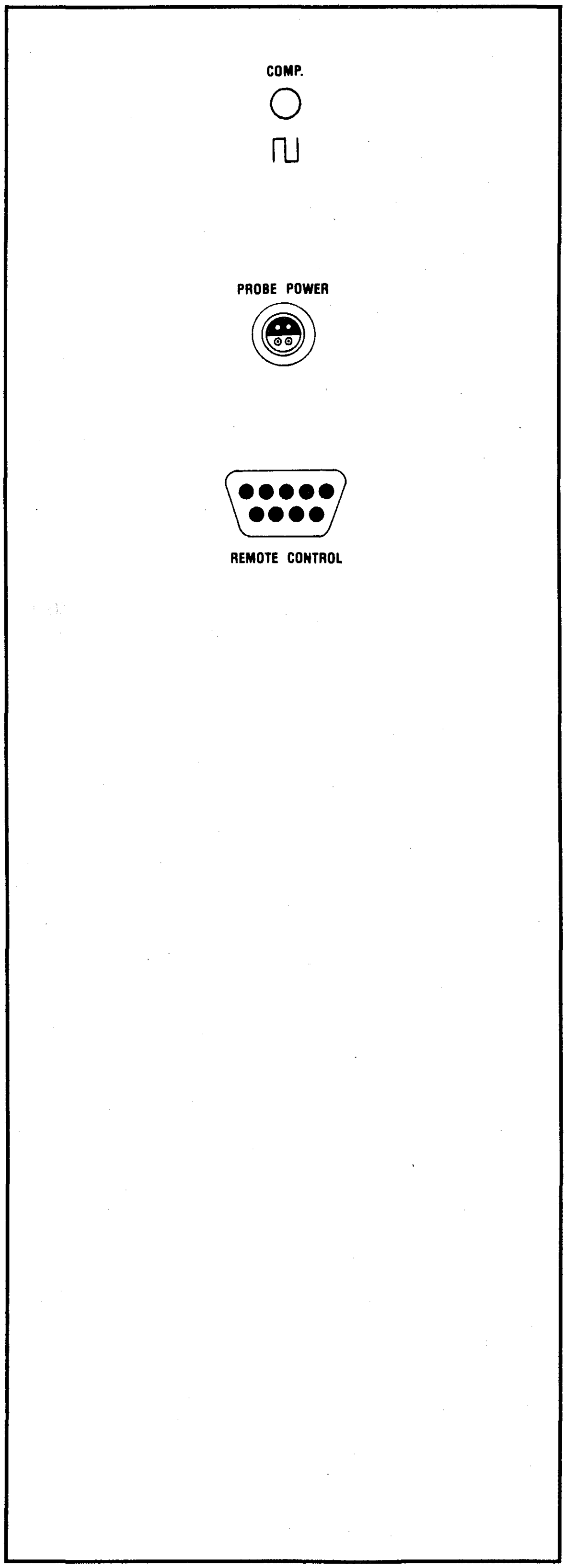
AC - The dc component is blocked while the ac component passes into the trigger circuit.

DC - Ac and dc components are input to the trigger circuit. Use when low frequency input signals are to be inspected, or the dc component is important.

TRIGGER LEVEL CONTROL & TRIGG'D LED

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

The green LED illuminates throughout each sweep.



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 a +12 Vdc and/or -12 Vdc output.

REMOTE CONTROL CONNECTOR

Permits limited remote control of the plug-in.

THE CHANNEL SWITCHES

Switch the channel on to capture/display data with that channel.

For example, the Channel A switch must be in the ON position to capture data with channel A.

NOTE: The channel must be turned on to use its Save Reference 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 when the mainframe's MEMORY switch is in the ALL position.

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		
	All	Halves	Quarters
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-1

THE DC/AC/GND SWITCHES

The DC/AC/GND switches determine whether ac and/or dc components of the input signal will enter the amplifier, or whether the amplifier's input will be grounded.

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

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

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

GND - 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."

Differential Amplifier Mode

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/GND switches associated with the inputs.

Single-ended Amplifier Mode

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/GND switch associated with the input.

#3. Ground the unused input by placing its AC/DC/GND switch to GND.

THE 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, 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.

IMPORTANT: Changes made to the plug-in's front panel controls will not be acknowledged until either the LIVE button is pressed or the next sweep is completed.

THE HOLD NEXT BUTTON

To select the Hold Next mode, press the Hold Next button while the plug-in is in the LIVE mode.

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

The Live, Hold Next and Hold Last buttons can be controlled from a remote station. Refer to page 8-30, "Remote Control Connector" descriptions.

THE VOLTS FULL SCALE SWITCH

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

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.

The X10 probe available from Nicolet is for use with 1 megohm input scopes. It has a 100 MHz bandwidth, 600 volts dc working voltage. Its cable length is 59 inches (1.5 meters).

Voltage Levels

Up to 4096 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:
4562 Plug-in - 2,047 levels
4851 Plug-in - 16,383 levels.

Negative voltages are displayed below the zero volts level with up to:
4562 Plug-in - 2,048 levels
4851 Plug-in - 16,384 levels.

Figure 8-1 illustrates the voltage levels for the 4562 plug-in.

Table 8-2 tabulates the Volts Full Scale ranges and corresponding Volts-Per-Level factors for both the 4562 and the 4851 plug-ins.

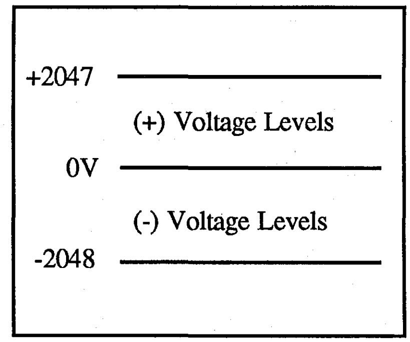


Figure 8-1

Volts Full Scale	Volts Per Level	
	4562	**4851**
100 mV	50 µV	6.25 µV
200 mV	100 µV	12.50 µV
400 mV	200 µV	25.00 µV
1 V	500 µV	62.50 µV
2 V	1 mV	125.00 µV
4 V	2 mV	250.00 µV
10 V	5 mV	625.00 µV
20 V	10 mV	1.25 mV
40 V	20 mV	2.50 mV

Table 8-2

THE TIME PER POINT SWITCH

The Time Per Point switch is 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.

Both plug-ins sample and digitize the input signal at preset rates.
4562 Plug-in - 500 nanoseconds
4851 Plug-in - 10 microseconds.

The selected Time Per Point determines which of the digitized samples will be selected for display on the screen.

EXAMPLE 8-1

This example illustrates the 4562 plug-in.

Figure 8-2: The input signal.

Figure 8-3: The signal super-imposed by the 500 nanosecond (0.5 microsecond) sampling rate.

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

Figure 8-5: Every other sample (black dots) is displayed when the Time Per Point is set to 1 µSec.

Figure 8-6: Every fifth sample (black dots) is displayed when the Time Per Point is set to 5 µSec.

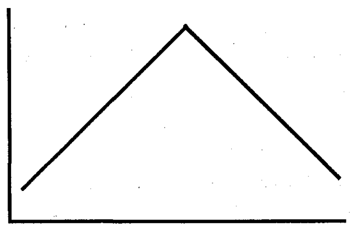


Figure 8-2

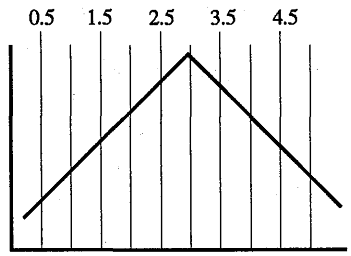


Figure 8-3

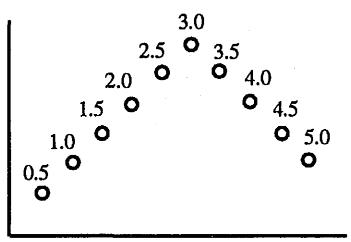


Figure 8-4

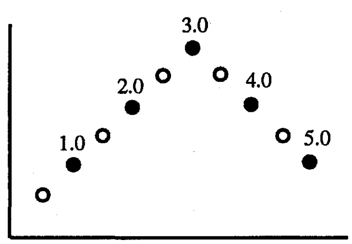


Figure 8-5

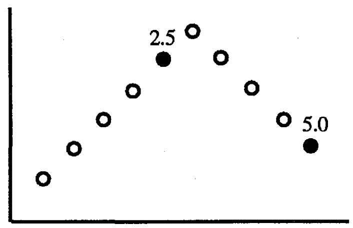


Figure 8-6

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 MEMORY switch.

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

Number Of Active Channels	Memory Switch		
	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 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: Divide by 2.
Three or four channels: Divide by 4.

TIME PER POINT SETTING	Memory Switch Positions (Data Points Per Sweep)		
	ALL (16K Points/Sweep)	H1/H2 (8K Points/Sweep)	Q1/Q2/Q3/Q4 (4K Points/Sweep)
	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	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
	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

(*) Time Per Point settings for the 4562 plug-in only.

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.

After the Address Advance command is applied to the Remote Control connector, the plug-in will begin sampling within the following time limits:
4562 plug-in - 220 nS
4851 plug-in - 20 µS.

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.

Delayed Displays

A delay occurs from the time of the first sample until a full screen display appears when the EXT I (fast) mode is selected. This occurs because each sample is stored in a buffer memory until enough samples to complete a full sweep have been captured.

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

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

Equation 8-1

Each sample is displayed as soon as it is captured when the EXT II (slow mode) is selected. This mode allows real-time monitoring of slow signals.

Number Of Active Channels	Memory Switch		
	All	Halves	Quarters
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-5

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 8-14).

Select the EXT I position when the Address Advance command rate ranges from -
4562 plug-in: 3.5 µS to 120 µS.
4851 plug-in: 20 µS to 150 µS.

The EXT I mode requires two external commands:
#1. A valid trigger input.
#2. A TTL input signal input to the Address Advance connector.

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

EXAMPLE 8-3

Figure 8-7: The input signal superimposed by Address Advance commands.

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

Figure 8-9: The digitized samples (dots) selected for display.

The EXT II Position
(Slow Mode)

Data is displayed immediately after each sample is captured and digitized when the EXT II mode is selected.

Select the EXT II position when the Address Advance command rate is greater than -
4562 plug-in: 120 µS
4851 plug-in: 150 µS.

The EXT II mode requires two external commands:
#1. A valid trigger.
#2. A TTL input signal input to the Address Advance connector.

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

EXAMPLE 8-4

Figure 8-7: The input signal superimposed by Address Advance commands.

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

Figure 8-9: The digitized samples (dots) selected for display.

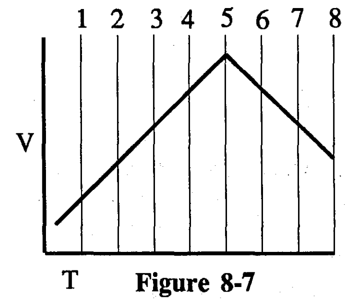


Figure 8-7

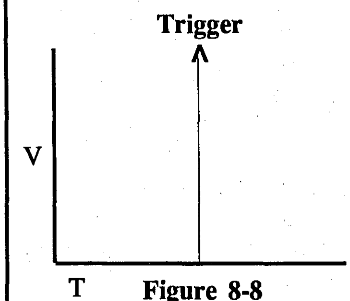


Figure 8-8

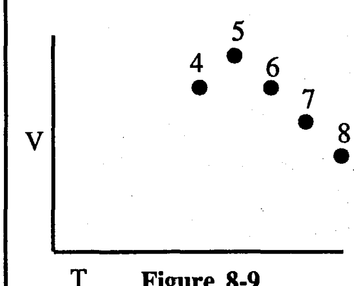


Figure 8-9

THE POSITION CONTROL

Vertically repositions a "live" signal on the screen.

On the 4562 plug-in, push the control knob in to coarse tune the adjustment. Leave the control knob out to fine tune the adjustment.

The Position control does 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 (+1.6 V to -0.4 V) down to (-1.6 V to +0.4 V) by using the Position control.

THE FILTER SWITCH

The 100 kHz (4562) and 1 kHz (4851) filters (both -3dB/point) reject high frequency "noise" from the input signal and can be used in any signal acquisition mode, including the Average and Point Average modes.

THE SAVE REFERENCE SWITCH

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

> **CAUTION:** The Trigger View mode overrides the Save Reference mode. Data displayed on the screen when the View Mode is turned on will be lost. If the data is important, record it on a diskette or place the mainframe MEMORY switch to an unimportant "half" or "quarter" position.

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 8-2

Figure 8-10: Typical signal captured before turning on Save Reference.

Figure 8-11: Resulting display after turning on Save Reference and changing the input signal's characteristics.

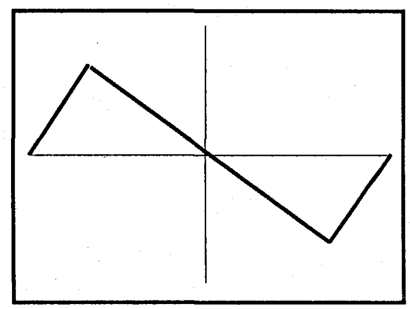


Figure 8-10

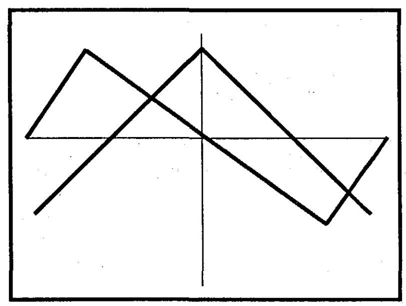


Figure 8-11

THE TRIGGER SOURCE SWITCH

E - Select the External trigger mode when triggers are input to the EXT input BNC. The amplitude of the signal must be ±240 mV (minimum) to qualify as a valid trigger.

A or B - Select A or B 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 2% 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).

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:

4562/4851/4570 - Set the Source switch to A, B, or EXT.

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

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

4562/4851/4570 - Set the Source switch to "S".

4175 - Select External and "S".

THE COUPLING SWITCH

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.

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

THE AVERAGE SWITCH

The Average mode 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.

Values captured during the first two sweeps are averaged and the result is stored in memory. The "new" values captured during the third sweep are averaged with the "old" stored values and the memory is updated once again. This process of averaging "new" and "old" values, and then updating the memory repeats with each successive sweep.

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.

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

Equation 8-2

Old = Average voltage value stored in the memory's address.

New = Newest sampled voltage value captured during the current sweep.

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

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

EXAMPLE 8-3

Figure 8-12: First sweep sampled at 1V1, 1V2, ... 1Vx.

Figure 8-13: Second sweep sampled at 2V1, 2V2, ... 2Vx.

Figure 8-14: 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 8-15: The resulting waveform display captured after several sweeps with Average turned on.

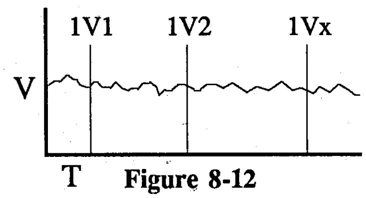


Figure 8-12

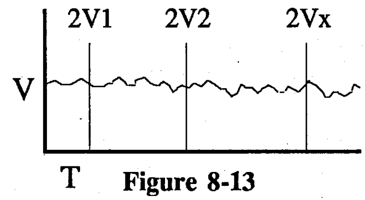


Figure 8-13

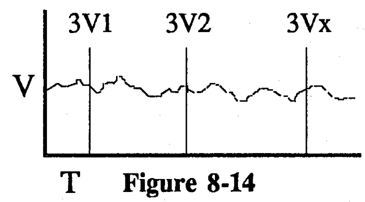


Figure 8-14

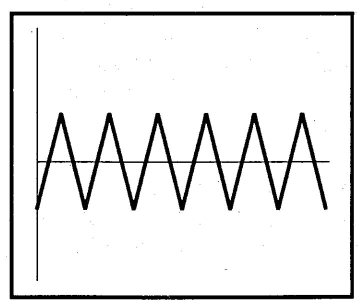


Figure 8-15

THE POINT AVERAGE SWITCH

The Point Average mode reduces the effects of "noise" on recurrent input signals when the time-per-point is slower than 500 microseconds.

The plug-in captures data at a constant rate -
4562 plug-in: 250 µS/sample
4851 plug-in: 500 µS/sample.

As each sample is captured, it is averaged with the samples previously captured 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 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.

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

Equation 8-4

Old = Average voltage value stored in the memory's address.

New = Newest sampled voltage value captured within the string.

K = Values listed in Table 8-7 according to the sweep in progress.

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

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

Equation 8-5

EXAMPLE 8-4

Assume that a string of three samples will be point averaged for each data point coordinate that is to be displayed.

Figure 8-16: The first string sampled at 1V1, 1V2, and 1V3 for the first data point coordinate. Sample 2V1 starts the second string of samples for the second data point.

If 1V1 = 6V, 1V2 = 8V, and 1V3 = 4V, the first data point's average value will equal 6.25 volts.

$$PV1 = 0V \times \frac{(1-1)}{1} + \frac{6V}{1} = 6V$$

$$PV2 = 6V \times \frac{(2-1)}{2} + \frac{8V}{2} = 7V$$

$$PV3 = 7V \times \frac{(4-1)}{4} + \frac{4V}{4} = 6.25V$$

Figure 8-17: The upper waveform illustrates a "noisy" signal captured without the Point Average mode.

The lower waveform illustrates the same "noisy" signal captured after one sweep with Point Average turned on.

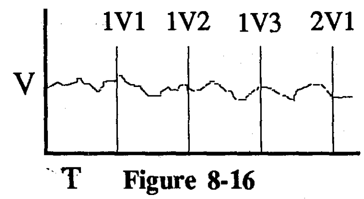


Figure 8-16

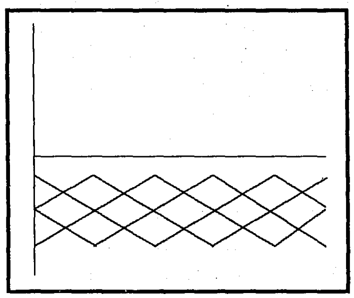


Figure 8-17

Combining the Average and Point Average Modes

The "sweep" Average and Point Average modes of operation can be combined if the selected Time-Per-Point is slower than 500 micro-seconds.

The effectiveness of averaging very "noisy," recurrent signals is enhanced when both of these modes are combined.

Essentially, Point Average values captured during the first sweep are stored in the memory's addresses. Then, as each "new" Point Average value is captured during the second sweep, it is "sweep" Averaged with the value previously stored in the memory's corresponding address. The resulting average values continually update the memory.

The process of "sweep" Averaging "older" values with "newer" Point Averaged values repeats with each sweep, providing additional improvements in the signal-to-noise ratio. The Filter switch can also be used in conjunction with the "sweep" Average and/or Point Average mode of operation.

THE TRIGGER AUTO/NORM SWITCH

Selects whether sweeps will be triggered automatically in the absence of a valid triggers (AUTO) or solely by an external source (NORM).

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

NORM - Sweeps are triggered by valid external trigger sources only.

THE TRIGGER VIEW SWITCH

The trigger View mode is used to select specific triggering characteristics.

> **CAUTION:** 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 main-frame MEMORY switch to an unimportant "half" or "quarter" position.
>
> In addition, the View Mode overrides the Save Reference and the Trigger Position controls.

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 are used to set the requirements that must be met to qualify the signal as a valid trigger.

a. Slope (page 8-23),
b. Minimum amplitude (page 8-23),
c. Minimum voltage change (page 8-24).

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

Selecting the VIEW mode

#1. Place the plug-in into the Hold mode.

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

#3. Turn the VIEW mode on.

#4. The plug-in will default to Auto-View. If Normal-View is desired, press the TRIGGER button again.

EXAMPLE 8-5

Figure 8-18: Typical VIEW display with "positive" slope selected.

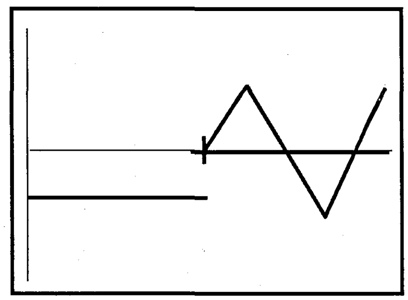


Figure 8-18

THE SLOPE SWITCH

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

CAUTION: 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 MEMORY switch to an unimportant "half" or "quarter" position.

(+) - 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 8-6

Figure 8-19: A positive slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-20: A negative slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-21: A dual slope display. The signal qualifies as a valid trigger at either (T1) or (T2).

THE LEVEL CONTROL

The Level control adjusts the threshold level that the signal must cross in order to qualify as a valid trigger.

CAUTION: 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 MEMORY switch to an unimportant "half" or "quarter" position.

Which threshold level must be crossed by the signal is a function of the SLOPE button.

(+) - 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 8-7

Figure 8-19: A positive slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-20: A negative slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-21: A dual slope display. The signal qualifies as a trigger at either point (T1) or (T2).

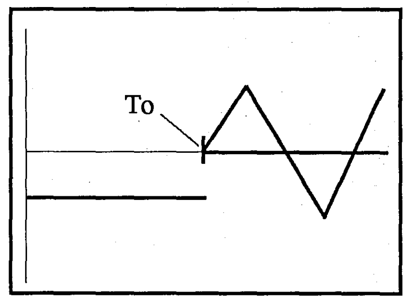


Figure 8-19

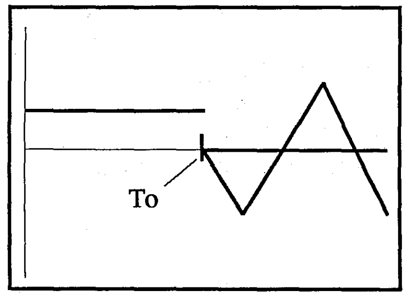


Figure 8-20

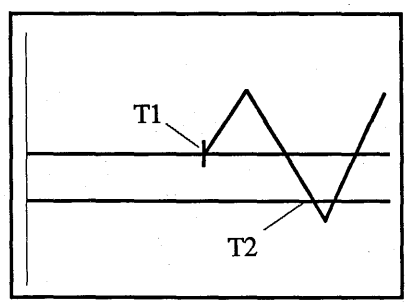


Figure 8-21

THE SENSITIVITY CONTROL

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

> **CAUTION:** 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 main-frame MEMORY switch to an unimportant "half" or "quarter" position.

NOTE: A default sensitivity of approximately 1/2 volt is selected by pressing both buttons simultaneously.

The "window" voltage can be adjusted from a range of 250 milli-volts to 20 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.

To inspect the upper and lower level voltage values, turn Autocenter on and press the Left or Right CURSOR button.

EXAMPLE 8-8

Figure 8-22: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.

Figure 8-23: The dashed line on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger.

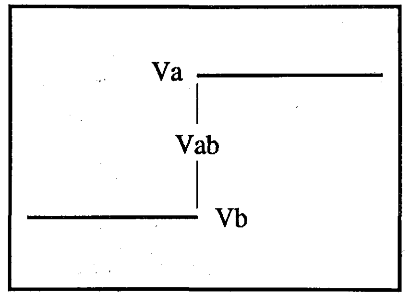


Figure 8-22

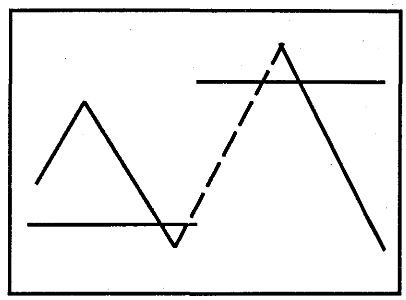


Figure 8-23

Recurrent (+) 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 8-9

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

Figure 8-24: 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 8-25: 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.

Recurrent 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 8-10

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

Figure 8-26: Valid triggers occur at points (T1 through T4) each time the signal crosses the threshold levels.

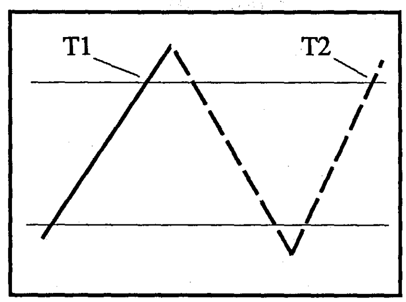


Figure 8-24

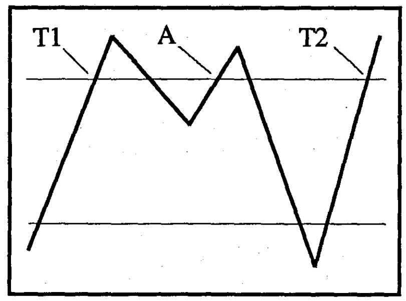


Figure 8-25

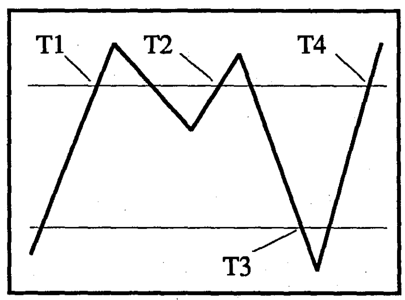


Figure 8-26

Adjusting for (+) or (-) Slope Triggers

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

#2. COUPLING: As required.

#3. Set the AUTO/NORM switch to Auto.

#4. Turn trigger VIEW on.

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

#6. Set the trigger SOURCE to either Internal or External as required.

#7. Set the trigger COUPLING switch to either DC or AC as required.

#8. Press the LIVE button.

#9. Adjust the POSITION control for the best trace placement on the screen.

#10. Set the VOLTS FULL SCALE switch as required.

#11. Adjust the trigger SENSITIVITY control until the threshold level is fully compressed and then reverse its direction until the "window" exceeds any "noise" spikes present.

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

#13. Fine tune the trigger SENSITIVITY and LEVEL controls as required.

#14. After the Sensitivity and Level have been properly adjusted, select normal (NORM) triggering. The plug-in continues to trigger.

NOTE: The TRIG'D LED illuminates throughout each sweep.

Adjusting for Dual Slope Triggers

#1. SLOPE: Dual

#2. COUPLING: As required.

#3. Set the AUTO/NORM switch to Auto.

#4. Turn trigger VIEW on.

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

#6. Set the trigger SOURCE switch for Internal or External triggering as required.

#7. Set the trigger COUPLING switch to either DC or AC as required.

#8. Press the LIVE button.

#9. Adjust the POSITION control for the best trace placement on the screen.

#10. Set the VOLTS FULL SCALE switch as required.

#11. Adjust the trigger SENSITIVITY control until the threshold level is fully compressed.

#12. Adjust the trigger LEVEL control until the "window" is centered between the desired positive and negative trigger points.

#13. Adjust the trigger SENSITIVIITY control until the upper and lower threshold levels to intersect the desired positive and negative trigger points.

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

#15. After the Sensitivity and Level have been properly adjusted, select normal (NORM) triggering. The plug-in continues to trigger.

NOTE: The TRIGG'D LED illuminates throughout each sweep.

THE 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).

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 main-frame FUNCTION switch away from RESET NUM when using the Position controls.

LIVE MODE (Coarse Adjust)
The trigger cursor moves 1/8th of full screen at the end of each sweep when the Position control is pressed while in the Live Mode.

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

SET-UP MODE (Fine Adjust)
To enter the Setup mode, press the HOLD LAST and HOLD NEXT buttons at the same time.

NOTE: The Hold Last button must be released first. The trigger's rate of movement increases the longer a Position control is pressed. Releasing and then pressing the Position control returns the advance to a slower rate of movement. The letter "S" suffix is added to the Plug-in/Channel numerics (e.g., 1AS) when the Setup mode is selected.

CAUTION: Operating the DELAY buttons while in the Setup Mode alters the (T=0) origin, producing erroneous time numerics. The Setup Mode is exited by pressing either the HOLD LAST or LIVE button. However, the time numerics remain erroneous until a new sweep is triggered.

EXAMPLE 8-11

Figure 8-27: The three types of trigger displays and related sweeps.

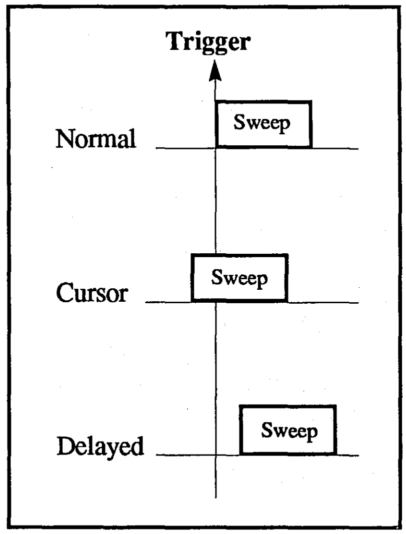


Figure 8-27

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 Setup mode, press the ZERO button.

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 ZERO button while tapping LIVE.

EXAMPLE 8-12

Figure 8-28: A single sweep is triggered at point (To) and ends at point (T+).

Figure 8-29: The corresponding Normal trigger display of the captured signal.

The Cursor Trigger Display

To select the Cursor Trigger mode, place the plug-in into the Setup mode (page 8-27) and press the channel's TRIG POSITION paddle to the right.

NOTE: If the plug-in is operating in the Live mode, valid triggers must be present while pressing the paddle. In addition, if a long sweep is in progress while in the Live mode, the Cursor trigger command may not be acknowledged until the next sweep is triggered. (The TRIG POSITION paddle must be pressed towards the right as the new sweep is triggered).

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

EXAMPLE 8-13

Figure 8-30: 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 8-31: The corresponding Cursor trigger display of the captured signal.

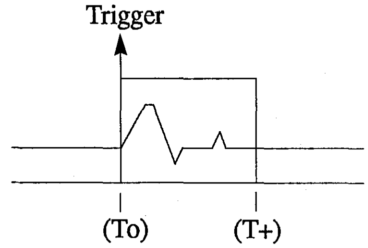


Figure 8-28

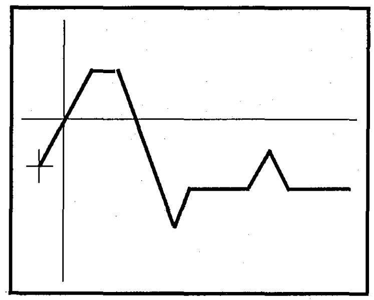


Figure 8-29

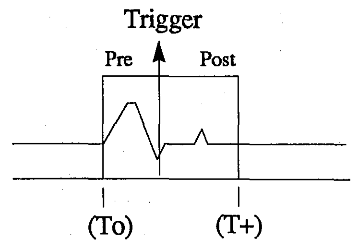


Figure 8-30

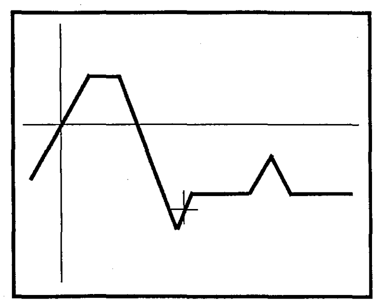


Figure 8-31

The 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 Setup mode (page 8-27) and press the channel's TRIG POSITION paddle to the left.

NOTE: If the plug-in is operating in the Live Mode, valid triggers must be present while the TRIG POSITION paddle is pressed. In addition, if a long sweep is in progress while in the Live mode, the Delayed Trigger command may not be acknowledged until the next sweep is triggered. (The TRIG POSITION paddle must be pressed towards the left when the new sweep is triggered).

The vertical cursor (trigger) moves off of screen left while the TRIG POSITION paddle 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.

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

$$\text{Tmax} = \frac{2^{24} \times (\text{TPP})}{(\text{Channels}) \times (\text{Memory})}$$

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
Quarters = 4

NOTE: Sometimes a very long delay may be inadvertently selected in the Delayed Trigger mode. To quickly clear the delay, hold in the ZERO button while tapping the Live button.

EXAMPLE 8-14

Figure 8-32: 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 8-33: The corresponding Delayed trigger display of the signal captured during the sweep.

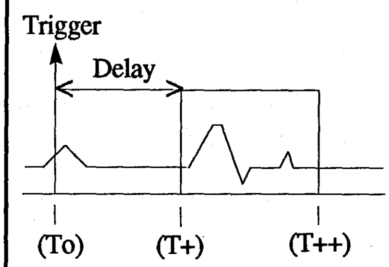


Figure 8-32

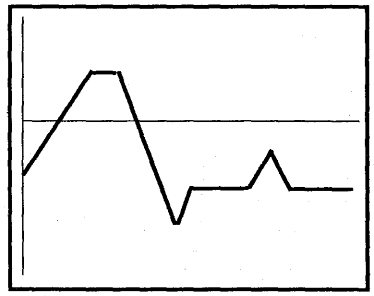


Figure 8-33

THE REMOTE CONTROL CONNECTOR

The remote control connector allows certain functions of the plug-in to be controlled from a remote station. Figure 8-34 identifies the function of each pin.

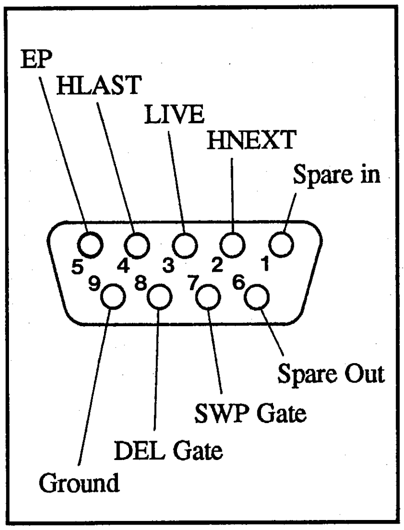


Figure 8-34

HOLD LAST, LIVE, HOLD NEXT INPUTS

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.

EP INPUT

The EP (Address Advance) input is used to advance the memory to its next address when the Time Per Point switch is in either the EXT I or EXT II positions.

The EP input should normally rest at less than 0.4 Vdc and then raise to more than 3 Vdc each time the memory is to advance one address.

DEL GATE OUTPUT

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 8-35 illustrates the three types of triggers and corresponding sweeps and Delayed Gate outputs.

SWP GATE OUTPUT

The Sweep Gate output is activated only during valid data point collections.

The output normally rests at 0.4 Vdc and rises to +3 Vdc when a sweep is in progress.

SPARE IN and SPARE OUT

Not currently being used.

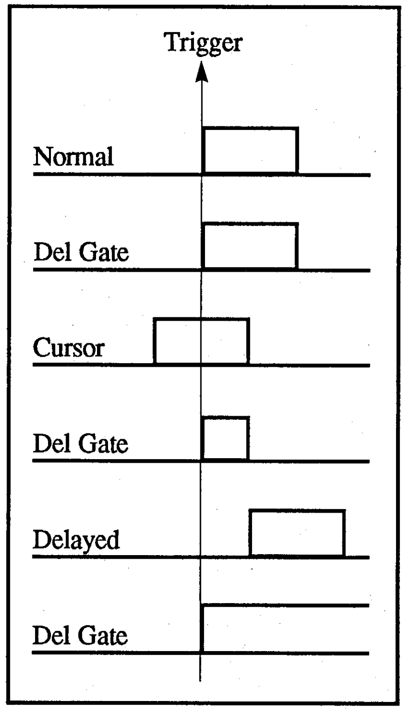


Figure 8-35

THE PROBE POWER CONNECTOR

The Probe Power connector furnishes +12 and -12 Vdc output voltages (maximum current equals 100 ma).

Figure 8-36 identifies the connector's voltage polarities and ground.

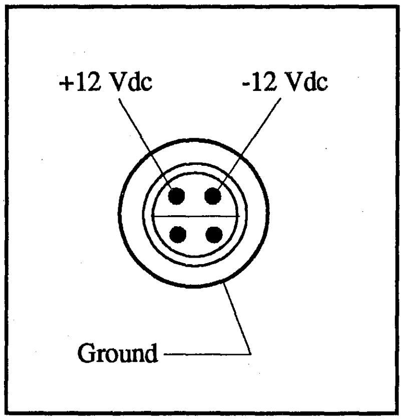


Figure 8-36

THE COMPENSATION POINT

A square wave signal appears on the screen when the optional X10 and X100 test probes are touched to the Compensation point.

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

IMPORTANT: The Time Per Point must be 20 microseconds or faster.

EXAMPLE 8-15

Figure 8-37 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.

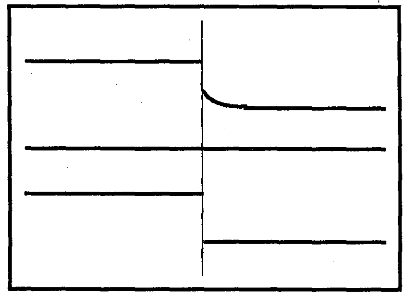
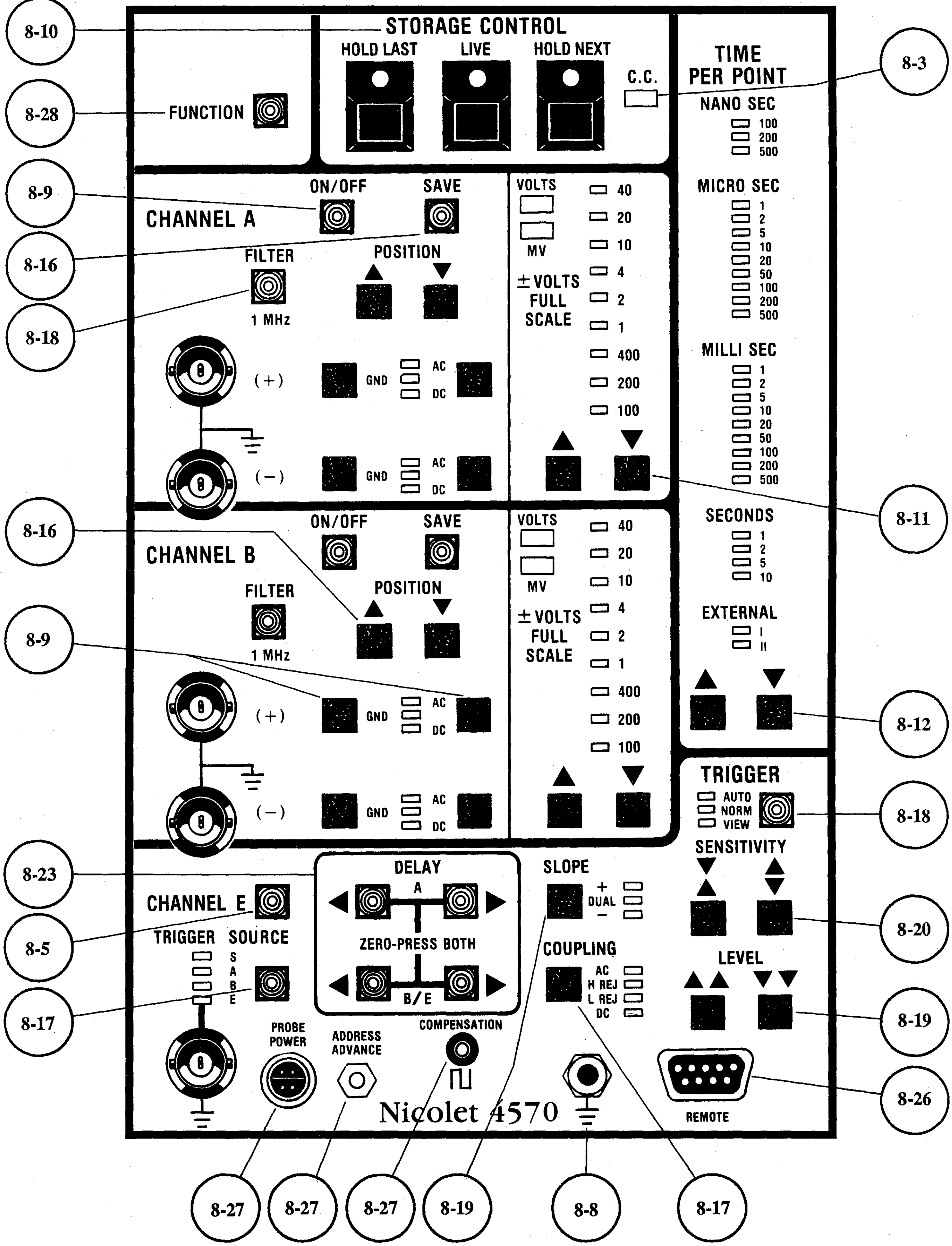


Figure 8-31

4570 PLUG-IN



STORAGE CONTROL
HOLD LAST
LIVE
HOLD NEXT
C.C.
FUNCTION
TIME PER POINT
NANO SEC
100
200
500
MICRO SEC
1
2
5
10
20
50
100
200
500
MILLI SEC
1
2
5
10
20
50
100
200
500
SECONDS
1
2
5
10
EXTERNAL
I
II
CHANNEL A
ON/OFF
SAVE
FILTER
1 MHz
POSITION
(+)
(−)
GND
AC
DC
VOLTS
MV
± VOLTS FULL SCALE
40
20
10
4
2
1
400
200
100
CHANNEL B
TRIGGER
AUTO
NORM
VIEW
SENSITIVITY
LEVEL
CHANNEL E
TRIGGER SOURCE
S
A
B
E
DELAY
A
ZERO-PRESS BOTH
B/E
SLOPE
+
DUAL
−
COUPLING
AC
H REJ
L REJ
DC
PROBE POWER
ADDRESS ADVANCE
COMPENSATION
Nicolet 4570
REMOTE
8-10
8-28
8-9
8-16
8-18
8-3
8-11
8-16
8-9
8-12
8-18
8-23
8-5
8-17
8-20
8-19
8-26
8-27
8-27
8-27
8-19
8-8
8-17

INTRODUCTION

The Model 4570 Plug-in uses two 12-bit, 100 nanosecond digitizers.

Other Plug-in features include -

Analog bandwidth (-3 dB) for the 1 Megohm input is DC to 5 MHz.

Differential amplifier operation.

15,872 (16K) word memory.

Positive, negative, or dual slope triggering.

Normal, Pre- and Post-trigger, and Delayed trigger displays.

A 6-bit, 100 nanosecond digitizer to digitize the input of the external trigger input.

A Trigger View mode to select the trigger's qualifying characteristics.

1 MHz Filter to reduce the effects of "noise" on the signals.

A Save Reference mode to compare "live" and saved signals.

Complete controllability via GPIB or RS232 interface.

Test point compensation.

A plus/minus probe power output.

User selectable functions for data manip-ulation. Functions include sweep averaging, FFT, max/min, and multiplication.

IMPORTANT: The following procedure will override the Power Off Memory feature (column three of this page) and make the 4094 opera-tional again if the front panel controls perform erratically when power is turned on (or during normal operation) -

#1. Turn the power off.
#2. Press and hold all four DELAY buttons simultaneously.
#3. Turn the power back on.
#4. Release the DELAY buttons.

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, use the following procedure to select the Hold mode.

#1. Press and hold the HOLD LAST button.
#2. Momentarily press the LIVE button.
#3. Release the HOLD LAST button.

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 4570 front panel controls are controllable via the 4094 computer interfaces (see Section 13, page 13-37b).

Power Off Memory

The 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.

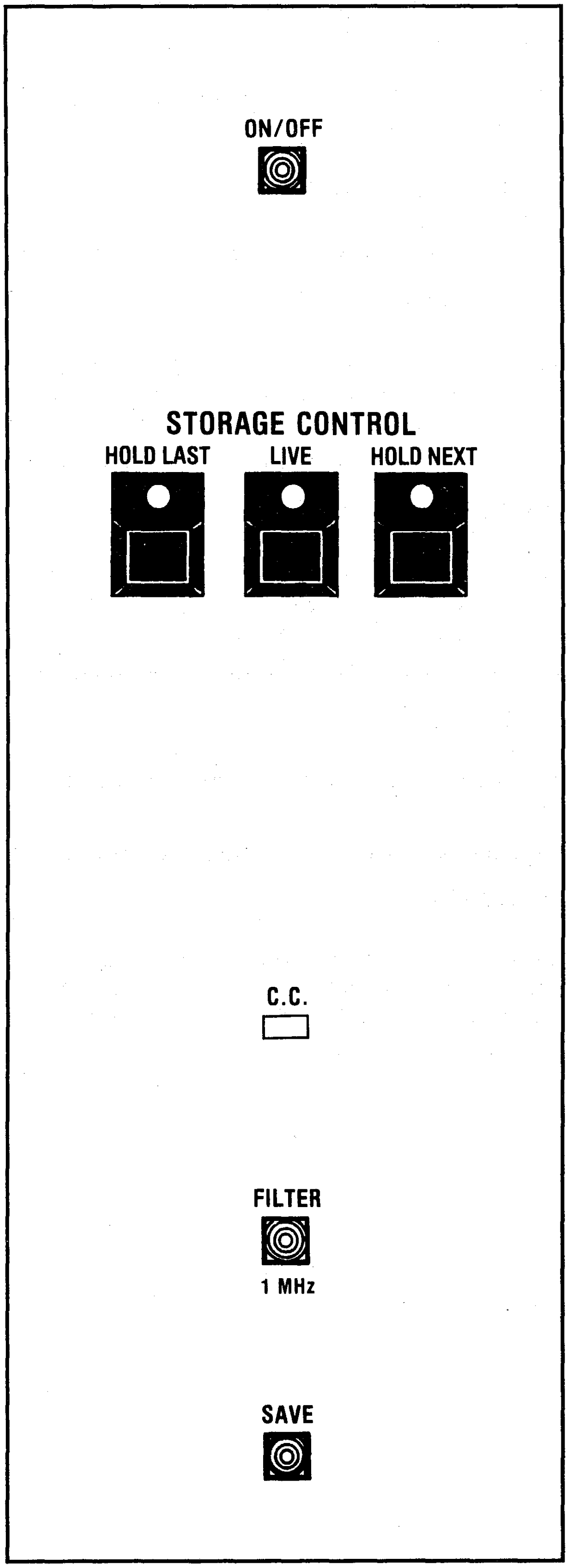
NOTE: If the oscilloscope "beeps" five times when power is applied, the oscilloscope is still operational, but the Power Off Memory function may not retain the 4570's front panel settings if power is removed. If this condition occurs, contact:

Nicolet Instruments Corporation
Test Instruments Divsion,
Service Department
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 4570'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. Channel E and channel B share memory space in the plug-in. Channel E cannot be turned on if channel B's SAVE mode is active.

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

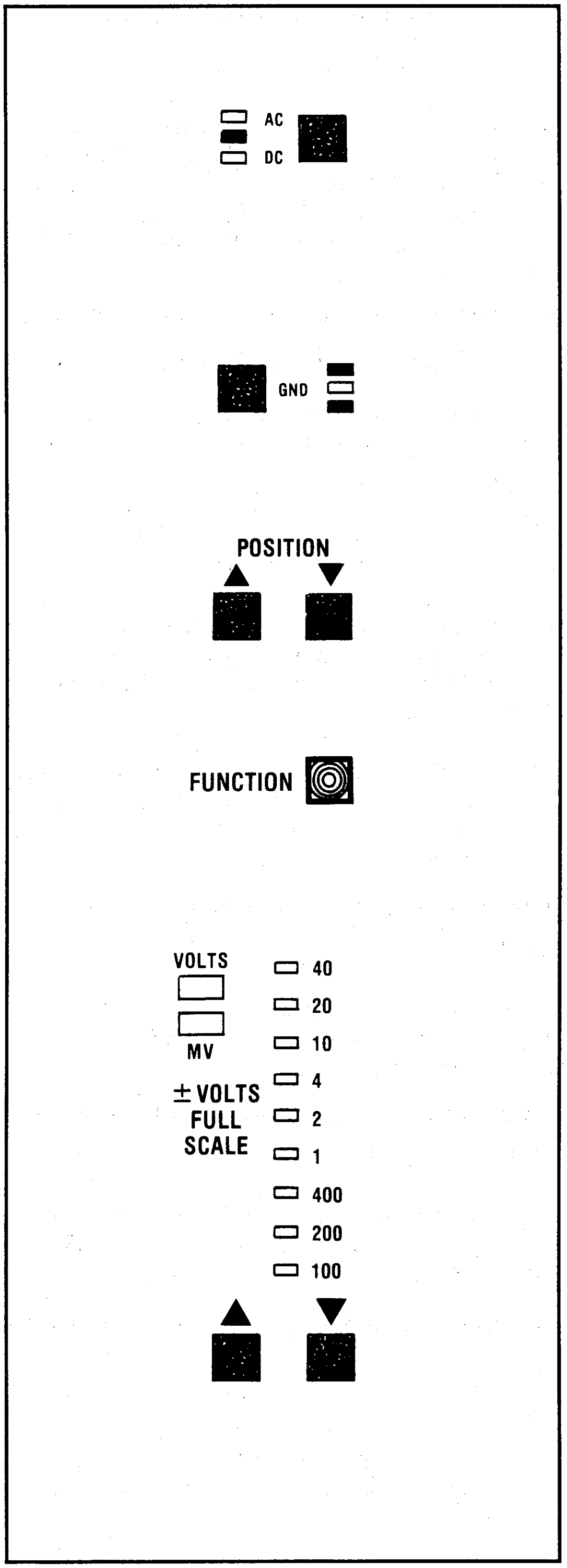
When the C.C. LED is illuminated, the scope is under computer control and the front panel controls will have no effect.

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. The Channel B SAVE function cannot be turned on if Channel E is turned on



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

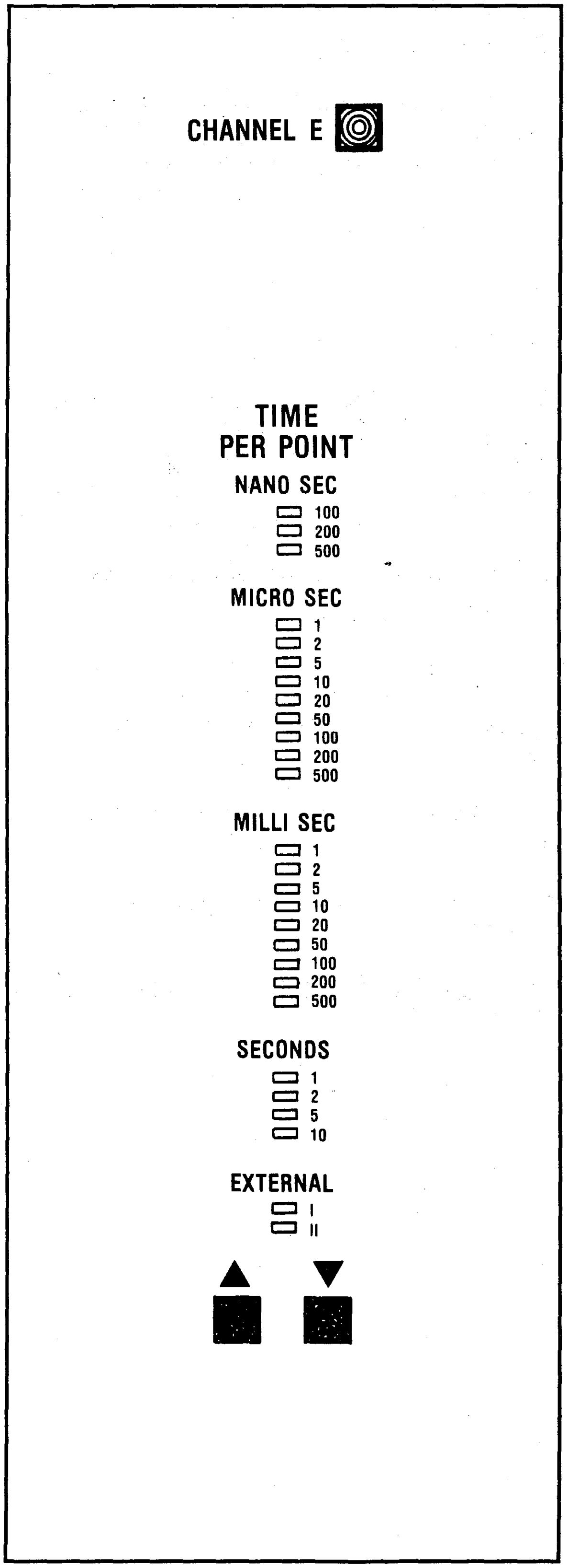
Vertically positions the trace in the direction of the arrows. Press both buttons simultaneously to return the trace to screen vertical center.

FUNCTION BUTTON

Activates the currently selected data manipulation function.

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.



CHANNEL E

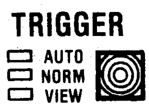
The CHANNEL E button allows viewing of the trigger signal applied to the EXT input BNC. Channel E uses half of channel B's memory to display the external trigger.

IMPORTANT: Channel E cannot be turned on if the channel B SAVE mode is 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.



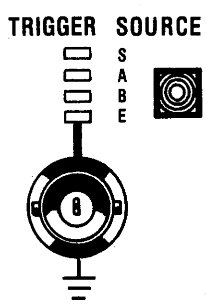
TRIGGER BUTTON

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).



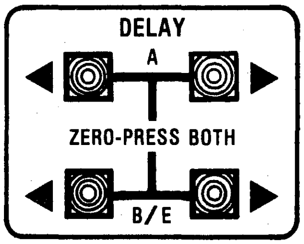
TRIGGER SOURCE

(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.

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

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

(E) - Triggers are derived from signals input to the EXT input BNC.



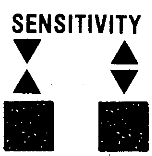
TRIGGER DELAY BUTTONS

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/E & B/E>) for channels B and E. Zero triggering is selected when both buttons (e.g., <A & A>) are off.

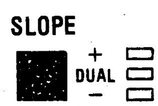
Cursor Trigger - Press (A>) for channel A, or (B/E>) for either channel B or channel E. Cursor triggering is selected when (A>) and/or (B/E>) are lighted.

Delayed Trigger - Press (<A) for channel A, or (<B/E) for channel B or channel E. Cursor triggering is selected when (<A) and/or (<B/E) 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".



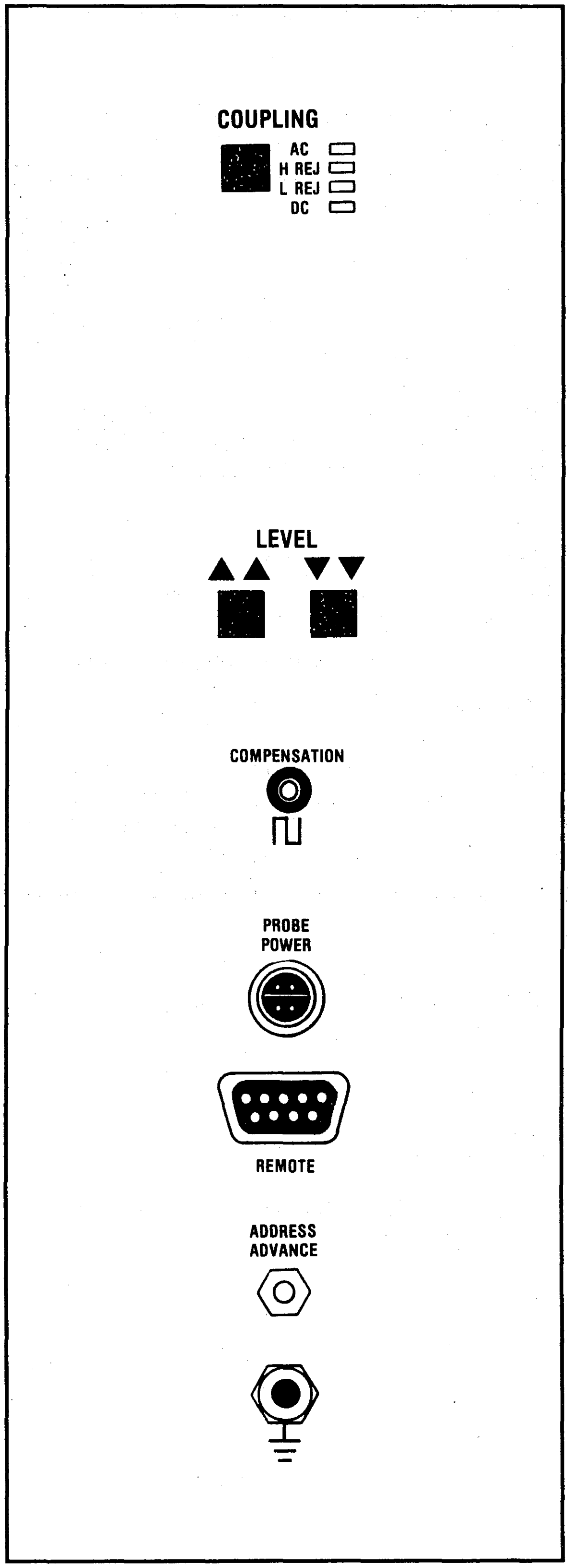
TRIGGER SLOPE BUTTON

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 1 MHz are rejected.

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

L REJ - Frequencies less than 1 kHz 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 and +5 Vdc outputs with ground.

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.

THE 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 when 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 each 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		
	All	Halves	Quarters
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-1

THE 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."

THE 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 Amplifier Mode

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.

Single-ended Amplifier Mode

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.

THE 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, 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

The Live, Hold Next and Hold Last buttons can be controlled from a remote station. Refer to page 8-26, "Remote Control Connector" descriptions.

THE VOLTS FULL SCALE SWITCH

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

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.

The X10 probe available from Nicolet is for use with 1 megohm input scopes. It has a 100 MHz bandwidth, 600 volts dc working voltage. Its cable length is 59 inches (1.5 meters).

Voltage Levels

Up to 4096 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 2047 levels. Negative voltages are displayed below the zero volts level with up to 2048 levels. See Figure 8-1.

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

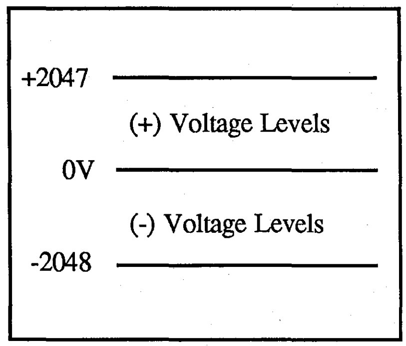


Figure 8-1

Volts Full Scale	Volts Per Level
100 mV	0.05 mV
200 mV	0.10 mV
400 mV	0.20 mV
1 V	0.5 mV
2 V	1.0 mV
4 V	2.0 mV
10 V	5 mV
20 V	10 mV
40 V	20 mV

Table 8-2

THE 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.

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 100 nanosecond sampling rate.

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

Figure 8-5: Every other sample (black dots) is displayed when the Time Per Point is set to 200 nSec.

Figure 8-6: Every fifth sample (black dots) is displayed when the Time Per Point is set to 500 nSec.

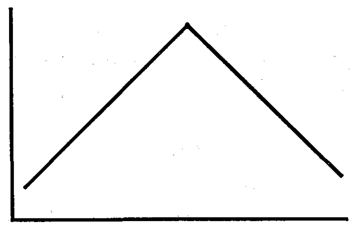


Figure 8-2

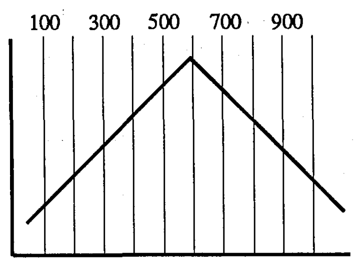


Figure 8-3

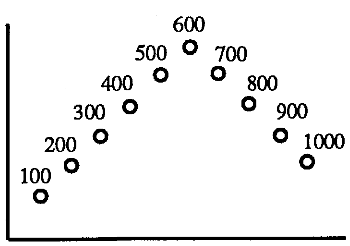


Figure 8-4

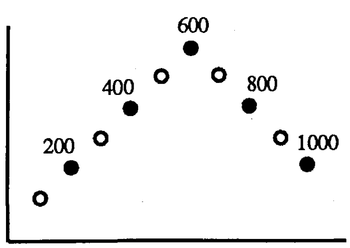


Figure 8-5

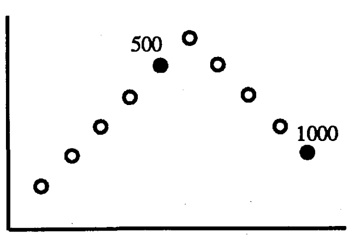


Figure 8-6

The 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 MEMORY switch.

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

Number Of Active Channels	Memory Switch		
	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 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: Divide by 2.
Three or four channels: Divide by 4.

TIME PER POINT SETTING	Memory Switch Positions (Data Points Per Sweep)		
	ALL (16K Points/Sweep)	H1/H2 (8K Points/Sweep)	Q1/Q2/Q3/Q4 (4K Points/Sweep)
	Microseconds Per Sweep		
100 nS	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 µS	15.880	7.940	3.970
2	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
	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	11.00

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.

Delayed Displays

A delay occurs from the time of the first sample until a full screen display appears when the EXT I (fast) mode is selected. This occurs because each sample is stored in a buffer memory until enough samples to complete a full sweep have been captured.

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

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

Equation 8-1

Number Of Active Channels	Memory Switch		
	All	**Halves**	**Quarters**
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-5

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 8-14).

Select the EXT I position when the Address Advance command rate ranges from 5 kHz to 2 MHz.

The EXT I mode requires two external commands:
#1. A valid trigger input.
#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) 100 nanoseconds.

The trigger initiates the sampling sequence and "captures" the first sample. The remaining samples are captured within 100 nS of each Address Advance command's leading, positive edge.

NOTE: The maximum speed for the EXT I mode is 2 MHz. Both the pulse width and the gap between the Address Advance command's pulses must be greater than 250 nS.

EXAMPLE 8-3

Figure 8-7: The input signal superimposed by Address Advance commands.

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

Figure 8-9: The digitized samples (dots) selected for display.

The EXT II Position (Slow Mode)

Data is displayed after each sample is digitized when the EXT II mode is selected.

Select the EXT II position when the Address Advance command rate ranges from 0 to 5 kHz.

The EXT II mode requires two external commands:
#1. A valid trigger.
#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) 100 nanoseconds.

The trigger initiates the sampling sequence and "captures" the first sample. The remaining samples are captured within 100 nS of each Address Advance command's leading, positive edge.

NOTE: The maximum speed for the EXT II mode is 5 kHz. Both the pulse width and the gap between the Address Advance command pulses must be greater than 250 nS.

EXAMPLE 8-4

Figure 8-7: The input signal superimposed by Address Advance commands.

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

Figure 8-9: The digitized samples (dots) selected for display.

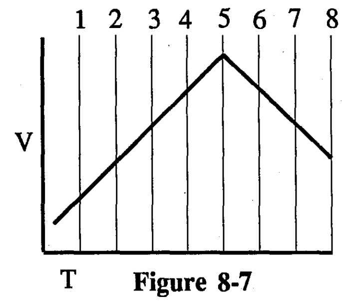


Figure 8-7

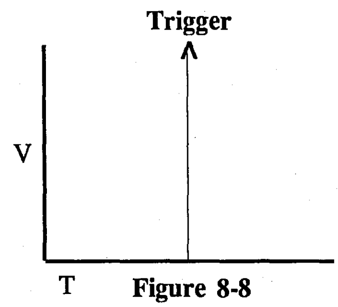


Figure 8-8

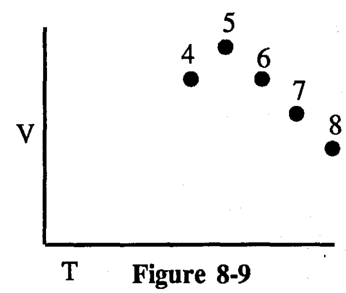


Figure 8-9

THE 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 crosshair follows the offset and the zero reference level is updated only after the button is released and any 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

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

> **CAUTION:** 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 MEMORY switch to an unimportant "half" or "quarter" position.

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 8-10: Typical signal captured before turning on Save Reference.

Figure 8-11: Resulting display after turning on Save Reference and changing the input signal's characteristics.

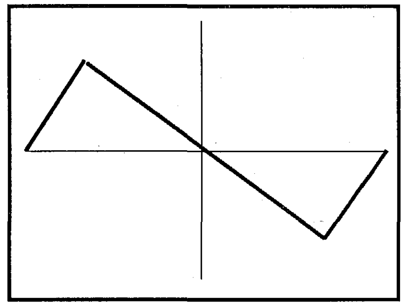


Figure 8-10

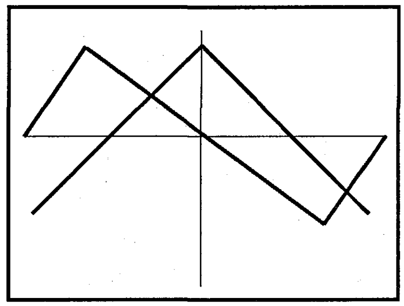


Figure 8-11

THE TRIGGER SOURCE BUTTON

E - Select the External trigger mode when triggers are input to the EXT input BNC. The amplitude of the signal must be ±240 mV (minimum) to qualify as a valid trigger.

A or B - Select A or B 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 2% 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).

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:

4562/4851/4570 - Set the Source switch to A, B, or EXT.

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

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

4562/4851/4570 - Set the Source switch to "S".

4175 - Select External and "S".

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.

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

H REJ - Rejects frequencies greater than 1 MHz.

L REJ - Rejects frequencies less than 100 Hz.

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 external trigger sources only.

VIEW - Used to select specific triggering characteristics.

> **CAUTION:** 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 main-frame 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 are used to set the requirements that must be met to qualify the signal as a valid trigger.

a. Slope (page 8-19),
b. Minimum amplitude (page 8-19),
c. Minimum voltage change (page 8-20).

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

Selecting the VIEW mode

#1. Place the plug-in into the Hold mode.

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

#3. Turn the VIEW mode on.

#4. The plug-in will default to Auto-View. If Normal-View is desired, press the TRIGGER button again.

EXAMPLE 8-7

Figure 8-12: Typical VIEW display with "positive" slope selected.

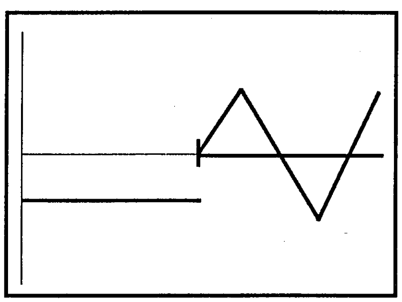


Figure 8-12

THE FILTER BUTTON

The 1 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 1 MHz filter is activated when the Filter button is illuminated.

THE SLOPE BUTTON

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

CAUTION: 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 main-frame MEMORY switch to an unimportant "half" or "quarter" position.

(+) - 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 8-13: A positive slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-14: A negative slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-15: A dual slope display. The signal qualifies as a valid trigger at either (T1) or (T2).

THE LEVEL BUTTONS

The Level control adjusts the threshold level that the signal must cross in order to qualify as a valid trigger. Pressing both buttons simultaneously sets the level to "0" volts.

CAUTION: 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 main-frame MEMORY switch to an unimportant "half" or "quarter" position.

Which threshold level must be crossed by the signal is a function of the SLOPE button.

(+) - 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 8-13: A positive slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-14: A negative slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-15: A dual slope display. The signal qualifies as a trigger at either point (T1) or (T2).

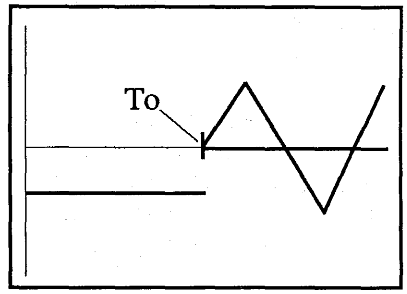


Figure 8-13

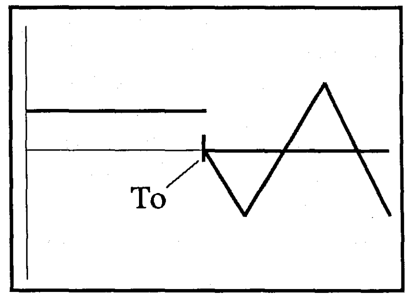


Figure 8-14

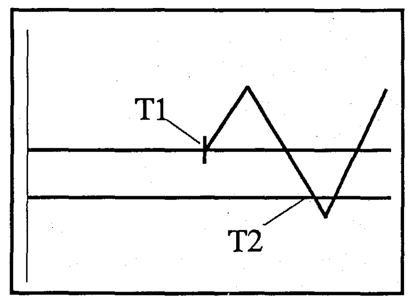


Figure 8-15

THE SENSITIVITY BUTTONS

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

> **CAUTION:** 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 MEMORY switch to an unimportant "half" or "quarter" position.

(⇕): Widens the window.

(⧖): Narrows the window.

NOTE: A default sensitivity of approximately 1/2 volt is selected by pressing both buttons simultaneously.

The "window" voltage can be adjusted from a range of 250 millivolts to 20 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.

To inspect the upper and lower level voltage values, turn Autocenter on and press the LEFT or RIGHT cursor button.

EXAMPLE 8-10

Figure 8-16: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.

Figure 8-17: The dashed line on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger.

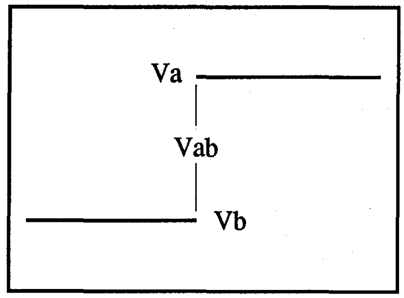


Figure 8-16

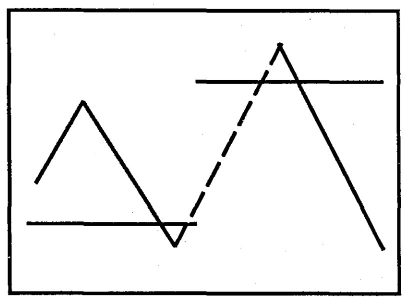


Figure 8-17

Recurrent (+) or (-) Slope Triggers

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 8-18: 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 8-19: 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.

Recurrent Dual Slope Triggers

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 8-20: Valid triggers occur at points (T1 through T4) each time the signal crosses the threshold levels.

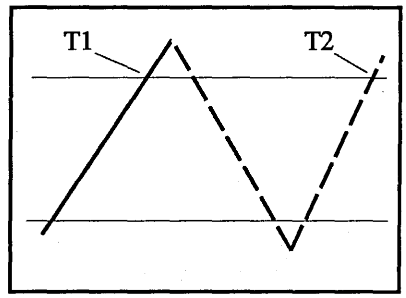


Figure 8-18

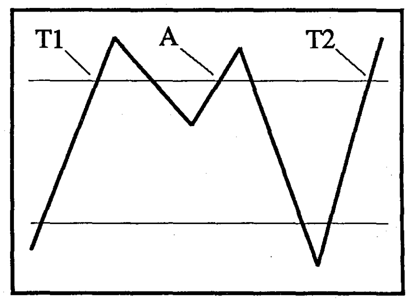


Figure 8-19

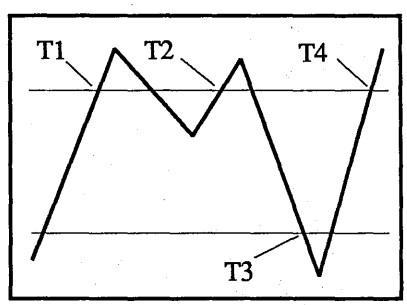


Figure 8-20

Adjusting for (+) or (-) Slope Triggers

#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. Press the LIVE button.

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

#9. VOLTS FULL SCALE: As required.

#10. Press the "left" SENSITIVITY button until the threshold level is fully compressed. Then press the "right" Sensitivity button until the "window" exceeds any "noise" spikes present.

#11. Adjust the LEVEL control 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. The plug-in continues to trigger.

NOTE: The Trigger button illuminates throughout each sweep.

Adjusting for Dual Slope Triggers

#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. Press the LIVE button.

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

#9. VOLTS FULL SCALE: As required.

#10. SENSITIVITY: Press the "left"Sensitivity button until the threshold level is fully compressed.

#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. 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 main-frame 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)
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, press the HOLD LAST and HOLD NEXT buttons at the same time.

NOTE: The Hold Last button must be released first. The trigger's rate of movement increases the longer a DELAY button is pressed. Releasing and then repressing the Delay button returns the advance to a slower rate of movement. The letter "S" suffix is added to the Plug-in/Channel numerics (e.g., 1AS) when the Setup mode is selected.

IMPORTANT: Operating the DELAY buttons while in the "set-up" mode alters the (T=0) origin, producing erroneous time numerics. The Setup mode is exited by pressing either the HOLD LAST or LIVE button. However, the time numerics remains erroneous until a new sweep is triggered.

EXAMPLE 8-13

Figure 8-21: The three types of trigger displays and related sweeps.

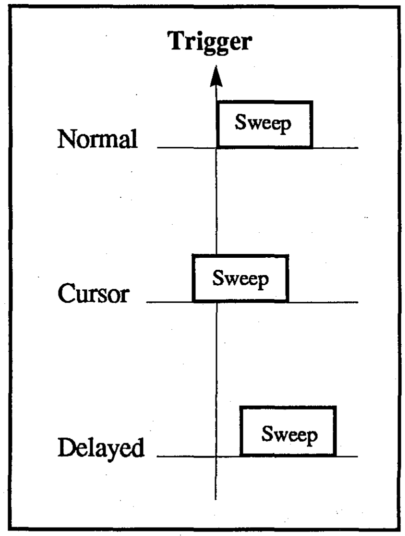


Figure 8-21

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.

EXAMPLE 8-14

Figure 8-22: A single sweep is triggered at point (To) and ends at point (T+).

Figure 8-23: The corresponding Normal trigger display of the captured signal.

The Cursor Trigger Display

To select the Cursor Trigger mode, place the plug-in into the "Setup" mode (page 8-23) 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.

EXAMPLE 8-15

Figure 8-24: 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 8-25: The corresponding Cursor trigger display of the captured signal.

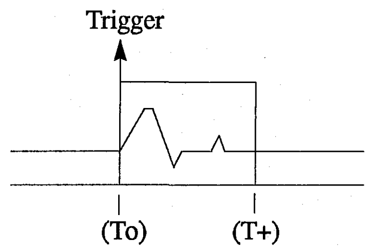


Figure 8-22

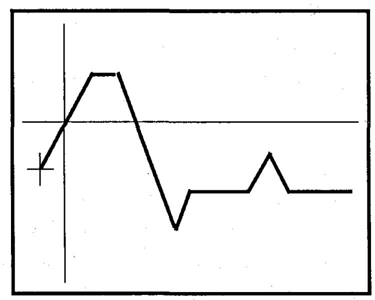


Figure 8-23

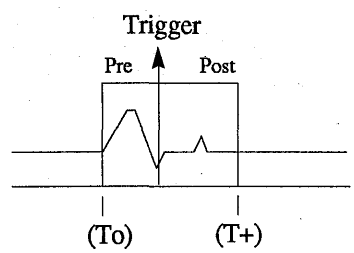


Figure 8-24

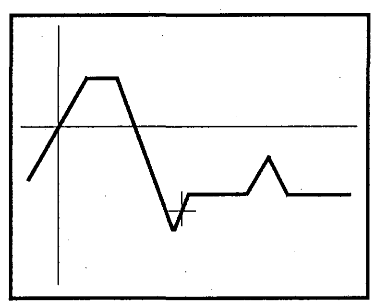


Figure 8-25

The 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 "Setup" mode (page 8-23) 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 main-frame's vertical cursor. The main-frame's vertical cursor can be moved after the delay has been set to inspect specific data point coordinates.

Equation 8-2 approximates the maximum time delay (Tmax) that can be selected.

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

Equation 8-2

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

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.

EXAMPLE 8-16

Figure 8-26: 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 8-27: The corresponding Delayed trigger display of the signal captured during the sweep.

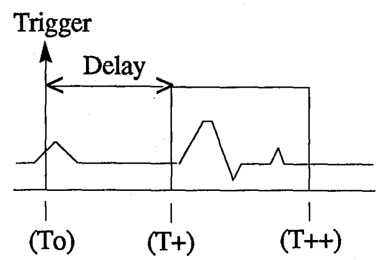


Figure 8-26

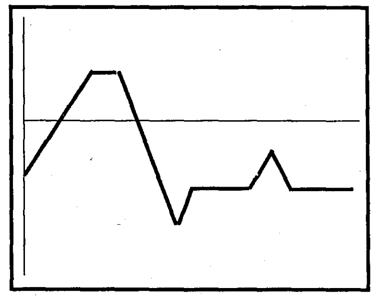


Figure 8-27

THE REMOTE CONTROL CONNECTOR

The remote control connector allows certain functions of the plug-in to be controlled from a remote station. Figure 8-28 identifies the function of each pin.

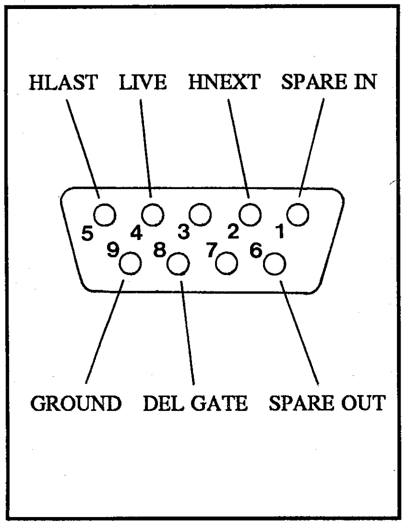


Figure 8-28

Hold Last, Live, 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.

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 8-29 illustrates the three types of triggers and corresponding sweeps and Delayed Gate outputs.

Spare In & Spare Out

Not currently being used.

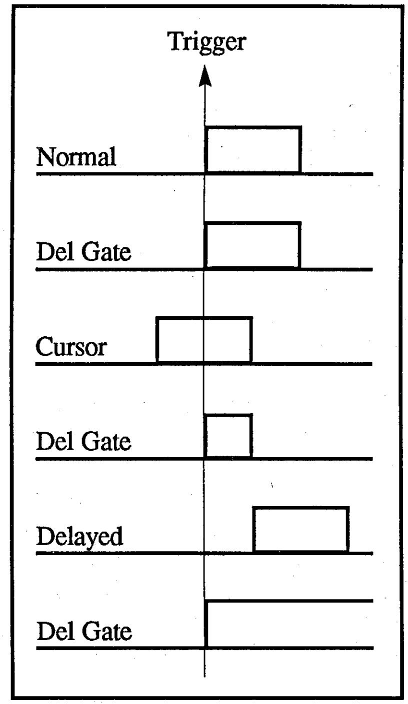


Figure 8-29

THE ADDRESS ADVANCE CONNECTOR

The Address Advance connector inputs the signals 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 one address.

THE PROBE POWER CONNECTOR

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

Figure 8-30 identifies the connector's voltage polarities and ground.

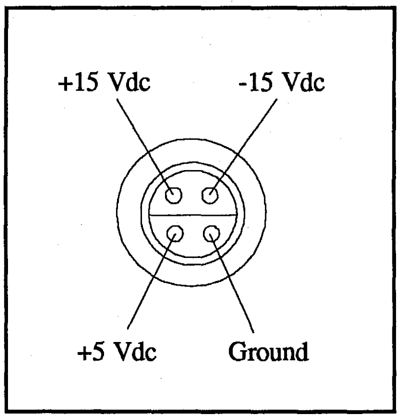


Figure 8-30

THE COMPENSATION POINT

A square wave signal appears on the screen when the optional X10 and X100 test probes are touched to the Compensation point.

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

IMPORTANT: The Time Per Point must be 20 microseconds or faster.

EXAMPLE 8-17

Figure 8-31 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.

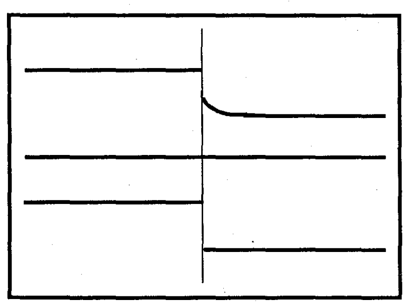


Figure 8-31

THE FUNCTION BUTTON

The FUNCTION button, when illuminated, will execute the function selected from the following list. Use the procedure at the right to select and execute a function.

NOTE: The plug-in defaults to the Virtual Averaging function when power is applied initially to the plug-in.

IMPORTANT: The plug-in must be in the LIVE mode and the FUNCTION button must be illuminated to execute the selected function. If the FUNCTION button is not illuminated, the plug-in will operate normally.

SELECTING & EXECUTING A FUNCTION

#1. Place the plug-in into the HOLD LAST mode (HOLD LAST LED on only).

#2. Enter the SET-UP mode.
   a. Depress and hold HOLD LAST.
   b. Depress and hold HOLD NEXT.
   c. Release HOLD LAST.
   d. Release HOLD NEXT.

NOTE: All three Storage LEDs should be illuminated and the current Function title should appear.

#3. Tap the FUNCTION button until the desired function appears on the screen.

#4. When the desired function appears, exit the SET-UP mode by pressing the LIVE or HOLD LAST button.

#5. The plug-in executes the selected function only if the FUNCTION button is illuminated.

AVERAGE FUNCTIONS

Select either Virtual Averaging or Exponential Averaging 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.

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

Values captured during the first two sweeps are averaged and the result is stored in memory. The "new" values captured during the third sweep are averaged with the "old" stored values and the memory is updated once again. This process of averaging "new" and "old" values and then updating the memory repeats with each successive sweep.

Virtual Averaging

Virtual averaging 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.

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

Equation 8-3

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	K=2	K=4	K=8	K=16

Table 8-6

The term "K" is computed from Equation 8-4. The result is rounded off to the nearest, lower power of two.

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

Equation 8-4

Exponential Averaging

The value of K in Equation 8-3 is always equal to 4 when exponential averaging is selected. This forces the display to respond quickly to any changes in the signal.

NOTE: The effects of exponential averaging will not be evident until the first six sweeps have been completed.

EXAMPLE 8-18

This example illustrates the Virtual Averaging mode.

Figure 8-32: First sweep sampled at 1V1, 1V2, ... 1Vx.

Figure 8-33: Second sweep sampled at 2V1, 2V2, ... 2Vx.

Figure 8-34: 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 8-35: The resulting waveform display captured after several sweeps with Average turned on.

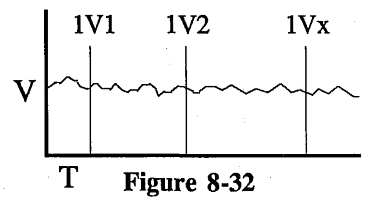


Figure 8-32

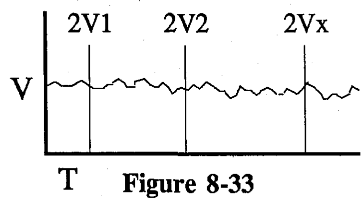


Figure 8-33

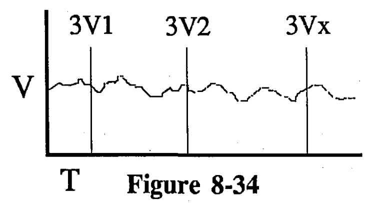


Figure 8-34

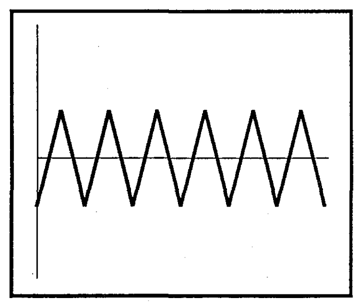


Figure 8-35

FOURIER TRANSFORM

IMPORTANT: Both SAVE modes and CHANNEL E will be turned off automatically and any data recorded by them will be lost when the FOURIER TRANSFORM function is executed.

The FOURIER TRANSFORM mode displays the spectrum of an incoming signal for examination of its frequency content. The oscilloscope uses 512 points to calculate a 256-point spectrum. This calculation requires approximately 1/2 second. The update rate is approximately 2 displays per second.

Signal Acquisition

When running in the Fourier Transform mode, select a suitable Time Per Point setting to obtain a meaningful FFT display.

Generally, the Time Per Point setting is much slower than that which would normally be used when examining signals with the voltage vs. time display. Trial and error (or Table 8-7, page 8-32) may be used to select a Time Per Point, but if the incoming signal contains significant frequencies above 1/2 the digitizing rate, aliasing will distort the results (see page 8-33, Aliasing and the Nyquist Frequency).

In the interest of speed, the fast Fourier transform is performed on the first 512 points of the incoming time-related signal. Be certain that the frequencies of interest are contained in the initial portion of the signal.

EXAMPLE 8-19

If a short, repetitive burst is under examination, the burst must be located in the first 512 points on the left side of the screen. See Figure 8-36.

To see the time domain signal which will be used for the FFT calculation, put your cursor at the 256th point on the waveform and apply expansion until 512 points are displayed (Figure 8-36).

Figure 8-37 shows the expanded display of the first 512 points in Figure 8-36.

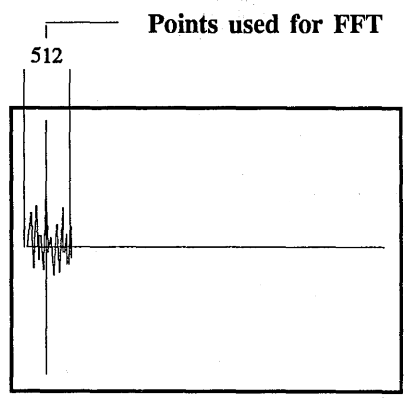


Figure 8-36

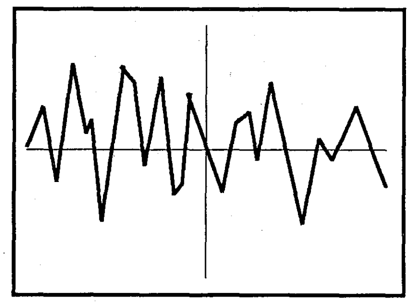


Figure 8-37

APPROXIMATE VALUES			
Time Per Point	**Digitizing Rate (Max)**	**Display Frequency Spectrum**	**Display Resolution (Interval between Points)**
100 nS	10 MHz	0 - 5 MHz	20 kHz
200 nS	5 MHz	0 - 2.5 MHz	10 kHz
500 nS	2 MHz	0 - 1 MHz	4 kHz
1 µS	1 MHz	0 - 500 kHz	2 kHz
2 µS	500 kHz	0 - 250 kHz	1 kHz
5 µS	200 kHz	0 - 100 kHz	400 Hz
10 µS	100 kHz	0 - 50 kHz	200 Hz
20 µS	50 kHz	0 - 25 kHz	100 Hz
50 µS	20 kHz	0 - 10 kHz	40 Hz
100 µS	10 kHz	0 - 5 kHz	20 Hz
200 µS	5 kHz	0 - 2.5 kHz	10 Hz
500 µS	2 kHz	0 - 1 kHz	4 Hz
1 mS	1 kHz	0 - 500 Hz	2 Hz
2 mS	500 Hz	0 - 250 Hz	1 Hz
5 mS	200 Hz	0 - 100 Hz	0.4 Hz
10 mS	100 Hz	0 - 50 Hz	0.2 Hz
20 mS	50 Hz	0 - 25 Hz	0.1 Hz
50 mS	20 Hz	0 - 10 Hz	0.04 Hz
100 mS	10 Hz	0 - 5 Hz	0.02 Hz
200 mS	5 Hz	0 - 2.5 Hz	0.01 Hz
500 mS	2 Hz	0 - 1 Hz	0.004 Hz
1S	1 Hz	0 - 0.5 Hz	0.002 Hz

Table 8-7

$$\text{Maximum Digitizing Rate} = \frac{1}{\text{Time Per Point Switch Setting}}$$

$$\text{Displayed Frequency Spectrum} = \frac{\text{Maximum Digitizing Rate}}{2}$$

$$\text{Display Resolution} = \frac{\text{Displayed Frequency Spectrum}}{250}$$

Aliasing and the Nyquist Frequency

Aliasing occurs if a waveform is undersampled. A sine wave sampled at less than twice its frequency will produce aliasing.

Figure 8-38 illustrates an 83.3 Hz sine wave sampled at 100 Hz. Notice that the apparent frequency, or "alias" is 16.6 Hz, a much lower frequency than that of the actual waveform. From Figure 8-39, it is clear that a sampling rate of exactly twice the sine wave frequency will not define the signal either.

Sampling theory requires a sampling rate of slightly more than twice the signal frequency for recognition of the signal. The 83.3 Hz signal, then, requires a sampling rate of slightly more than 166.6 Hz.

In the frequency domain, aliasing of this sort causes a "folding back" of frequencies, and distorts both the amplitude and phase information of the Fourier transform. Frequency folding can be visualized as an accordian-like graph (Figure 8-40).

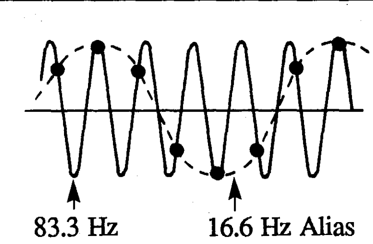
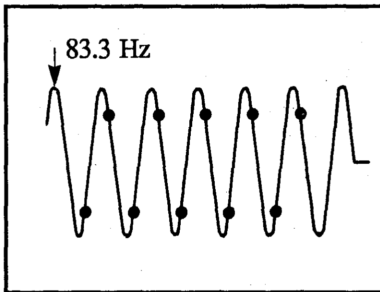


Figure 8-38



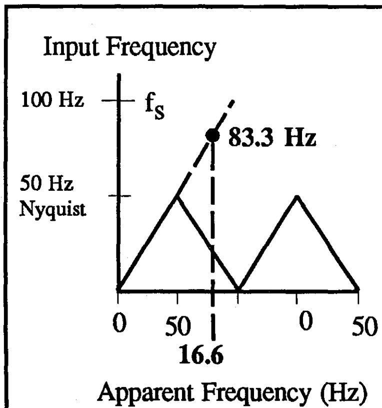
Sampling at 166.6 Hz
Nyquist Frequency = 8.3. Hz

Figure 8-39

With the 100 Hz sampling rate in Figure 8-38, any frequency component higher than 50 Hz will be folded back to appear as a lower frequency. Thus the 83.3 Hz sine wave appears as an aliased 16.6 Hz. The point at which folding begins to occur is the Nyquist frequency, or 1/2 the sampling frequency.

If frequencies above Nyquist are present to a significant degree in a signal, the frequency spectrum will be distorted. One must either use a higher sampling rate, or filter out the unwanted high frequencies. Thus, if one is using a 100 kHz rate (10 microseconds/point), the signal's frequencies above 50 kHz should be eliminated or at least greatly reduced with a 50 kHz low pass filter.

In the case of the example in Figure 8-38, a higher sampling rate (e.g., 200 Hz) would be adequate to avoid frequency folding. However, for complex signals, one cannot always be certain which high frequencies are present, so filtering is necessary.



Folding Diagram for Fs = 100 Hz

Figure 8-40

FFT Mathematics

After acquisition of 512 time-domain data points, the 4570 applies a Hanning window function to the data. In comparison with FFT's using a simpler box window, the Hanning window reduces "side lobes" caused by truncation and widens the frequency band at 1/2 peak amplitude.

$$X_{(t)} = \frac{1 - \cos\frac{2t}{T}}{2} \quad 0<t<T$$

Equation 8-6

The Fast Fourier Transform algorithm used for the frequency calculation is the Cooley-Tukey and Sande-Tukey base 4 twiddle factor algorithm. For a complete description of this algorithm, and of FFT's in general, refer to THE FAST FOURIER TRANSFORM by E. Oran Brigham, Prentice Hall, NJ, 1974.

Notes for Users of Disk Drives, Plotters, and Computers

Disk Drives

Storing and recalling FFT spectra on the 4094's disk drives may be done in the same manner as time domain waveforms.

Plotters

If you try to plot the FFT display using the 4094's push-button plot function, the plot will execute with the standard 4094 plot format. It will be labeled in volts and time rather than RMS volts and Hertz. The numerics are correct, but must be "understood" as RMS volts and Hertz. In order to be assured of plotting calculated points, the cursors must rest on a calculated point when selecting the waveform to be plotted.

Computers

Results of the Fourier Transform mode may be output to a computer over the interfaces, but special care must be taken.

Use Table 8-9 to select the correct waveform number and step number in the "D" command. Table 8-9 also shows the normalizing set number to be used when retrieving normalizing with the "N" command. Data and normalizing are received in a time and volts format, so these must be "understood" to be represent Hertz and RMS volts for the FOURIER TRANSFORM function display.

See the Input/Output instructions (section 13 of this manual) for full information on interfacing.

Please contact the application engineers at Nicolet if you have further questions concerning computer interfacing.

Number of Channels	Channel Identifier	Waveform Number	Step Number	Normset Number
1	Any	1	2	0
2	A	1	2	0
2	B	2	2	1
4	1A	1	2	0
4	2A	2	2	1
4	1B	3	2	2
4	2B	4	2	3

Note: Assume that the mainframe MEMORY GROUP switch was in "ALL" when the data was captured.

Table 8-9

SAMPLE PROGRAM

The following sample program inputs data and normalizing to a computer (HP BASIC) if one FFT was acquired with the mainframe MEMORY switch in the ALL position.

10 OUTPUT 714;"C,4,2,13,10"	Set record separators to CR/LF
20 ENTER 714; E	Read error code.
30 DIM D(248)	Dimension data array.
40 OUTPUT 714; "D,0,1,0,248,2"	Data is output in ASCII for waveform #1, starting at the first point and giving 248 (**see Note 1**) values. A step of 2 assures that these are calculated values.
50 ENTER 714; E	Read the error code.
60 FOR I=1 TO 248 70 ENTER 714; D(I) 80 DISP D(I) 90 NEXT I	Loop to input individual data point values..
100 ENTER 714; E	Read error code.
110 DIM N(7)	Dimension normalizing array.
120 OUTPUT 714; "N,0"	Request normalizing information for waveform 1.
130 ENTER 714; E	Read error code.
140 FOR J=1 TO 7 150 ENTER 714; N(J) 160 DISP N(J) 170 NEXT J	Loop to input normalizing information.
180 ENTER 714; E	Read error code.
190 END	End of program.

NOTE 1: Although a 256-point FFT is calculated, 248 values are displayed.

THE MAX/MIN FUNCTION

The MAX/MIN function displays two data points per sample period. The first point locates the maximum voltage sampled during that sample period. The second point locates the minimum voltage sampled during the same sample period.

Table 8-10 (single channel) and Table 8-11 (multiple channels) illustrate the pattern used to display the results on the screen for some of the combinations with the SAVE function turned on/off.

NOTE: Two data points are dumped for each sample period when using the MAX/MIN mode and the FUNCTION button is unlighted.

NUMBER OF CHANNELS	SAMPLE PERIOD			
	1st	2nd	3rd	4th
One Channels (*) (A or B or E)	A a • •	A a • •	A a • •	A a ➛ etc. • •
One Channel with Save (*) (A or B)	A a • •	A a • •	A a • •	A a ➛ etc. • •

Single Channel
Table 8-10

NUMBER OF CHANNELS	SAMPLE PERIOD			
	1st	2nd	3rd	4th
Two Channels (**) (A and B or E)	A B a b • • • •	A B a b • • • •	A B a b • • • •	A B a b ➛ etc. • • • •
Three Channels (A and B and E)	A B a b • • • •	A E a e • • • •	A B a b • • • •	A E a e ➛ etc. • • • •
Three Channels with CHA Save (A and B and E)	A B a b • • • •	A E a e • • • •	A B a b • • • •	A E a e ➛ etc. • • • •

Multiple Channels
Table 8-11

THE A+B FUNCTION

IMPORTANT: Both SAVE modes and CHANNEL E will be turned off automatically and any data recorded by them will be lost when the A+B function is executed. In addition, both channels are forced on (if not already on) when the A+B function is executed.

Three waveforms are displayed when waveform A and waveform B are added together.
#1. Waveform A
#2. Waveform B
#3. Result of A + B

NOTE: The time resolution is halved due to the use of every other pair of points to store the result.

To ensure that both channels capture data with identical Volts Full Scale ranges -

#1. The channel B Volts Full Scale selector copies the channel A Volts Full Scale range automatically when the A+B function is executed initially.

#2. If the Volts Full Scale range is changed on one channel, the other channel will duplicate the voltage change automatically while the A+B function is being executed.

The resulting waveform is centered vertically on the screen and identified with the letter "R" (Result) by the Plug-in/Channel Identifier when it is being decoded by the numerics.

Figure 8-38 illustrates the pattern that will be used to display the two original waveforms and the result of adding channel A and channel B.

SAMPLE PERIOD				
1st	**1st**	**3rd**	**3rd**	**5th**
A B ● ●	x x ● ●	A B ● ●	x x ● ●	A B ... etc. ● ●

Figure 8-38

A = Channel A voltage
B = Channel B voltage
x = Channel A + Channel B voltage

THE A-B FUNCTION

IMPORTANT: Both SAVE modes and CHANNEL E will be turned off automatically and any data recorded by them will be lost when the A-B function is executed. In addition, both channels are forced on (if not already on) when the A+B function is executed.

Subtracting waveform B from waveform A results in a three waveform display.
#1. Waveform A
#2. Waveform B
#3. Result of A - B

NOTE: The time resolution is halved due to the use of every other pair of points to store the result.

To ensure that both channels capture data with identical Volts Full Scale ranges -

#1. The channel B Volts Full Scale selector copies the channel A Volts Full Scale range automatically when the A-B function is executed initially.

#2. If the Volts Full Scale range is changed on one channel, the other channel will duplicate the voltage change automatically while the A-B function is being executed.

The resulting waveform is centered vertically on the screen and identified with the letter "R" (Result) by the Plug-in/Channel Identifier when it is being decoded by the numerics.

Figure 8-39 illustrates the pattern that will be used to display the two original waveforms and the result of subtracting channel B from channel A.

SAMPLE PERIOD				
1st	1st	3rd	3rd	5th
A B ● ●	x x ● ●	A B ● ●	x x ● ●	A B ... etc. ● ●

Figure 8-39

A = Channel A voltage
B = Channel B voltage
x = Channel A - Channel B voltage

THE A*B FUNCTION

IMPORTANT: Both SAVE modes and CHANNEL E will be turned off automatically and any data recorded by them will be lost when the A*B function is executed. In addition, both channels are forced on (if not already on) when the A*B function is executed.

Multiplying waveform A by waveform B results in a three waveform display -
#1. Waveform A
#2. Waveform B
#3. Result of A x B

NOTE: The time resolution is halved due to the use of every other pair of points to store the result.

The resulting waveform is centered vertically on the screen and identified with the letter "R" (Result) by the Plug-in/Channel Identifier when it is being decoded by the numerics.

Figure 8-40 illustrates the pattern that will be used to display the two original waveforms and the result of multiplying channel A by channel B.

SAMPLE PERIOD				
1st	**1st**	**3rd**	**3rd**	**5th**
A B • •	x x • •	A B • •	x x • •	A B ... etc. • •

Figure 8-40

A = Channel A voltage
B = Channel B voltage
x = Channel A x Channel B voltage

THE A/B FUNCTION

IMPORTANT: Both SAVE modes and CHANNEL E will be turned off automatically and any data recorded by them will be lost when the A/B function is executed. In addition, both channels are forced on (if not already on) when the A/B function is executed.

Dividing waveform A by waveform B results in a three waveform display -
#1. Waveform A
#2. Waveform B
#3. Result of A/B

NOTE: The time resolution is halved due to the use of every other pair of points to store the result.

The resulting waveform is centered vertically on the screen and identified with the letter "R" (Result) by the Plug-in/Channel Identifier when it is being decoded by the numerics.

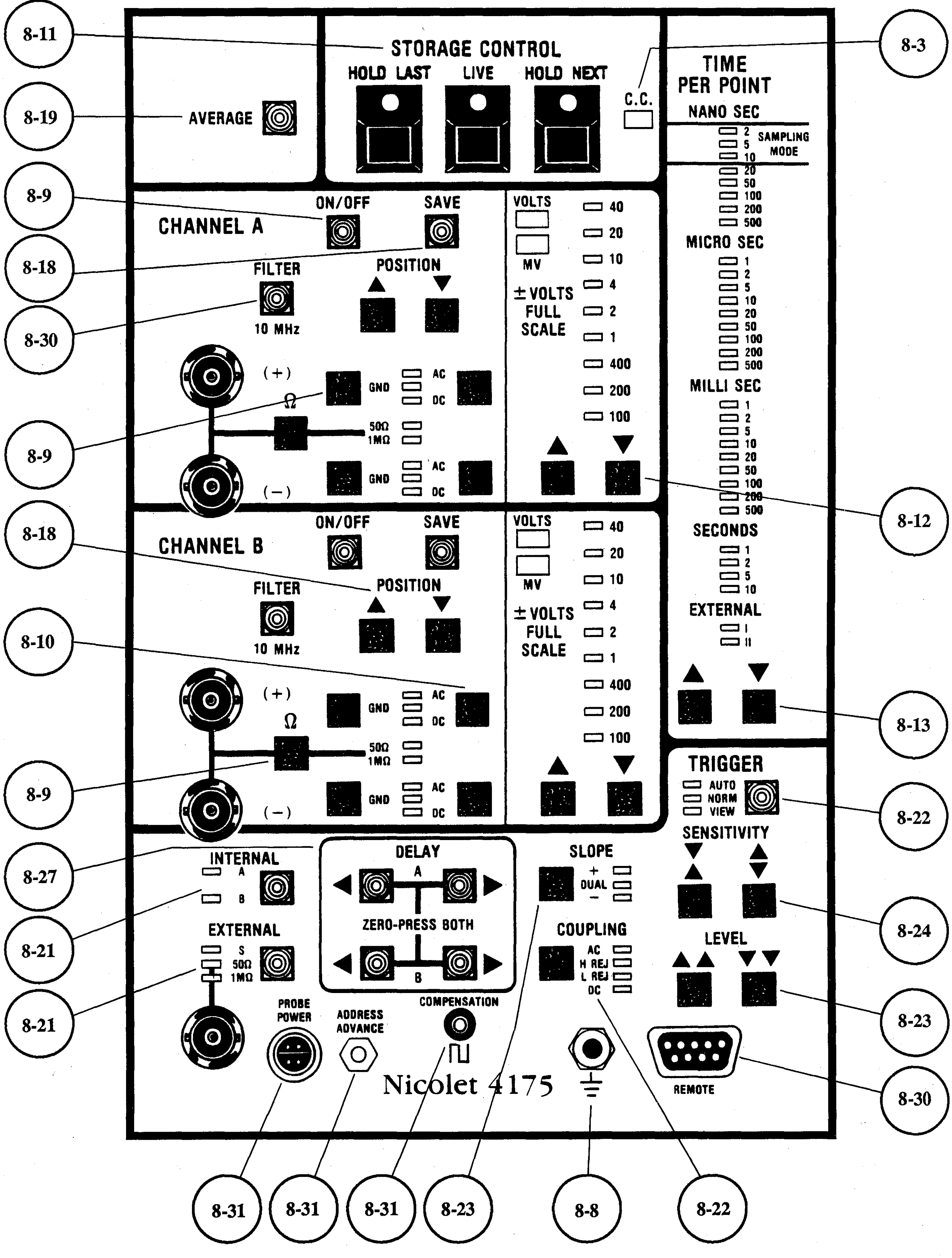
Figure 8-41 illustrates the pattern that will be used to display the two original waveforms and the result of dividing channel A by channel B.

SAMPLE PERIOD				
1st	**1st**	**3rd**	**3rd**	**5th**
A B • •	x x • •	A B • •	x x • •	A B ... etc. • •

Figure 8-41

A = Channel A voltage
B = Channel B voltage
x = Channel A/Channel B

4175 PLUG-IN



STORAGE CONTROL
HOLD LAST
LIVE
HOLD NEXT
C.C.
AVERAGE
TIME PER POINT
NANO SEC
SAMPLING MODE
MICRO SEC
MILLI SEC
SECONDS
EXTERNAL
CHANNEL A
CHANNEL B
ON/OFF
SAVE
FILTER
10 MHz
POSITION
VOLTS
MV
± VOLTS FULL SCALE
GND
AC
DC
50Ω
1MΩ
TRIGGER
AUTO
NORM
VIEW
SENSITIVITY
LEVEL
SLOPE
DUAL
COUPLING
H REJ
L REJ
INTERNAL
DELAY
ZERO-PRESS BOTH
PROBE POWER
ADDRESS ADVANCE
COMPENSATION
REMOTE
Nicolet 4175
8-11
8-19
8-9
8-18
8-30
8-10
8-27
8-21
8-3
8-12
8-13
8-22
8-24
8-23
8-31
8-8

INTRODUCTION

The Model 4175 Plug-in uses two 8-bit, 20 nanosecond digitizers.

Other Plug-in features include -

Equivalent time sampling to 2 nanoseconds/point for repetitive signals.

Analog bandwidth (-3 dB):
a. 50Ω input: 0.5 Hz - 75 Hz
b. 1 MΩ input: 3 kHz - 75 MHz

Differential amplifier operation.

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: The following procedure will override the Power Off Memory feature (column three of this page) and make the 4094 operational again if the front panel controls perform erratically when power is turned on (or during normal operation) -
#1. Turn the power off.
#2. Press and hold all four DELAY buttons simultaneously.
#3. Turn the power back on.
#4. Release the DELAY buttons.

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, use the following procedure to select the Hold mode.
#1. Press and hold the HOLD LAST button.
#2. Momentarily press the LIVE button.
#3. Release the HOLD LAST button.

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 front panel controls are controllable via the 4094 computer interfaces (see Section 13, page 13-37d).

Power Off Memory

The 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. If this condition occurs, contact:

Nicolet Instruments Corporation
Test Instruments Divsion,
Service Department
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).

OVERVOLTAGE

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

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

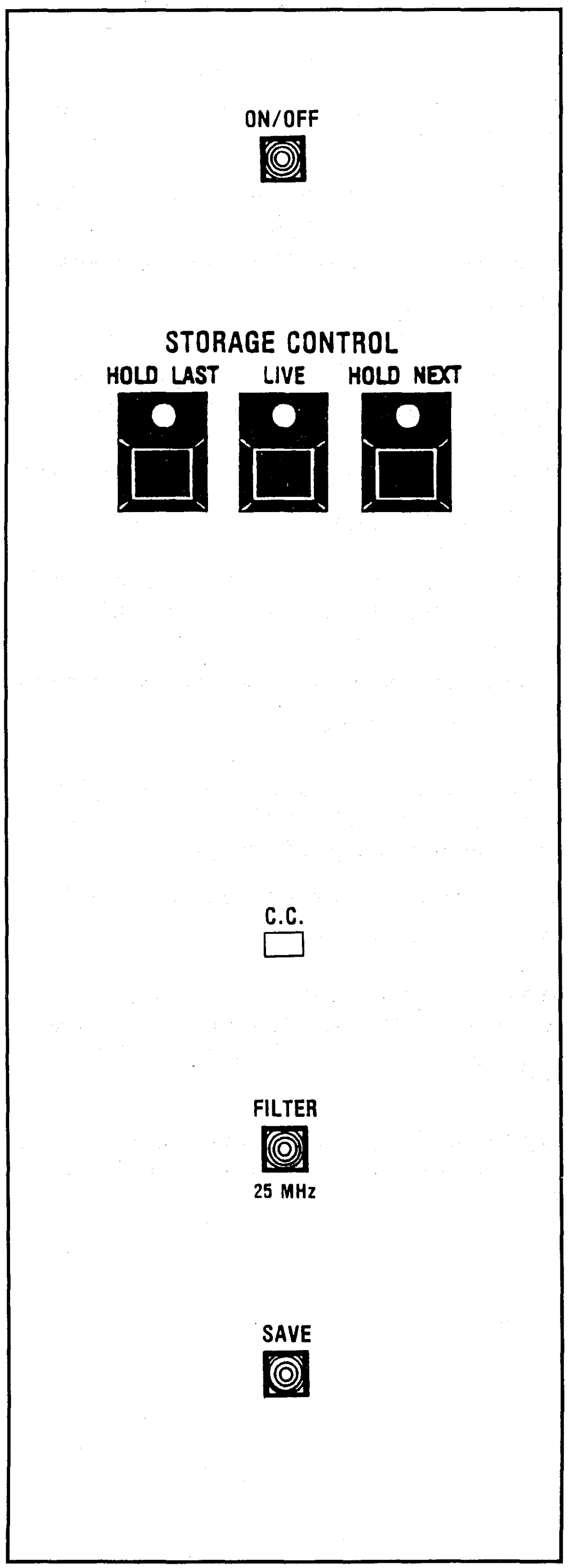
Example

If a voltage greater than ±5 Vrms 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.

Returning to Normal Operation:

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

#2. Press the Live button.



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

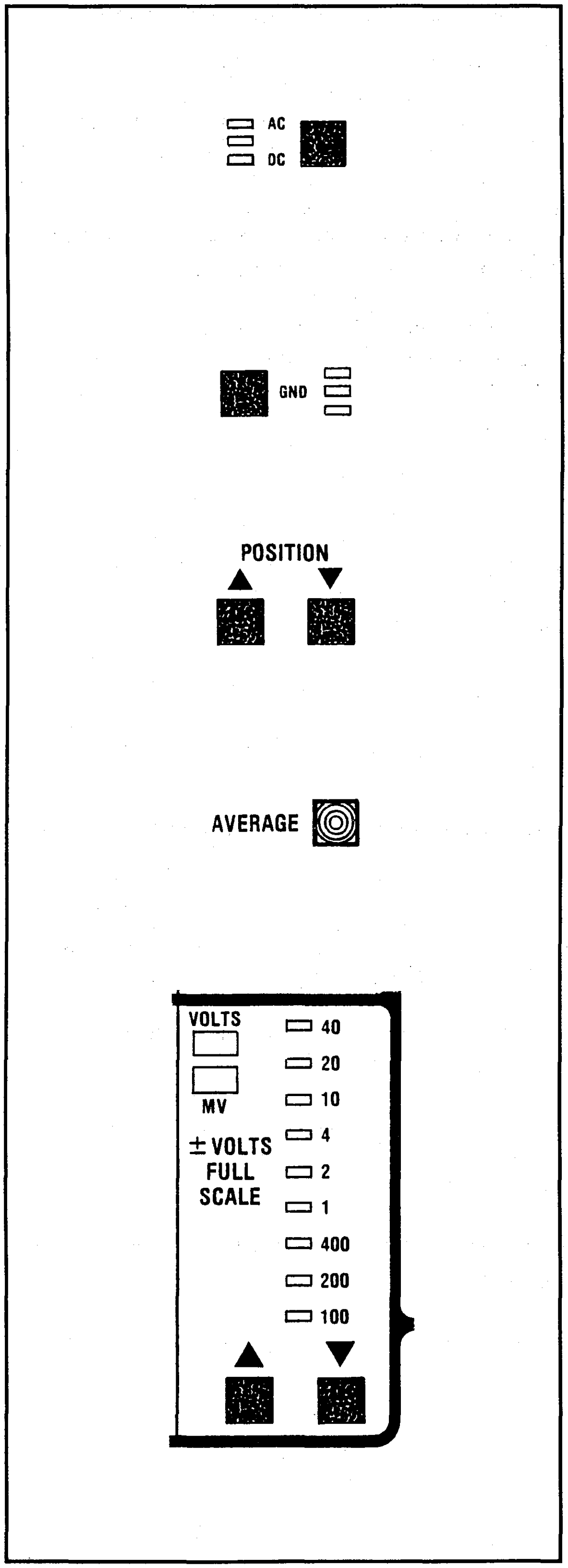
When the C.C. LED is illuminated, the scope is under computer control and the front panel controls will have no effect.

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.



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.

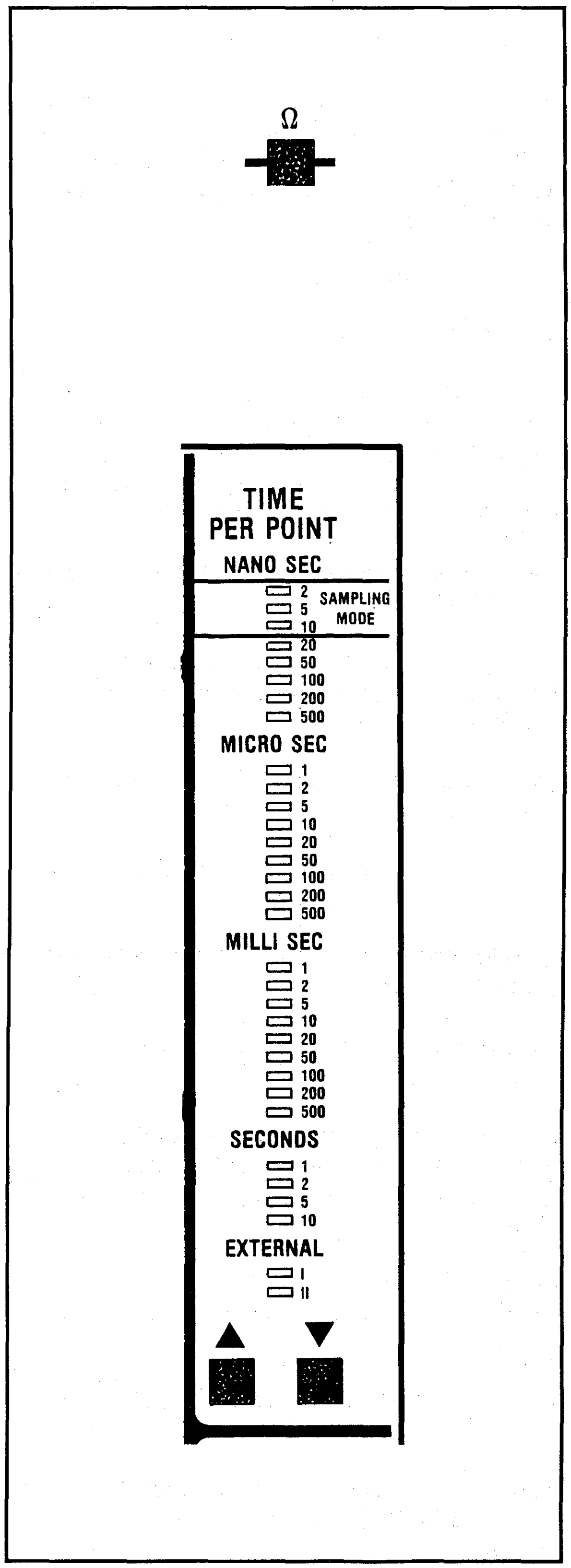
AVERAGE BUTTON

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 ±5 Vrms (maximum) input. (See Overvoltage, page 8-2).



Ω BUTTON

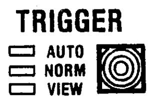
Selects whether the amplifier's input impedance is 50 ohms or 1 Megohm.

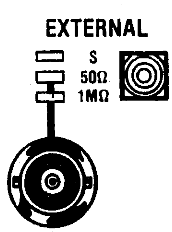
NOTE: The 50 ohm input impedance is limited to a ±5 Vrms (maximum) input. (See Overvoltage, page 8-2).

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.





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).

INTERNAL BUTTON

Selects which channel (A or B) will derive triggers. Internal triggering is activated when the Internal button is illuminated.

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

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

EXTERNAL BUTTON

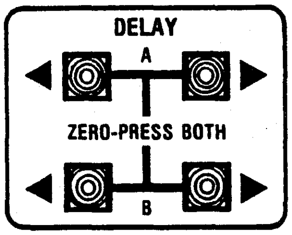
External triggering is selected when the External button is lighted.

(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 50Ω input impedance is limited to a ±5 Vrms (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.



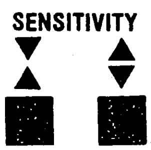
TRIGGER DELAY BUTTONS

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.

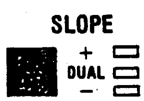
Cursor Trigger - Press the (A>) for channel A, or (B>) for channel B. Cursor triggering is selected when (A>) and/or (B>) are lighted.

Delayed Trigger - Press (<A) for channel A, or (<B) for channel B or channel E. Cursor 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".



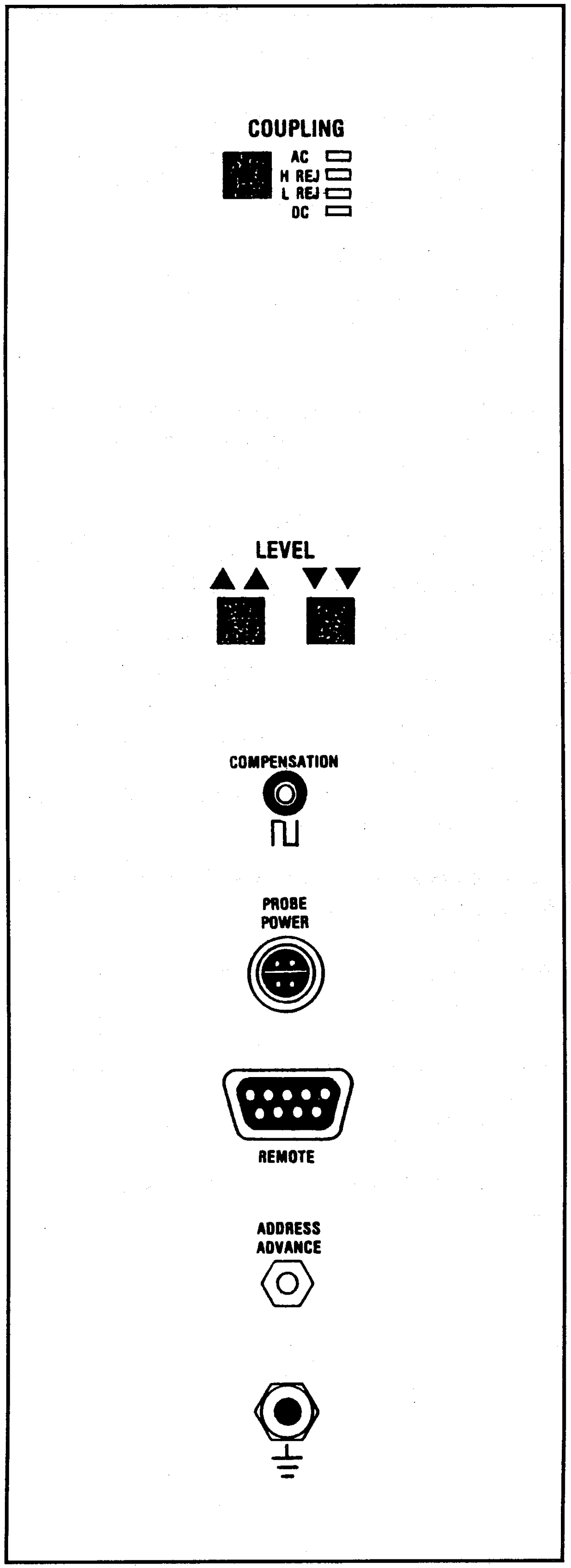
TRIGGER SLOPE BUTTON

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 and +5 Vdc outputs with ground.

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.

THE 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 when 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 each 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		
	All	Halves	Quarters
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-1

THE 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 - Selects the 50 ohm input impedance. The 50 ohm input impedance is limited to a ±5 Vrms input signal. (See Overvoltage, page 8-2.)

NOTE: The 50 ohm input impedance is recommended when capturing high speed signals (≥ 5 MHz) because 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 capturing slow speed input signals, and/or when the source impedance of the input signal is high.

THE 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 in the Specifications.

Differential Amplifier Mode

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 Amplifier Mode

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.

THE 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, 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

The Live, Hold Next and Hold Last buttons can be controlled from a remote station. Refer to page 8-28, "Remote Control Connector" descriptions.

THE VOLTS FULL SCALE SWITCH

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 ±5 Vrms 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.

The X10 probe available from Nicolet is for use with 1 megohm input scopes. It has a 100 MHz bandwidth, 600 volts dc working voltage. Its cable length is 59 inches (1.5 meters).

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.

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

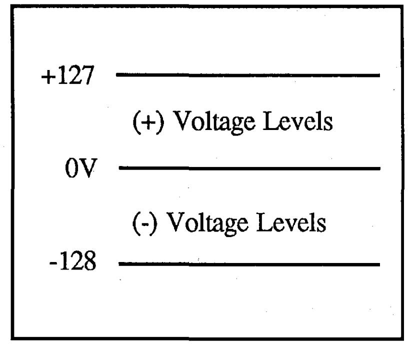


Figure 8-1

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

THE 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 (black dots) is displayed when the Time Per Point is set to 100 nSec.

Figure 8-6: Every fourth sample (black dots) is displayed when the Time Per Point is set to 200 nSec.

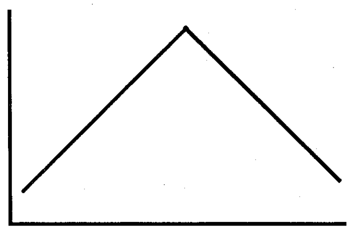


Figure 8-2

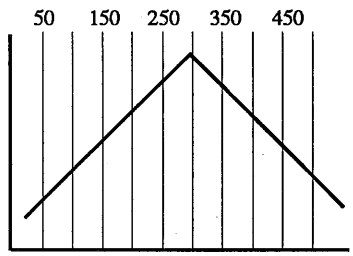


Figure 8-3

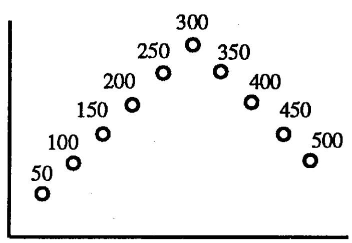


Figure 8-4

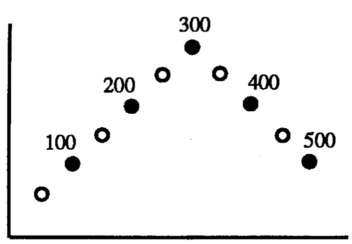


Figure 8-5

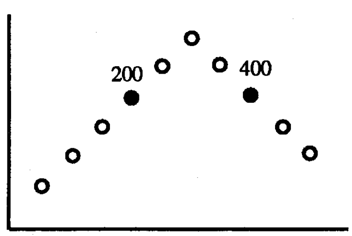


Figure 8-6

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 MEMORY switch.

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

Number Of Active Channels	Memory Switch		
	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.

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 skew 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 super-imposed 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) set of samples.

APPROXIMATE SWEEP TIMES

Table 8-4 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: Divide by 2.
Three or four channels: Divide by 4.

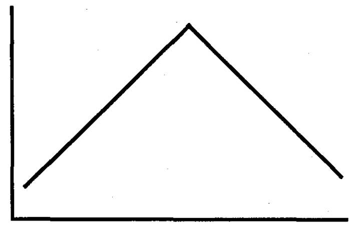


Figure 8-7

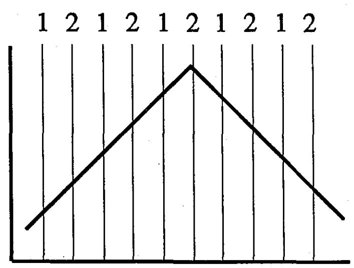


Figure 8-8

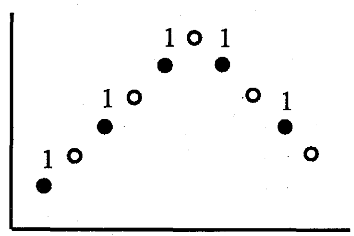


Figure 8-9

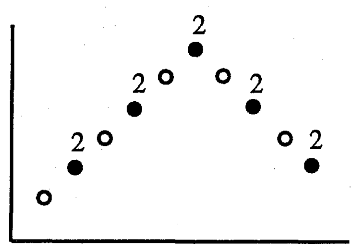


Figure 8-10

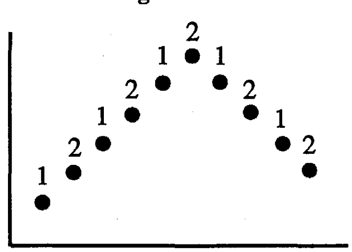


Figure 8-11

TIME PER POINT SETTING	Memory Switch Positions (Data Points Per Sweep)		
	ALL (16K Points/Sweep)	**H1/H2** (8K Points/Sweep)	**Q1/Q2/Q3/Q4** (4K Points/Sweep)
	Microseconds Per Sweep		
2 nS	31.760	15.880	7.940
5	79.400	39.700	19.850
10	158.80	79.400	39.700
20	317.600	158.800	79.400
50	794.000	397.00	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 µS	15.880	7.940	3.970
2	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
	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	11.00

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.

Number Of Active Channels	Memory Switch		
	All	**Halves**	**Quarters**
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-5

Delayed Displays

A delay occurs from the time of the first sample until a full screen display appears when the EXT I (fast) mode is selected. This occurs because each sample is stored in a buffer memory until enough samples to complete a full sweep have been captured.

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

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

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 8-16). Select the EXT I position when 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.
#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 nanoseconds.

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

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
(For EXT I & EXT II modes)

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

Figure 8-13: A valid trigger occurring at that point in time.

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

The EXT II Position (Slow Mode)

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 0 to 10 kHz (Averaging OFF) and DC to 1 kHz (Averaging ON).

The EXT II mode requires two external commands:
#1. A valid trigger.
#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 nanoseconds.

The trigger initiates the sampling sequence and "captures" the first sample. The remaining samples are captured within 100 nS of each Address Advance command's leading, positive edge. The first three Advanced Pulses following a valid trigger are only used to "synchronize" the logic. Data collection begins on the fourth Advance Pulse after a valid trigger.

NOTE: The maximum speed for the EXT II mode is 10 kHz (Averaging ON) and 1 kHz (Averaging OFF). Both the pulse width and the gap between the Address Advance command pulses must be greater than 25 nS.

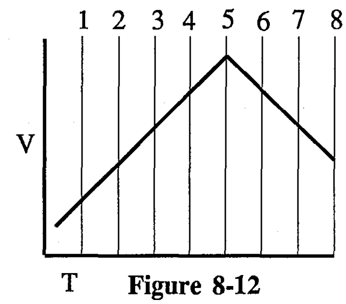


Figure 8-12

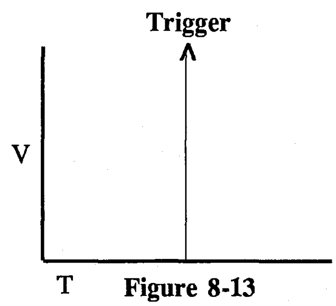


Figure 8-13

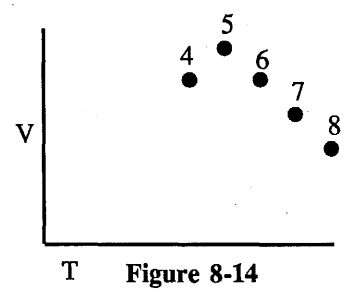


Figure 8-14

THE 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 crosshair follows the offset and the zero reference level is updated only after the button is released and any 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

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

CAUTION: 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 main-frame MEMORY switch to an unimportant "half" or "quarter" position.

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 8-4

Figure 8-15: Typical signal captured before turning on Save Reference.

Figure 8-16: Resulting display after turning on Save Reference and changing the input signal's characteristics.

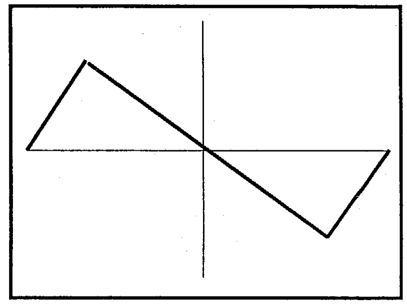


Figure 8-15

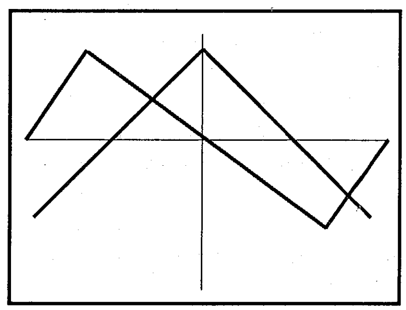


Figure 8-16

THE AVERAGE BUTTON

Turn on the Average mode to reduce the effects of "noise" on recurrent input sgnals 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" sweep 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 8-5

Figure 8-17: First sweep sampled at 1V1, 1V2, ... 1Vx.

Figure 8-18: Second sweep sampled at 2V1, 2V2, ... 2Vx.

Figure 8-19: Third sweep sampled at 3V1, 3V2, ... 3Vx.

Figure 8-20: 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.

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

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

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

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

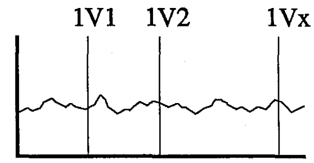


Figure 8-17

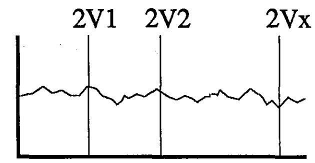


Figure 8-18

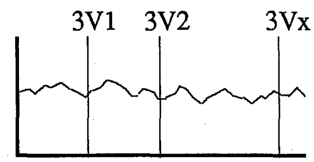


Figure 8-19

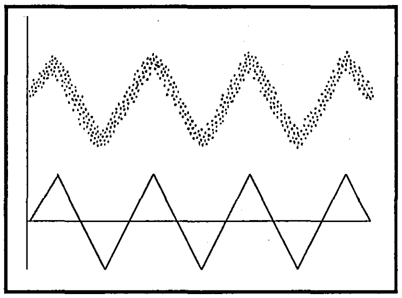


Figure 8-20

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

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

NOTE: The source impedance of the trigger signal must be low compared to 50 ohms to avoid excessive attenuation. It is preferable to use the external 50 ohm mode when using the Sampling Mode (i.e., Time Per Point = 2 nS, 5 nS, 10 nS).

1MΩ - Select the 1 megohm inut impedance when capturing 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.

4175/4180 - Select Internal (A or B) or External (50Ω or 1MΩ).

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

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

4175/4180 - Select External and "S".

THE 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 also enables the trigger's characteristics to be viewed on the screen if so 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 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 external trigger sources 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.

> **CAUTION:** 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 main-frame 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 are used to set the requirements that must be met to qualify the signal as a valid trigger.

a. Slope (page 8-23),
b. Minimum amplitude (page 8-23),
c. Minimum voltage change (page 8-24).

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

Selecting the VIEW mode

#1. Place the plug-in into the Hold mode.

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

#3. Turn the VIEW mode on.

#4. Press the LIVE button.

EXAMPLE 8-6

Figure 8-21: Typical VIEW display with "positive" slope selected.

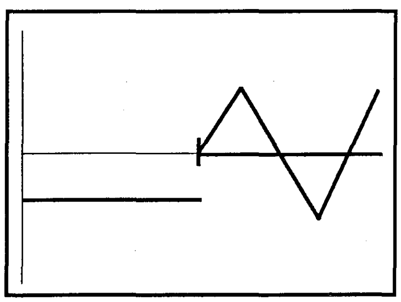


Figure 8-21

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 only an input impedance of 1 megohm is selected. (Frequencies of approx-imately 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 fequencies 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 SLOPE BUTTON

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

> **CAUTION:** 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 MEMORY switch to an unimportant "half" or "quarter" position.

(+) - 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 8-7

Figure 8-22: A positive slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-23: A negative slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-24: A dual slope display. The signal qualifies as a valid trigger at either (T1) or (T2).

THE LEVEL BUTTONS

The Level control adjusts the threshold level that the signal must cross in order to qualify as a valid 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.

> **CAUTION:** 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 MEMORY switch to an unimportant "half" or "quarter" position.

Which threshold level must be crossed by the signal is a function of the SLOPE button.

(+) - 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 8-8

Figure 8-22: A positive slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-23: A negative slope display. The signal qualifies as a valid trigger at point (To).

Figure 8-24: A dual slope display. The signal qualifies as a trigger at either point (T1) or (T2).

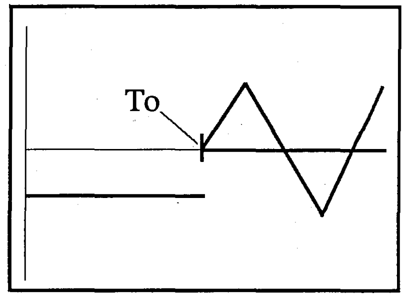


Figure 8-22

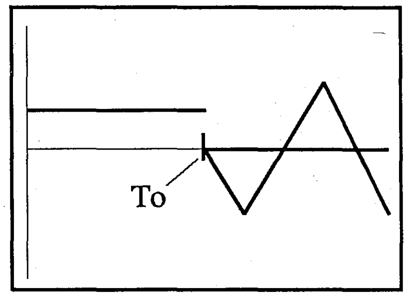


Figure 8-23

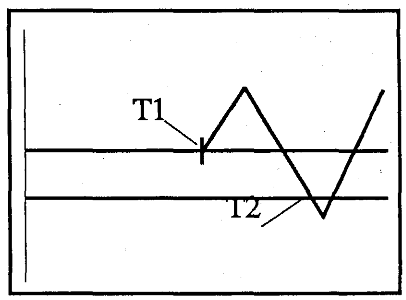


Figure 8-24

THE SENSITIVITY BUTTONS

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

> **CAUTION:** 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 MEMORY switch to an unimportant "half" or "quarter" position.

(⇕): Widens the window.

(⧖): Narrows the window.

NOTE: Maximum sensitivity is selected by pressing both buttons simultaneously. 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.

To inspect the upper and lower level voltage values, turn Autocenter on and press the LEFT or RIGHT cursor button.

EXAMPLE 8-9

Figure 8-25: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.

Figure 8-26: The dashed line on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger.

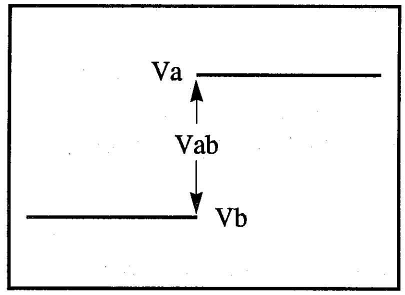


Figure 8-25

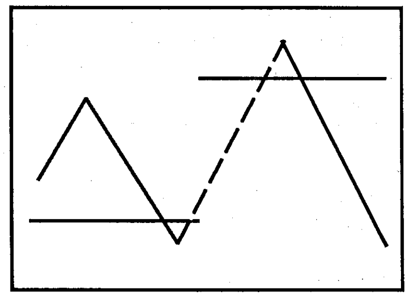


Figure 8-26

Recurrent (+) or (-) Slope Triggers

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 8-10

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

Figure 8-27: 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 8-28: 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.

Recurrent Dual Slope Triggers

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 8-11

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

Figure 8-29: Valid triggers occur at points (T1 through T4) each time the signal crosses the threshold levels.

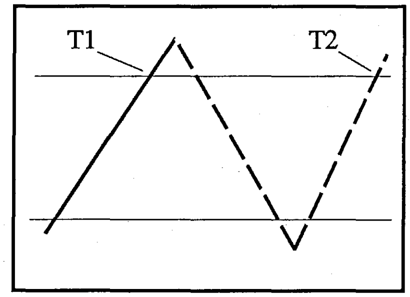


Figure 8-27

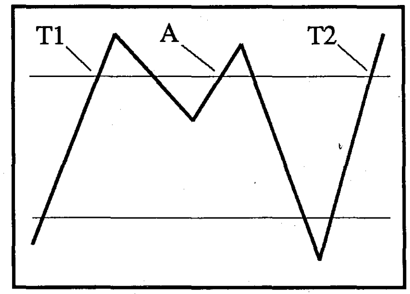


Figure 8-28

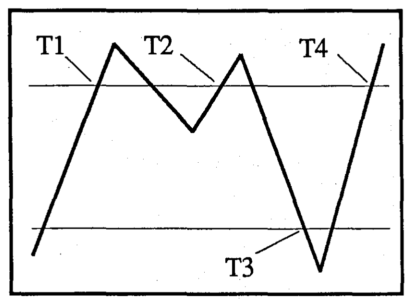


Figure 8-29

Adjusting for (+) or (-) Slope Triggers

#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. Press the LIVE button.

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

#9. VOLTS FULL SCALE: As required.

#10. Press the "left" SENSITIVITY button until the threshold level is fully compressed. Then press the "right" Sensitivity button until the "window" exceeds any "noise" spikes present.

#11. Adjust the LEVEL control 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. The plug-in continues to trigger.

NOTE: The Trigger button illuminates throughout each sweep.

Adjusting for Dual Slope Triggers

#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. Press the LIVE button.

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

#9. VOLTS FULL SCALE: As required.

#10. SENSITIVITY: Press the "left"Sensitivity button until the threshold level is fully compressed.

#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. 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 main-frame 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)
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, press and hold in the HOLD LAST and then tap the HOLD NEXT button.

NOTE: The Hold Last button must be released first. The trigger's rate of movement increases the longer a DELAY button is pressed. Releasing and then repressing the Delay button returns the advance to a slower rate of movement. The letter "S" suffix is added to the Plug-in/Channel numerics (e.g., 1AS) when the Setup mode is selected.

IMPORTANT: Operating the DELAY buttons while in the "set-up" mode alters the (T=0) origin, producing erroneous time numerics. The Setup mode is exited by pressing either the HOLD LAST or LIVE button. However, the time numerics remains erroneous until a new sweep is triggered.

EXAMPLE 8-12

Figure 8-30: The three types of trigger displays and related sweeps.

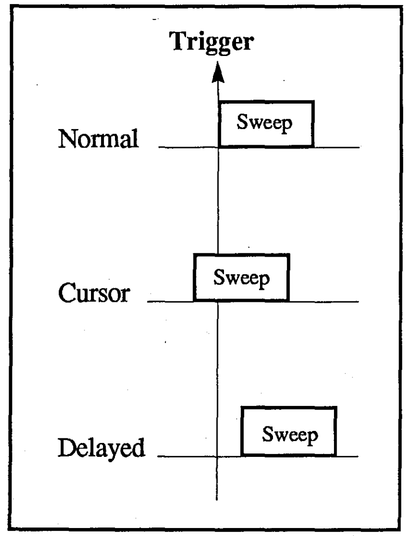


Figure 8-30

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.

Example 8-13

Figure 8-31: A single sweep is triggered at point (To) and ends at point (T+).

Figure 8-32: The corresponding Normal trigger display of the captured signal.

The Cursor Trigger Display

To select the Cursor Trigger mode, place the plug-in into the "Setup" mode (page 8-27) 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 either a slow sweep or the sampling mode, a Cursor Trigger display can be quickly set by pressing the Live button while holding in the (A>) or (B>) Delay button.

Example 8-14

Figure 8-33: 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 8-34: The corresponding Cursor trigger display of the captured signal.

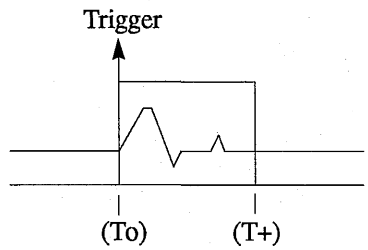


Figure 8-31

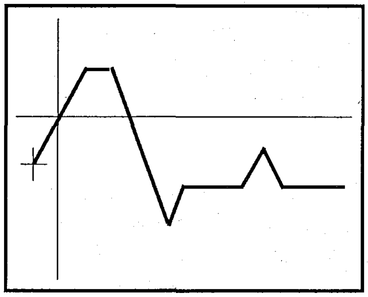


Figure 8-32

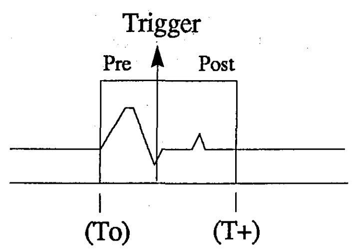


Figure 8-33

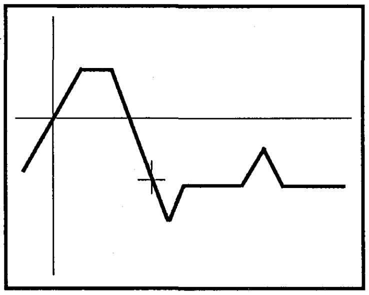


Figure 8-34

The 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 "Setup" mode (page 8-27) 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 main-frame's vertical cursor. The main-frame's vertical cursor can be moved after the delay has been set to inspect specific data point coordinates.

Equation 8-2 approximates the maximum time delay (Tmax) that can be selected.

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

Equation 8-2

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

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.

Example 8-15

Figure 8-35: 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 8-26: The corresponding Delayed trigger display of the signal captured during the sweep.

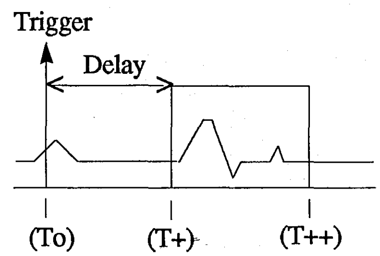


Figure 8-35

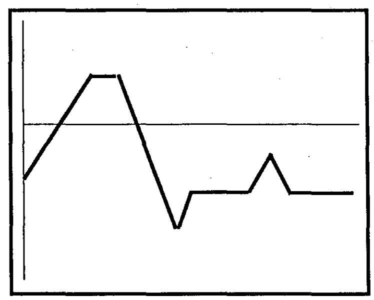


Figure 8-36

THE FILTER BUTTON

The 10 MHz (-3 dB 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.

THE REMOTE CONTROL CONNECTOR

The remote control connector allows certain functions of the plug-in to be controlled from a remote station. Figure 8-37 identifies the function of each pin.

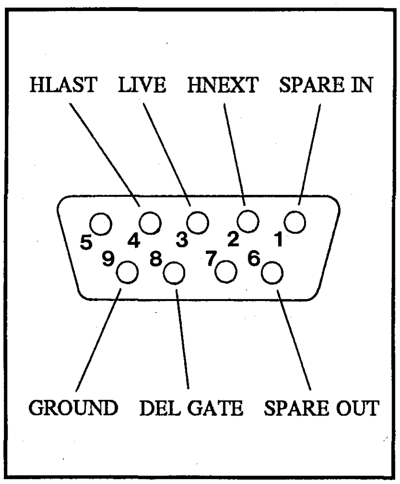


Figure 8-37

Hold Last, Live, 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.

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 8-38 illustrates the three types of triggers and corresponding sweeps and Delayed Gate outputs.

Spare In & Spare Out

Not currently being used.

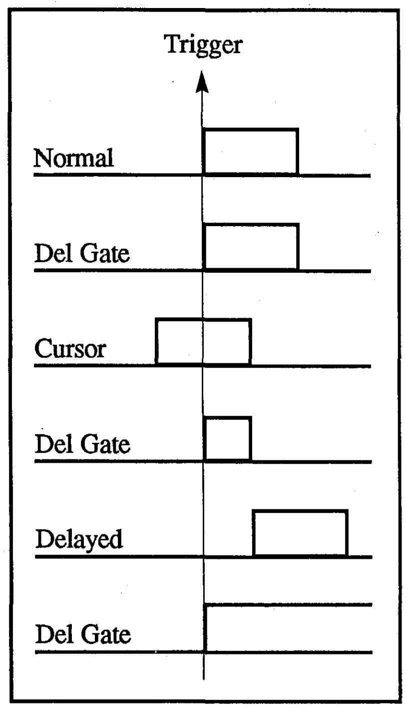


Figure 8-38

THE ADDRESS ADVANCE CONNECTOR

The Address Advance connector inputs the signals 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 one 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 preset at the factory 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
Test Instruments Division
Service Department
Madison, Wisconsin 53711
Telephone (608) 273-5010

THE PROBE POWER CONNECTOR

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

Figure 8-39 identifies the connector's voltage polarities and ground.

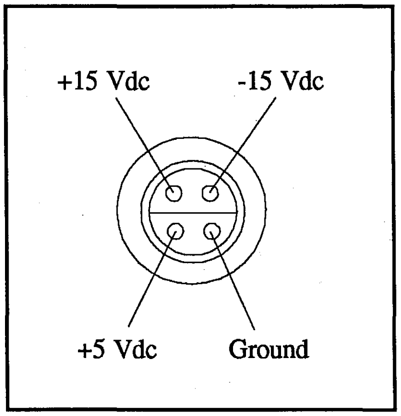


Figure 8-39

THE COMPENSATION POINT

A square wave signal appears on the screen when the optional X10 and X100 test probes are touched to the Compensation point.

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

IMPORTANT: The Time Per Point must be 20 microseconds or faster.

EXAMPLE 8-16

Figure 8-40 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.

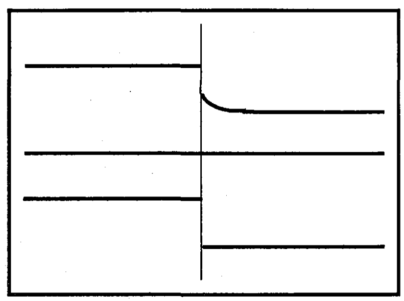
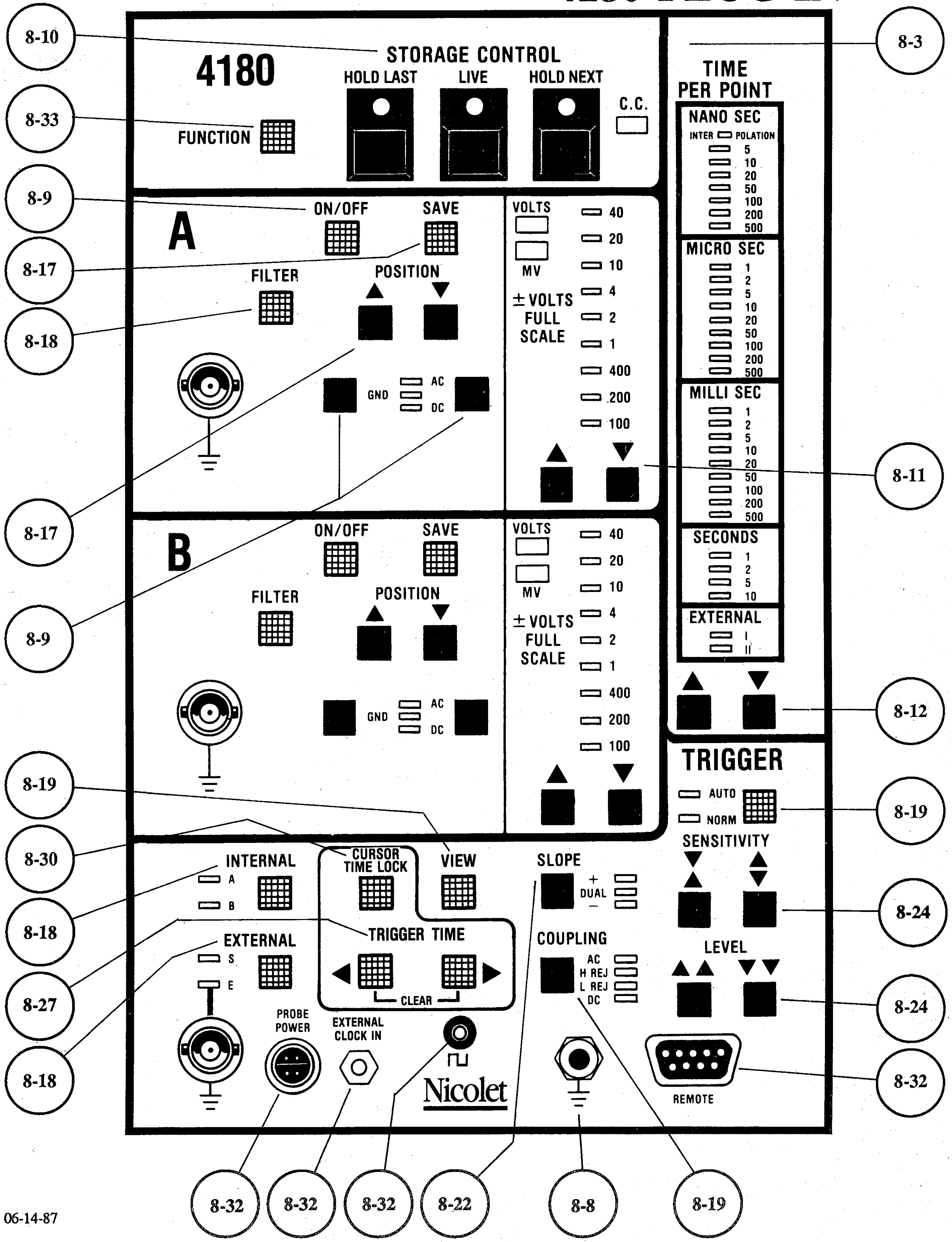


Figure 8-40

4180 PLUG-IN


8-10
8-33
8-9
8-17
8-18
8-17
8-9
8-19
8-30
8-18
8-27
8-18
8-3
8-11
8-12
8-19
8-24
8-24
8-32
8-32
8-32
8-32
8-22
8-8
8-19
4180
STORAGE CONTROL
HOLD LAST
LIVE
HOLD NEXT
C.C.
FUNCTION
TIME PER POINT
NANO SEC
INTER POLATION
5 10 20 50 100 200 500
MICRO SEC
1 2 5 10 20 50 100 200 500
MILLI SEC
1 2 5 10 20 50 100 200 500
SECONDS
1 2 5 10
EXTERNAL
I II
A
ON/OFF
SAVE
FILTER
POSITION
GND AC DC
VOLTS
MV
± VOLTS FULL SCALE
40 20 10 4 2 1 400 200 100
B
ON/OFF
SAVE
FILTER
POSITION
GND AC DC
VOLTS
MV
± VOLTS FULL SCALE
40 20 10 4 2 1 400 200 100
TRIGGER
AUTO
NORM
SENSITIVITY
LEVEL
INTERNAL
A
B
CURSOR TIME LOCK
VIEW
SLOPE
+ DUAL −
EXTERNAL
S
E
TRIGGER TIME
CLEAR
COUPLING
AC H REJ L REJ DC
PROBE POWER
EXTERNAL CLOCK IN
Nicolet
REMOTE

INTRODUCTION

The Model 4180 Plug-in uses two 8-bit, 5 nanosecond digitizers.

Other features include -

Analog bandwidth (-3 dB) for 1 Megohm inputs is DC to 100 MHz.

15,872 (16K) word memory.

User selectable functions for real time data manipulation. Functions include sweep averaging, FFT, max/min, add, subtract, multiply, and divide.

Positive, negative, or dual slope triggering.

Normal Sweep, Mid Signal trigger, and Delayed Sweep displays.

Trigger View mode to select the trigger's qualifying characteristics.

1 MHz Filter to reduce the effects of "noise" on the signals.

Save Reference mode to compare "live" and saved signals.

Complete controllability via GPIB or RS232 interface.

Test point compensation.

Plus/minus probe power output.

HOLD MODE

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, use the following procedure to select the Hold mode.

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

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 4180 front panel controls are controllable via the 4094 computer interfaces (see Section 13, page 13-37c).

POWER OFF MEMORY

The 4180 retains its front panel settings when power is removed from the 4094. The original front panel settings will return when power is reapplied.

IMPORANT: If the 4094 "beeps" five times during power-up, the plug-in may not retain its front panel settings if power is removed. If this condition occurs, contact:

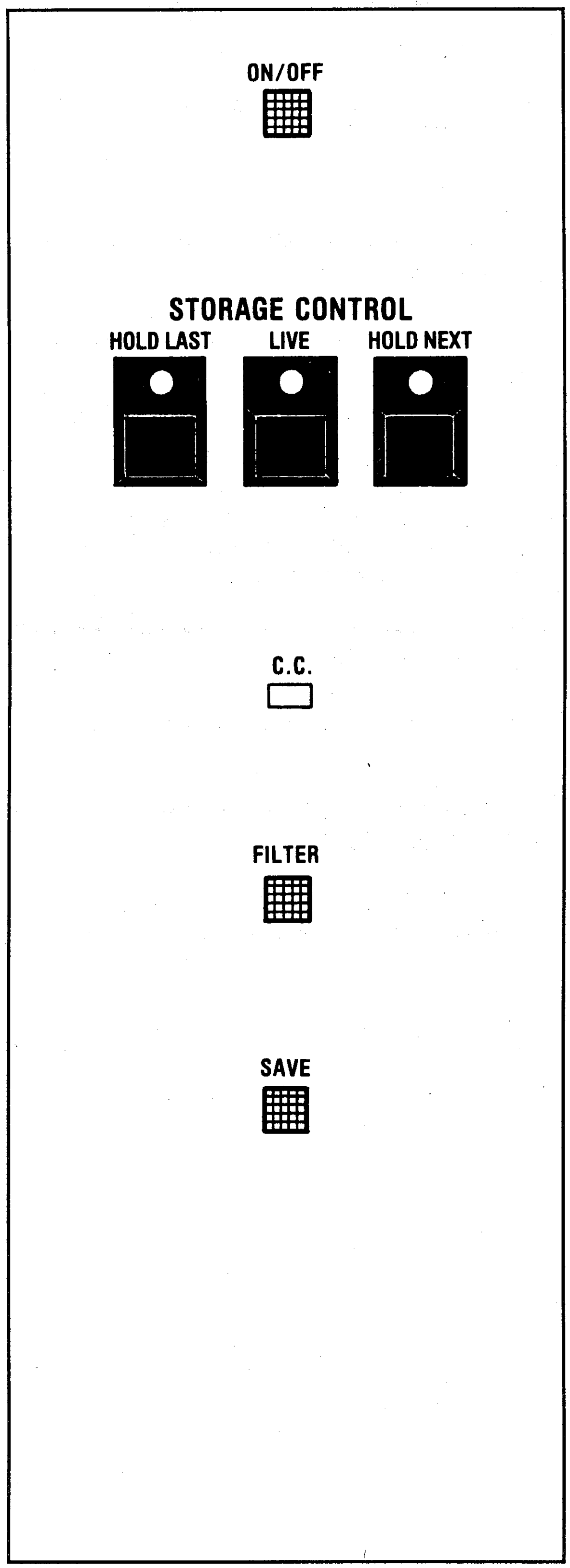
Nicolet Instruments Corporation
Test Instruments Divsion,
Service Department
Madison, Wisconsin 53711
Telephone (608) 273-5010

If overseas, contact your local Nicolet representative.

MASTER RESET

IMPORTANT: Use the following procedure to override the Power Off Memory feature if the front panel controls perform erratically after power is applied (or during normal operation) -

#1. Turn the power off.
#2. Press and hold both Trigger Time buttons simultaneously.
#3. Turn the power back on.
#4. Release the Trigger Time buttons.



CHANNEL ON/OFF BUTTONS

Enables or disables the channel for data collection.

STORAGE CONTROL BUTTONS

LIVE - New data is displayed each time a sweep is triggered.

HOLD NEXT - Data captured during the next sweep is stored in memory.

HOLD LAST - Data captured during the last sweep (including a sweep already in progress) is stored in memory.

C.C. LED

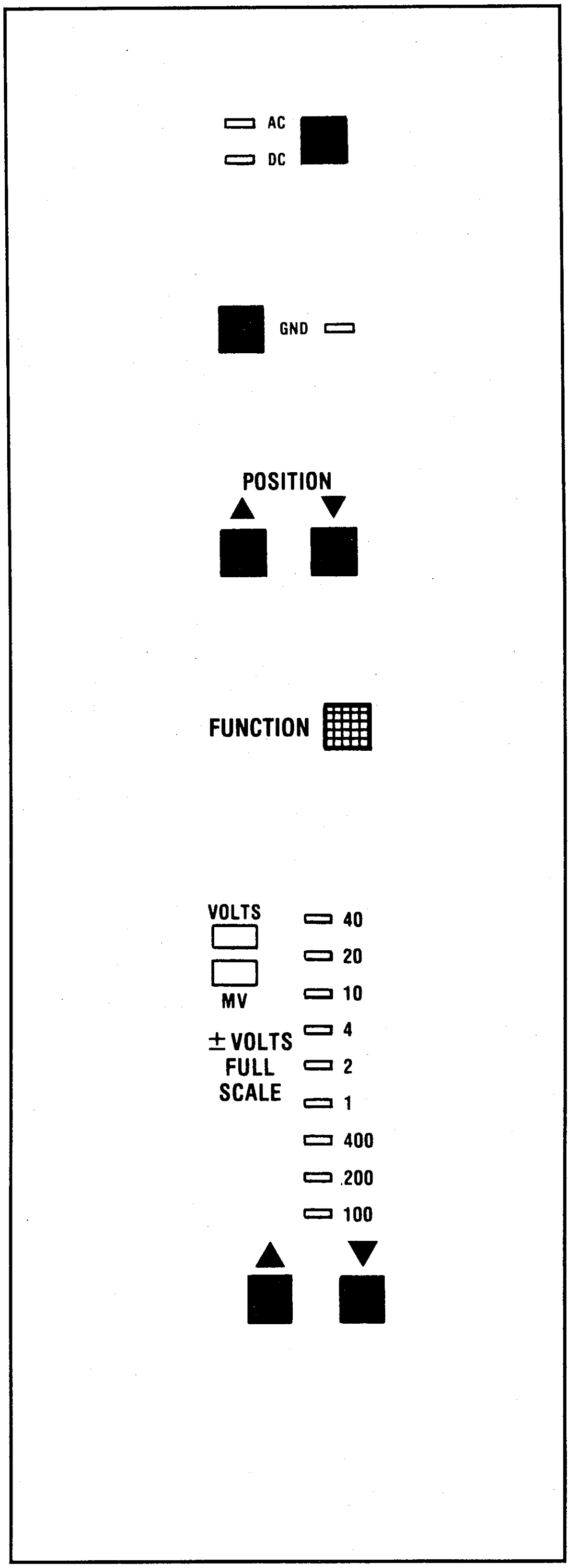
The 4094 is under computer control and the front panel controls have no effect when the C.C. LED is illuminated.

FILTER BUTTON

Enables/disables bandwidth limiting.

SAVE BUTTON

Retains half of the data points captured during the previous sweep.



DC/AC BUTTON

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

AC - Blocks the dc component.

GND BUTTON

Grounds the amplifier's input, but does not affect the coupling.

POSITION BUTTONS

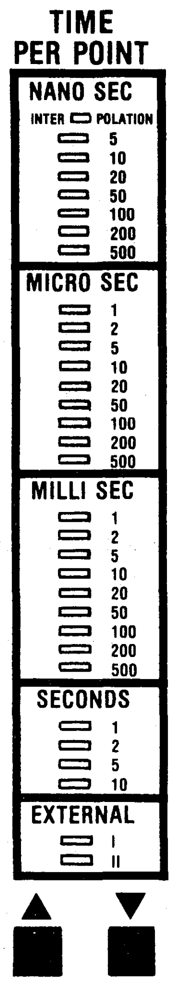
Vertically positions the trace in the direction of the arrows. Press both buttons simultaneously to return to the user-defined default settings.

FUNCTION BUTTON

Activates the selected data manipulation function.

VOLTS FULL SCALE

Allows the 4094 to accept input signals ranging from ±100 millivolts full scale to ±40 volts full scale.



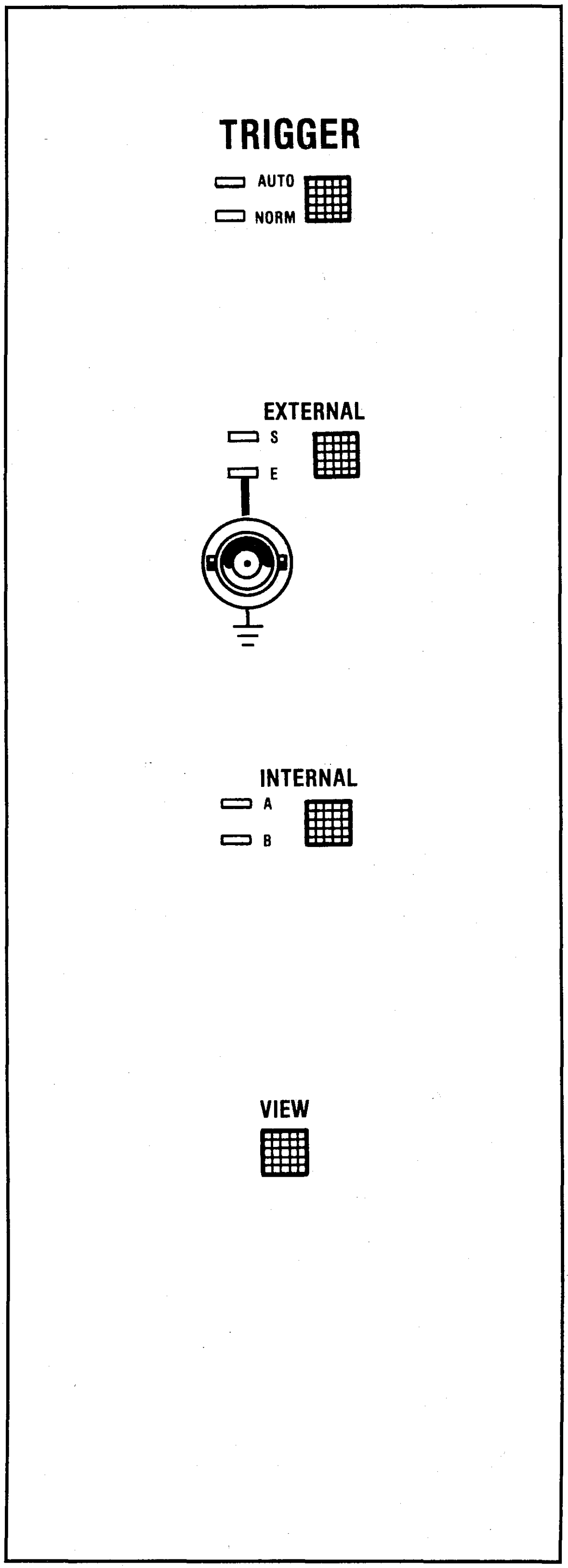
TIME PER POINT

Press the Time Per Point Up/Down buttons to select the time resolution of the signal to be captured.

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

Interpolation Mode

The Interpolation Mode allows fast signals to be viewed easier than is possible with the 5 nanosecond range. The display can be magnified by up to x16 when the Interpolation Mode is used. See page 8-14.



TRIGGER BUTTON

The trigger button lights at the start of each sweep and remains illuminated until the sweep ends.

AUTO - Sweeps are initiated in the absence of valid triggers.

NORM - Sweeps are initiated only by valid triggers.

EXTERNAL BUTTON

Selects either External or Slave triggering.

(E) - Triggers are derived from signals input to the EXT input BNC.

(S) - Triggers are derived from a Master plug-in.

INTERNAL BUTTON

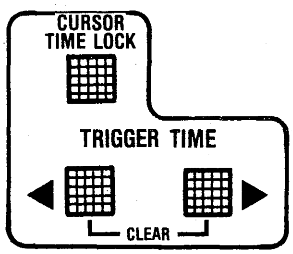
Internal triggering is activated when the Internal button is illuminated.

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

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

VIEW BUTTON

Displays the trigger source, trigger level, and trigger sensitivity. Forces the Auto Trigger mode when entering the View Mode.



CURSOR TIME LOCK & TRIGGER TIME BUTTONS

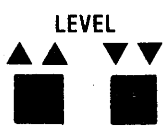
The Cursor Time Lock button is used to maintain a constant time interval between the trigger and the position of the vertical cursor whenever the sweep length or sampling speed is changed. The Cursor Time Lock mode is turned on when the button is lit.

The Trigger Time buttons select the Time Window that will be displayed relative to the trigger point.

Mid Signal Trigger - Press (Trigger Time >) to the desired pretrigger setting. Mid Signal Trigger is selected when (Trigger Time >) is illuminated.

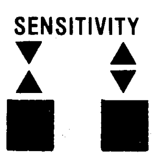
Delayed Sweep - Press (Trigger Time <) to the desired delay trigger setting. Delayed Sweep is selected when (Trigger Time <) is illuminated.

Clear - Press both Trigger Time buttons simultaneously to reset the trigger time to the left edge of the screen (Normal Sweep). This mode is selected when both Trigger Time buttons are turned off.



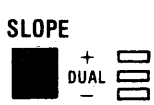
TRIGGER LEVEL BUTTONS

The trigger Level buttons adjust the voltage level that must be crossed by the triggering signal to qualify it as a valid trigger.



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.



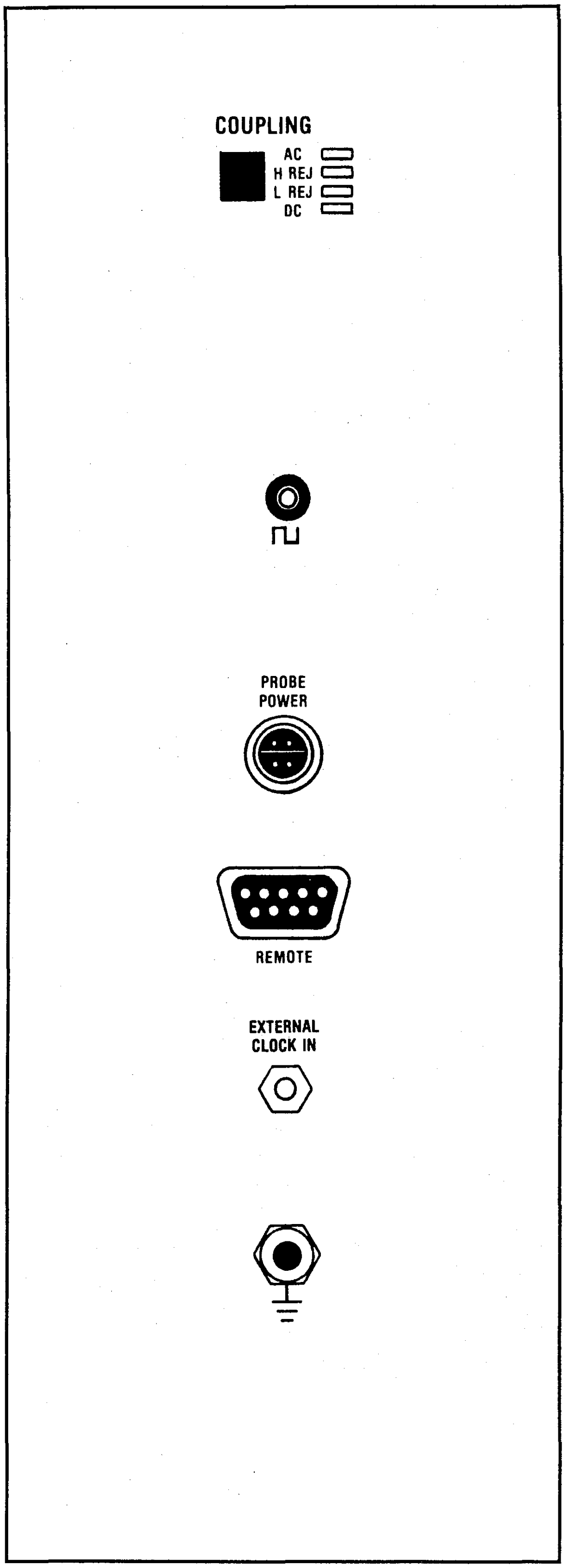
TRIGGER SLOPE BUTTON

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

(+) - Positive-going voltage transitions only.

(-) - Negative-going voltage transitions only.

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



TRIGGER COUPLING BUTTON

AC - The dc component is blocked.

H REJ - Frequencies above 1 MHz are rejected.

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

L REJ - Frequencies less than 75 kHz are rejected.

COMPENSATION POINT

Touch the x10 or x100 test probe to the compensation point when compensating the probes for the best squarewave response times.

PROBE POWER CONNECTOR

Provides ±15 and +5 Vdc outputs with ground.

REMOTE CONTROL CONNECTOR

Permits limited remote control of the plug-in.

EXTERNAL CLOCK IN

Clock input for External I & II modes.

GROUND

Chassis ground.

THE CHANNEL BUTTONS

The channel ON/OFF button(s) select which channel(s) will capture/display data. For example, the channel A On/Off button must be illuminated to capture/display data with channel A.

NOTE: The status of the On/Off buttons are recognized by the 4094 at the end of each sweep, or after the sweep has been reset by pressing the Live button. In addition, 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 when the mainframe Memory switch is in the ALL position.

NOTE: Turning a channel off will turn all of its LEDs off unless that channel is being used as the trigger source.

The record length for each channel is determined by Table 8-1. This table is for single plug-in operation only.

Number Of Active Channels	Memory Switch		
	All	Halves	Quarters
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-1

THE DC/AC BUTTONS

The DC/AC buttons are used to select whether 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.

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

THE GND BUTTON

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

THE STORAGE CONTROL BUTTONS

The LIVE, HOLD NEXT and HOLD LAST buttons determine whether or not the display memory is updated with new data each time a valid trigger initiates a sweep.

The LIVE Button

Press the LIVE button to select the Live mode. This mode allows new data to be captured for display each time a sweep is triggered.

Pressing the LIVE button erases data from the screen, readying it for the next display. It also serves as a "master reset," allowing the plug-in to recognize changes made to the 4180 front panel settings since the last sweep.

The HOLD NEXT Button

Press the HOLD NEXT button to select the Hold Next mode.

The Hold Next mode allows a single sweep to be triggered by the next valid trigger. The plug-in goes into the Hold Mode (HOLD LAST on, LIVE and HOLD NEXT off) at the end of the sweep, thus preventing additional sweeps from being triggered. The data captured during the sweep is stored in memory.

HOLD NEXT (1-Shot)

While in the Hold Mode (Live and Hold Next off, Hold Last on), press and release the Hold Next button. This will initiate a 1-shot sweep and place the plug-in into the Hold Mode upon the next valid trigger.

The HOLD LAST Button

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

Data captured during the last sweep is stored in memory. If a sweep is already in progress when the button is pressed, then that data will be stored in memory at the end of the sweep. The plug-in enters the Hold Mode (HOLD LAST on, LIVE and HOLD NEXT off) at the end of the sweep, thus preventing additional sweeps from being triggered.

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

Remote Control

The Live, Hold Next and Hold Last buttons can be controlled from a remote station. Refer to page 8-32, "Remote Control Connector" descriptions.

THE VOLTS FULL SCALE SWITCH

Allows input signals ranging from ±100 millivolts full scale to ±40 volts full scale to be measured when the x1 probe is used.

The X10 Probe

The optional x10 probe allows a maximum input voltage of ±400 volts full scale. The correct voltage range and screen numerics are registered automatically when the x10 ring is grounded.

The x10 probe available from Nicolet is for use with 1 megohm input scopes. It has a 100 MHz bandwidth and a 600 volts dc working voltage. Its cable length is 59 inches (1.5 meters).

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.

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

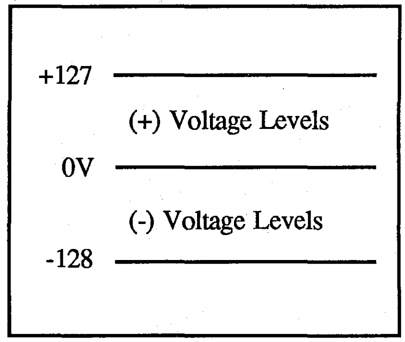


Figure 8-1

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

THE 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.

NOTE: The Time Per Point function also includes an Interpolation Mode, see page 8-14.

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 5 nanosecond sampling rate.

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

Figure 8-5: Every other sample (black dots) is displayed when the Time Per Point is set to 10 nSec.

Figure 8-6: Every fourth sample (black dots) is displayed when the Time Per Point is set to 20 nSec.

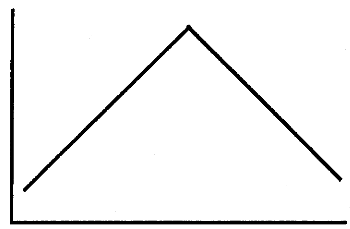


Figure 8-2

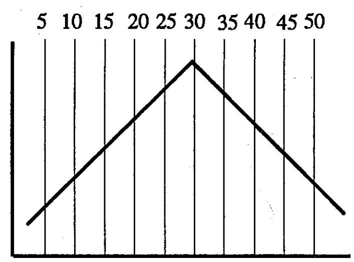


Figure 8-3

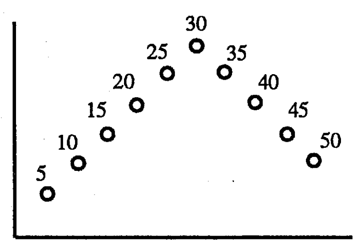


Figure 8-4

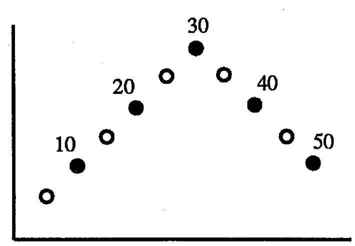


Figure 8-5

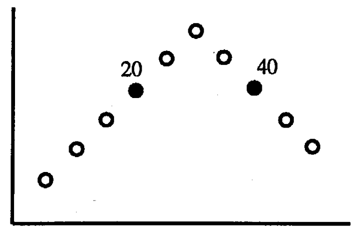


Figure 8-6

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 MEMORY switch.

#3. Whether or not Save Reference is turned on (page 8-17).

Table 8-3 tabulates the approximate number of memory addresses used to record each input signal. This table is for single plug-in operation only.

Number Of Active Channels	Memory Switch		
	All	Halves	Quarters
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-3

SWEEP TIMES

Table 8-4 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: Divide by 2.
Three or four channels: Divide by 4.

TIME PER POINT SETTING	Memory Switch Positions (Data Points Per Sweep)		
	ALL (16K Points/Sweep)	H1/H2 (8K Points/Sweep)	Q1/Q2/Q3/Q4 (4K Points/Sweep)
	Microseconds Per Sweep		
5 nS	79.400	39.700	19.850
10	158.800	79.400	39.700
20	317.600	158.800	79.400
50	794.000	317.600	158.800
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 µS	15.880	7.940	3.970
2	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
	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	11.00

Table 8-4

The Interpolation Mode

The Interpolation Mode allows fast signals to be viewed easier than is possible with the 5 nanosecond range. This is accomplished by computing and filling in the points between the true sampled points of the displayed waveform. The display can be magnified by up to x16 when the Interpolation Mode is used.

Activating Interpolation

#1. Press the Time Per Point "UP" button until the 5 nS/pt range illuminates and then release the button.

#2. Press and then release the "UP" button to activate Interpolation.

NOTE: Interpolation is activated when both the 5nS/pt and Interpolate indicators illuminate.

Magnifying Interpolation

After selecting the Interpolation mode, press and release the "UP" button to increase the magnification by a factor of two (2). The maximum magnification is x16.

Deactivating Interpolation

Press and hold the Time Per Point "DOWN" button until the Interpolation indicator turns off.

Numerics In Interpolation

All numerics are displayed properly for each corresponding Interpolation magnification factor.

The EXT I & II Positions

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

#1. It is necessary to sample syncronously with an external event.
#2. The desired time-per-point is not available, or
#3. The sampling rate is generated from a nonlinear time base.

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

#1. The number of channels turned on.
#2. The position selected on the mainframe's MEMORY switch.
#3. Whether or not Save Reference is turned on.

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

NOTE: Table 8-5 is for <u>single</u> plug-in operation only.

Delayed Displays

A delay occurs from the time of the first sample until a full screen display appears when the EXT I (fast) mode is selected. This occurs because each sample is stored in a buffer memory until enough samples to complete a full sweep have been captured.

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

Time Delay = addresses x period

Equation 8-1

Number Of Active Channels	Memory Switch		
	All	Halves	Quarters
ONE	16K	8K	4K
TWO	8K	4K	2K

Table 8-5

The EXT I Position (Fast Mode)

Data is delayed from being displayed until enough samples have been captured to complete a full sweep, (see Delayed Displays, page 8-15).

Select the EXT I position when the External Clock rate ranges from 2 kHz to 20 MHz.

The EXT I mode requires two external signals:
#1. A valid trigger input.
#2. A TTL input signal input to the External Clock In connector.

NOTE: The signal's rise/fall time must be equal to (or less than) 10 nSec.

The trigger initiates the sampling sequence. The samples are captured within 10 nSec of each External Clock In command's leading, positive edge.

NOTE: The maximum speed for the EXT I mode is 20 MHz. The pulse width must be greater than 20 nSec and the period must be greater than 50 nSec.

EXAMPLE 8-3

Figure 8-7: The input signal superimposed by External Clock In signals.

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

Figure 8-9: The digitized samples (dots) selected for display.

The EXT II Position (Slow Mode)

Data is displayed after eight samples are digitized when the EXT II mode is selected.

Select the EXT II position when the External Clock rate ranges from 1 Hz to 2 kHz.

The EXT II mode requires two external signals:
#1. A valid trigger.
#2. A TTL input signal input to the External Clock In connector.

NOTE: The signal's rise/fall time must be equal to (or less than) 10 nSec.

The trigger initiates the sampling sequence and "captures" the first sample. The remaining samples are captured within 10 nSec of each External Clock In command's leading, positive edge.

NOTE: The maximum speed for the EXT II mode is 2 kHz. The pulse width must be greater than 20 nSec and the period must be greater than 500 µSec.

EXAMPLE 8-4

Figure 8-7: The input signal superimposed by External Clock In signals.

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

Figure 8-9: The digitized samples (dots) selected for display.

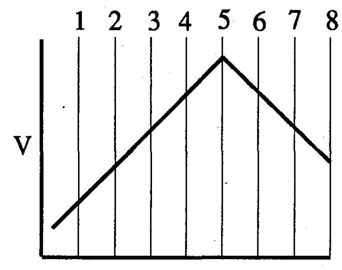


Figure 8-7

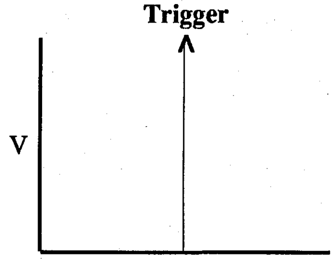


Figure 8-8

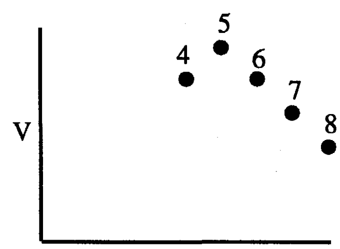


Figure 8-9

THE POSITION BUTTONS

Vertically repositions a "live" signal on the screen. Pressing both Position buttons simultaneously sets the trace to its default value. 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.

NOTE: The voltage numerics remain unchanged while the Position buttons are being pressed. The small crosshair follows the offset and the zero reference level is updated only after the button is released and the sweep is reinitialized.

Changing the Position Default

#1. Move the trace to the desired position on the screen using either the Position (UP) or (DOWN) button and then release the button.

#2. Press and hold both Position buttons. The position of the trace will momentarily return to the previously saved default. Release both buttons when the the new default position reappears.

THE SAVE BUTTON

Turn on the Save Reference mode to compare "live" and "stored" signals.

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" (Retain) suffix is added to the Plug-in/Channel Identifier when "saved" data is being decoded. For example "1AR".

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

EXAMPLE 8-5

Figure 8-10: Typical signal captured before turning on Save Reference.

Figure 8-11: Resulting display after turning on Save Reference and changing the input signal's characteristics.

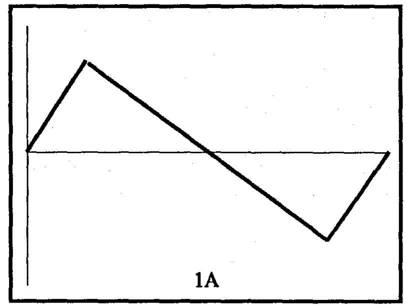


Figure 8-10

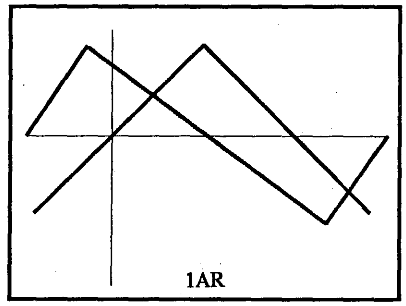


Figure 8-11

THE FILTER BUTTON

Bandwidth limits frequencies above 1 MHz (-3dB).

The 1 MHz filter is activated when the Filter button is illuminated.

THE TRIGGER SOURCE BUTTONS

The INTERNAL (A/B) Button

A or B - Select accordingly when deriving triggers from signals input to the channel A or channel B input BNCs.

The EXTERNAL (E/S) Button

E - An external triggering signal can be applied to the EXT input BNC. The full scale input is ±8V.

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

Set the master plug-in's trigger source accordingly for the plug-in model being used:

4562/4851/4570
Set the Trigger Source to A, B, or EXT.

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

4180
Select Internal (A or B) or External (E).

The Slave Plug-in

Set the slave plug-ins' trigger source accordingly for the plug-in model being used:

4562/4851/4570
Set the Trigger Source to "S".

4175
Select External (S).

4180
Select External (S).

THE TRIGGER COUPLING BUTTON

AC - Signals are capacitively coupled to the trigger detection circuit. DC components and frequencies below 2 Hertz are attenuated while ac components pass.

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

H REJ - Rejects frequencies greater than 1 MHz.

L REJ - Rejects frequencies less than 75 kHz.

THE TRIGGER BUTTON

Selects whether sweeps will be triggered automatically in the absence of valid triggers (AUTO) or solely by valid triggers (NORM).

AUTO - Sweeps are automatically triggered if a valid trigger is not received within 15 milliseconds after completing the last sweep.

NORM - Sweeps are triggered by valid triggers only.

THE VIEW BUTTON

Three different trigger View modes can be used to select specific triggering characteristics. Each mode alters the operation of the Level and Sensitivity buttons differently, and determine what triggering information is displayed at the top of the screen. Refer to pages 8-20 and 8-21 for additional information.

When View is turned on, the front panel LEDs indicate the status of the trigger source only. The channel ON/OFF and SAVE buttons have no effect.

NOTE: Interpolation and trigger Delays are not allowed in the View mode. All Functions are inhibited in View (except Exponential Average which must be activated after entering the View mode by depressing the plug-in's FUNCTION button).

The View display consists of a Slope/Level Indicator, Trigger Input Signal, 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).

In View, the Channel Identifier is displayed at the bottom center of the screen.

The Slope/Level Indicator sets the following three requirements that must be met before a sweep can be triggered in the Normal Trigger mode.

a. Slope (page 8-22)
b. Level (page 8-24)
c. Sensitivity (page 8-24).

Turning the VIEW Mode On

#1. Press the VIEW button.

#2. The triggering will default to the Auto Mode. If the Normal Mode is desired, press the TRIGGER button.

EXAMPLE 8-7

Figure 8-12: Typical Level/Sensitivity VIEW display with "positive" slope triggering selected.

The Trigger View Operations

Three different trigger View modes (page 8-21) can be selected to determine how the Level and Sensitivity buttons will work, and which trigger View readouts will appear at the top of the display.

The three modes are -

a. Trigger/Sensitivity Mode (Defaulted to on Power-up Reset.)

b. Center/Sensitivity Mode

c. Upper/Lower Mode.

Changing the Trigger View Mode of Operation -

#1. If not already in the View mode press the View button.

#2. Press and hold the View button until the desired View Mode appears at the top of the screen and then release the button.

The readouts and trigger View operation will remain in the selected configuration until either the mode is changed or the plug-in is master reset (page 8-1).

A description of each View operation follows on the next page.

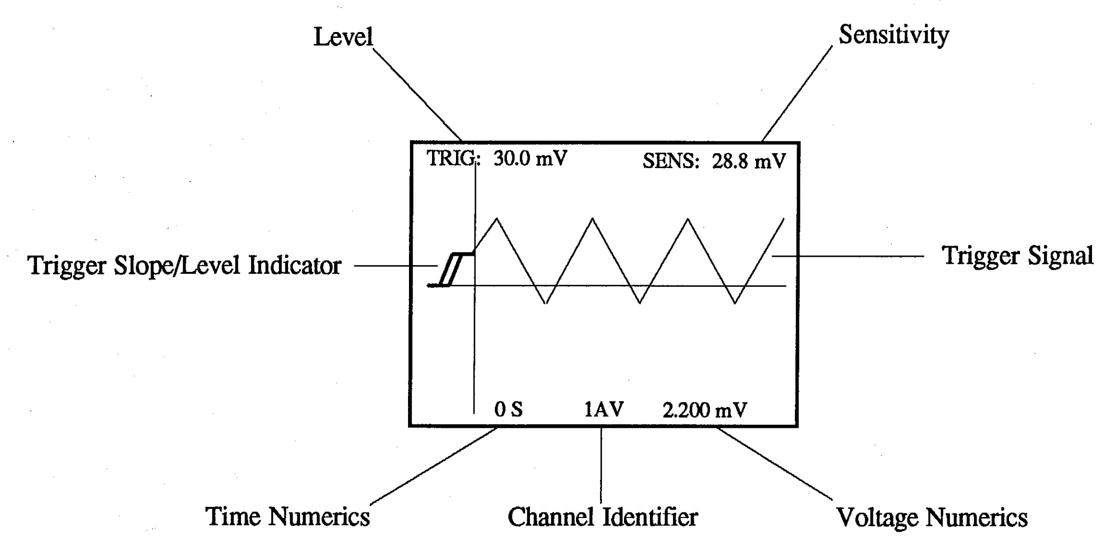


Figure 8-12

1. Trigger/Sensitivity Mode

The trigger View readouts (Figure 8-13) display the trigger level and sensitivity threshold values necessary to generate a valid trigger.

(+) or (-) Slope Triggering

Use the Level buttons to raise/lower the trigger level. The Sensitivity buttons widen/narrow the trigger window. In this mode, changing the sensitivity does not change the trigger level, and changing the level does not change the sensitivity.

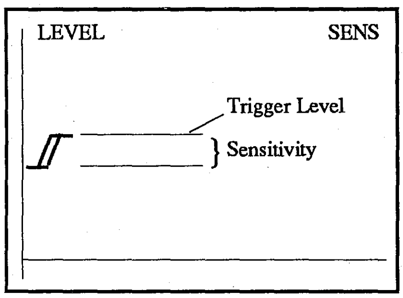


Figure 8-13

Dual Slope Triggering

Use the Level buttons to raise/lower both trigger levels.

Use the Sensitivity buttons to widen/narrow the trigger window. The left readout displays the +Trig level and the right readout displays the -Trig level (Figure 8-14).

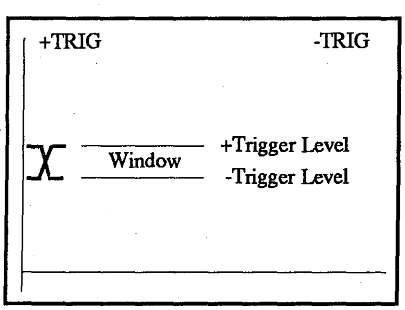


Figure 8-14

2. Center/Sensitivity Mode

The left trigger View readout (Figure 8-15) displays the Center Point between the upper and lower levels. The right readout displays the trigger sensitivity.

(+), (-), or Dual Slope Triggering

Use the Level buttons to raise/lower both trigger levels. The Sensitivity buttons widen/narrow the distance between the two levels.

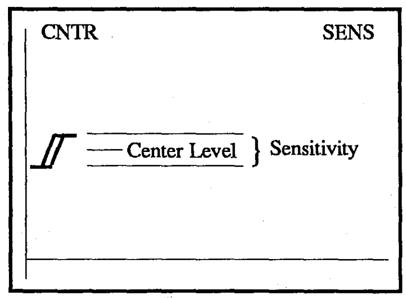


Figure 8-15

3. Upper/Lower Mode

The left trigger View readout (Figure 8-16) displays the Upper level. The right readout displays the Lower level.

(+), (-), or Dual Scope Triggering

Use the Level buttons to raise/lower the lower level. The Sensitivity buttons raise/lower the upper level.

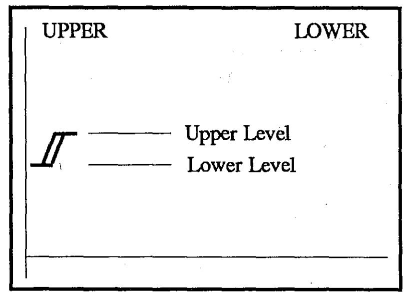


Figure 8-16

THE SLOPE BUTTON

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 it as a valid trigger.

DUAL - Either increasing or decreasing voltage values qualify the signal as a valid trigger.

(-) - The signal's voltage must be decreasing to qualify it as a valid trigger.

EXAMPLE 8-8

Figure 8-17: A positive slope display. The signal qualifies as a valid trigger at point (T+).

Figure 8-18: A negative slope display. The signal qualifies as a valid trigger at point (T-).

Figure 8-19: A dual slope display. The signal qualifies as a valid trigger at either (T+) or (T-).

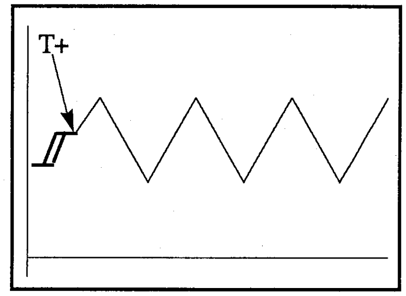


Figure 8-17

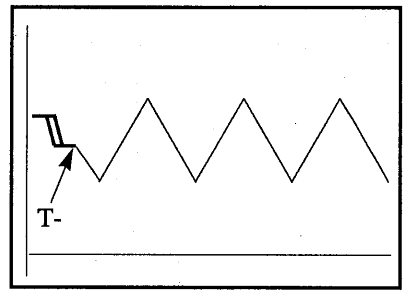


Figure 8-18

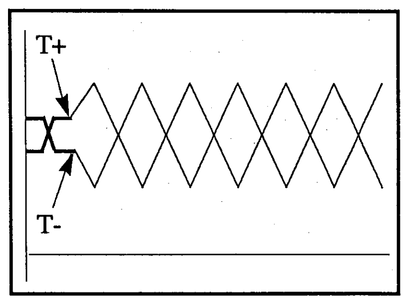


Figure 8-19

Recurrent (+) or (-) Slope Triggers

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 8-9

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

Figure 8-20: The first trigger occurs at point (T1). A second trigger will be initiated at (T2) if the signal path (represented by the dashed lines) drops below the lower level, passes through the window and crosses the upper level.

Figure 8-21: 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 level. A trigger will occur at point (T2) because the third positive slope began below the lower level.

Recurrent Dual Slope Triggers

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: The maximum trigger sensitivity is 3% of the selected Volts Full Scale range.

EXAMPLE 8-10

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

Figure 8-22: Valid triggers occur at points (T1 through T4) each time the signal crosses the upper/lower levels.

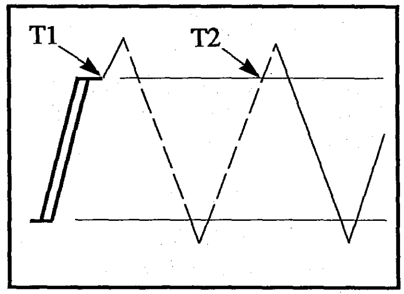


Figure 8-20

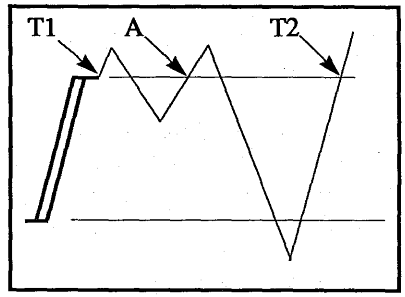


Figure 8-21

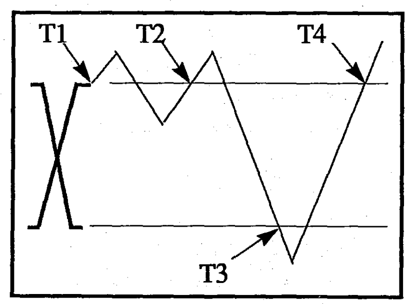


Figure 8-22

THE LEVEL BUTTONS

The Level control adjusts the threshold level that the signal must cross in order to qualify it as a valid trigger.

NOTE: The function of the Level buttons depends on which of the three possible trigger View modes is selected, see page 8-21.

Which threshold level must be crossed by the signal is a function of the SLOPE button.

(+) - The signal must cross the lower to upper threshold levels to qualify it as a valid trigger (see page 8-26).

(-) - The signal must cross the upper to lower threshold level to qualify it as a valid trigger (see page 8-26).

DUAL - The signal can cross either threshold level to qualify it as a valid trigger (see page 8-26).

EXAMPLE 8-11

Figure 8-23: A positive slope display. The signal qualifies as a valid trigger at point (T+).

Figure 8-24: A negative slope display. The signal qualifies as a valid trigger at point (T-).

Figure 8-25: A dual slope display. The signal qualifies as a trigger at either point (T+) or (T-).

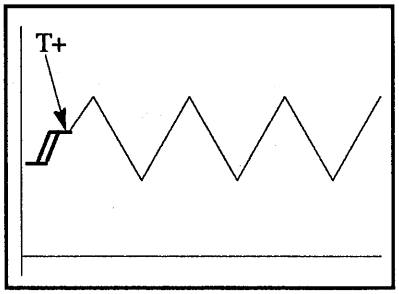


Figure 8-23

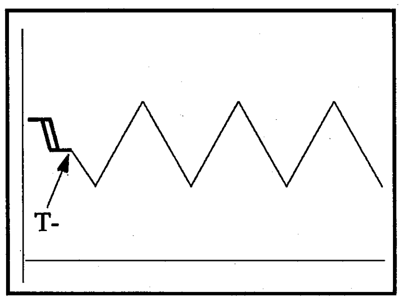


Figure 8-24

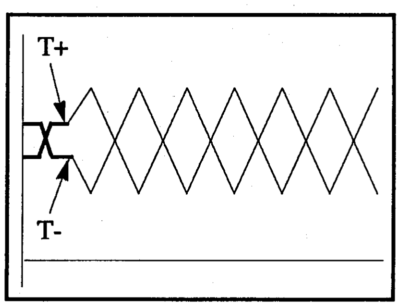


Figure 8-25

THE SENSITIVITY BUTTONS

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

NOTE: The function of the Sensitivity buttons is determined by which of the three trigger View modes is selected (see page 8-21).

EXAMPLE 8-12

Figure 8-26: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.

Figure 8-27: The dashed line on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger.

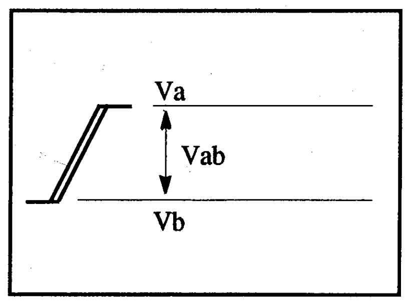


Figure 8-26

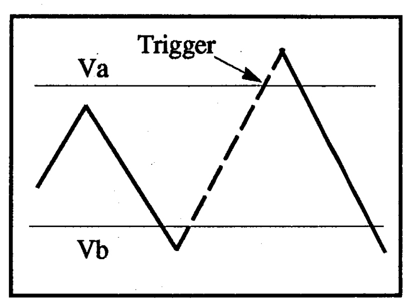


Figure 8-27

Level & Sensitivity Defaults

The last trigger Level and trigger Sensitivity settings "saved" while in the trigger View mode can be quickly recalled by using the Default Modes.

The Level Default Value

Momentarily depress both trigger Level buttons simultaneously to return to the last trigger Level "saved" while in the trigger View mode. The Level Default Value can be activated with the trigger View mode turned on or off.

NOTE: Activating the Level Default Value selects the previously stored Level and Sensitivity values.

Changing the Level Default

The trigger Level Default Value can only be changed while in the trigger View mode.

#1. Turn trigger View on.

#2. Select the desired trigger Level and Sensitivity.

#3. Depress and hold both Level buttons simultaneously. The trigger Level and Sensitivity will momentarily reset to the previously saved default values. Release both buttons when the new default values reappear on the screen.

The newly selected trigger Level will remain stored until either a Master Reset occurs (page 8-1) or the Level Default is changed and saved while in the View mode.

The Sensitivity Default Value

Press both trigger Sensitivity buttons simultaneously to recall the last trigger Sensitivity setting that was "saved" while in the trigger View mode. The Sensitivity Default Level can be activated with the trigger View mode turned on or off.

NOTE: Activating the Sensitivity Default Level will change the previously stored trigger Level and Sensitivity values.

Changing the Sensitivity Default

The trigger Sensitivity Default can only be changed while in the trigger View mode.

#1. Turn trigger View on.

#2. Select the desired trigger Level and Sensitivity.

#3. Depress and hold both trigger Sensitivity buttons simultaneously. The trigger level will reset to the previously saved default. Release both buttons when the new default setting selected in Step #2 reappears on the screen.

The newly selected trigger Sensitivity default values will remain stored until either a Master Reset (page 8-1) occurs or the selection is changed and saved while in the View mode.

Adjusting for (+) or (-) Slope Triggers

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

#2. COUPLING: As required.

#3. Press the VIEW button.

#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. Press the LIVE button.

#7. Adjust the Position control for the best trace placement on the screen.

#8. Adjust the Volts Full Scale as required.

#9. Press the "left" Sensitivity button until the threshold level is fully compressed and then press the "right" Sensitivity button until the "window" exceeds any "noise" spikes present.

#10. Adjust the Level control until the upper threshold (+ slope) or lower threshold (- slope) intersects the desired trigger point.

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

#12. After the Sensitivity and Level have been properly adjusted, select normal (NORM) triggering. The plug-in continues to trigger.

NOTE: The Trigger button illuminates throughout each sweep.

Adjusting for Dual Slope Triggers

#1. SLOPE: Dual

#2. COUPLING: As required.

#3. Press the VIEW button.

#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. Press the LIVE button.

#8. Adjust the Position control for the best trace placement on the screen.

#9. Adjust the Volts Full Scale as required.

#10. SENSITIVITY: Press the "left" Sensitivity button until the threshold level is fully compressed.

#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. The plug-in continues to trigger.

NOTE: The Trigger button illuminates throughout each sweep.

TRIGGER TIME BUTTONS

The TRIGGER TIME buttons are used to select the Normal Sweep (8-28), Mid Signal Trigger (8-28), or Delayed Sweep (8-29) display modes (see Figure 8-28).

EXAMPLE 8-13

Figure 8-28: The three types of trigger displays and related sweeps.

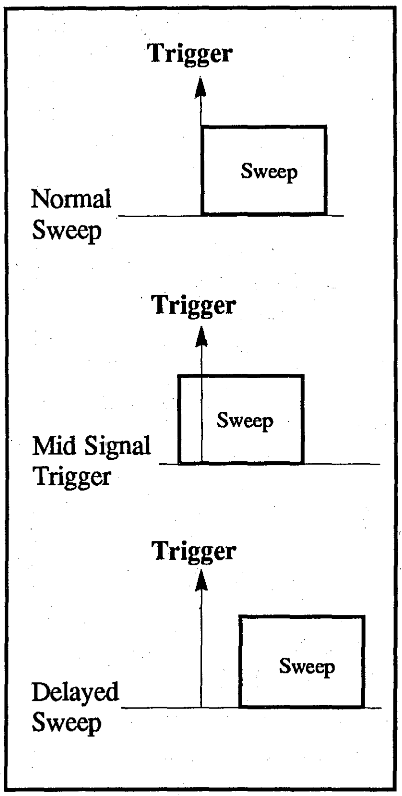


Figure 8-28

Adjusting the Trigger Time

The trigger time can be adjusted when setting up a Mid Signal Trigger or Delayed Sweep display in either the Live mode or Setup mode.

Live Mode

Depress the Trigger Time button (< or >) and the Trigger Point will be adjusted accordingly upon the next initialized trigger (Coarse Adjust).

OR:

Depress and hold the Live button while depressing the Cursor Time button (< or >), (Fine Adjust).

Setup Mode

Use the Setup mode when an exact delay time is desired (Fine Adjust).

#1. Place the 4180 into the Hold Mode (page 8-1).

#2. Depress and hold HOLD LAST.

#3. Depress and hold HOLD NEXT.

#4. Release HOLD LAST.

#5. Release HOLD NEXT.

NOTE: The HOLD LAST, HOLD NEXT, and LIVE LEDs light, indicating that the Setup mode is activated. The letter "S" suffix is added to the Plug-in/Channel numerics (e.g., 1AS) when the Setup mode is selected.

The trigger time is selected by pressing either the Trigger Time (<) or (>) button.

To increase the trigger cursor's rate of movement, depress and hold one of the Trigger Time buttons. To return to the slow rate of movement, release and then depress the Trigger Time button again.

IMPORTANT: Operating the Trigger Time buttons while in the Setup mode alters the (T=0) origin, thus producing erroneous time numerics.

Exiting the Setup Mode

The Setup mode is exited by pressing either the HOLD LAST or LIVE button. The time numerics, however, will remain erroneous until a new sweep is triggered.

NORMAL SWEEP Mode

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. The Normal Sweep display mode is present when both Trigger Time button LEDs are off.

- **Resetting to Normal Sweep Displays**

To reset the plug-in to the Normal Sweep display while the plug-in is in the "Setup" mode (page 8-27), press both Trigger Time (< and >) buttons at the same time.

To reset the plug-in to the Normal Sweep display when the plug-in is not in the "Setup" mode, press both Trigger Time (< and >) buttons at the same time and then depress the Live button.

NOTE: If the plug-in is in the LIVE mode and no triggers are occurring (or a long sweep/delay has been selected) the channel can be quickly reset to the Normal Sweep mode by holding in both of the Trigger Time (< and >) buttons while tapping LIVE.

EXAMPLE 8-14

Figure 8-29: A single sweep is triggered at point (To) and ends at point (T+).

Figure 8-30: The corresponding Normal Sweep display of the captured signal.

MID SIGNAL TRIGGER Mode

To select the Mid Signal Trigger mode, use the "Live" mode to coarse adjust the trigger time, or place the plug-in into the "Setup" mode to fine adjust the trigger time (see page 8-27) and press the Trigger Time (>) button.

The cursor (trigger) moves towards screen right while the (>) Trigger Time button is pressed. Pre-trigger events are displayed to the left of the cursor and post-trigger events to its right. The Mid Signal Trigger display mode is present when the Trigger Time (>) button is lit.

EXAMPLE 8-15

Figure 8-31: 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 8-32: The corresponding Mid Signal Trigger display of the captured signal.

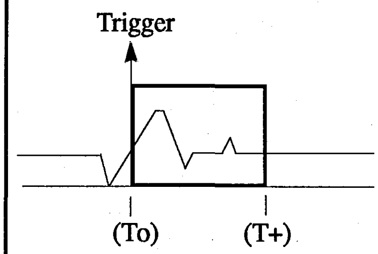
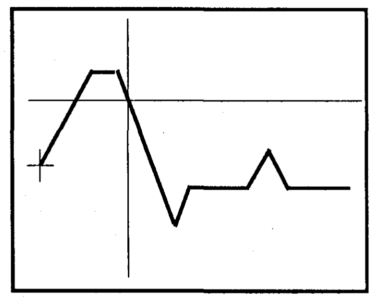


Figure 8-29



Normal Sweep
Figure 8-30

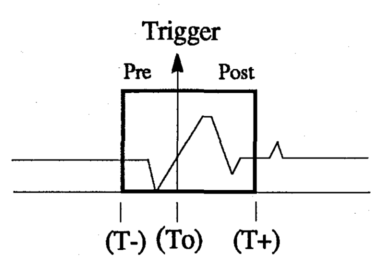
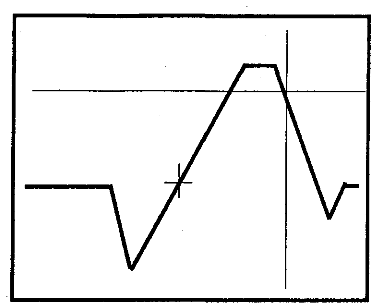


Figure 8-31



Mid Signal Trigger
Figure 8-32

DELAYED SWEEP Mode

To select the Delayed Sweep mode, use the "Live" mode to coarse adjust the trigger time, or place the plug-in into the "Setup" mode to fine adjust the trigger time (see page 8-27) and press the Trigger Time (<) button.

The vertical cursor (trigger) moves off of screen left while the (<) Trigger Time 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. The Delayed Sweep mode is present when the Trigger Time (<) button is lit.

NOTE: A long delay can be quickly cleared by holding in both Trigger Time (< and >) buttons while tapping the Live button. If the plug-in is in a slow sweep, a fine delay can be quickly set by pressing the Live button while holding in the (<) Trigger Time button.

Equation 8-2 approximates the maximum time delay (Tmax) that can be selected.

$$\text{Tmax} = \frac{2^{26} \times (\text{TPP})}{(\text{Channels}) \times (\text{Memory})}$$

Equation 8-2

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

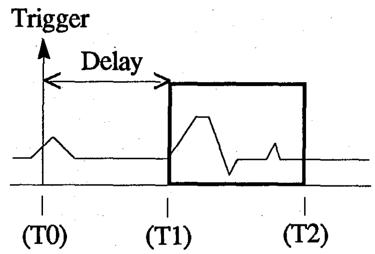
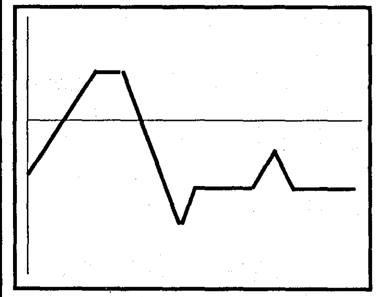


Figure 8-32



Delayed Sweep
Figure 8-33

EXAMPLE 8-16

Figure 8-32: A valid trigger at point (T0) initiates the time delay. After the delay has passed (T0 - T1), data is captured between times (T1 - T2).

Figure 8-33: The corresponding Delayed Sweep display of the signal captured during the sweep.

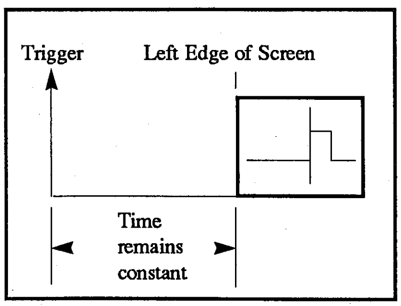
CURSOR TIME LOCK BUTTON

The Cursor Time Lock function allows the 4180 to maintain a constant time interval between the trigger and the position of the vertical cursor on the display whenever the sweep length or sampling speed is changed.

Cursor Time Lock Off

Refer to Figure 8-34. The time between the trigger and the left edge of the screen remains constant when the Time Per Point setting is changed.

This can cause the intended point of interest to be inadvertently forced out of the screen's viewing area when the time-per-point resolution is increased (see Example 8-17).

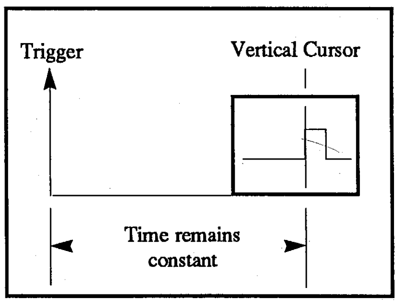


Cursor Time Lock Off
Figure 8-34

Cursor Time Lock On

Refer to Figure 8-35. The time between the trigger and the vertical cursor when the Cursor Time Lock function is turned on remains constant when the Time Per Point setting is changed.

Positioning the vertical cursor over a point of interest and then turning on the Cursor Time Lock function allows the point of interest (selected by the vertical cursor) to remain displayed at the same position on the screen while increasing the time-per-point resolution (see Example 8-18).



Cursor Time Lock ON
Figure 8-35

EXAMPLE 8-17

Figure 8-36: The Time Per Point was changed from 10 mS to 5 mS. Note that the right side of the screen, in effect, compresses towards the left side of the screen. The area of interest is then "forced" off of the resulting displaying area.

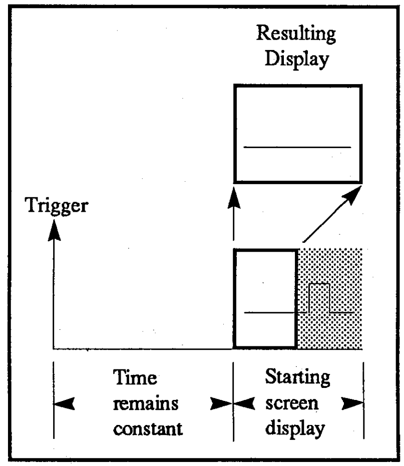


Figure 8-36

EXAMPLE 8-18

Figure 8-37: Changing the Time Per Point from 10 mS to 5 mS causes the screen, in effect, to compress towards the vertical cursor. The area of interest remains within the display area.

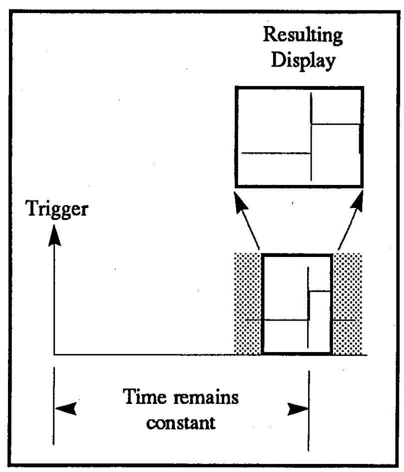


Figure 8-37

Using the Trigger Time Buttons

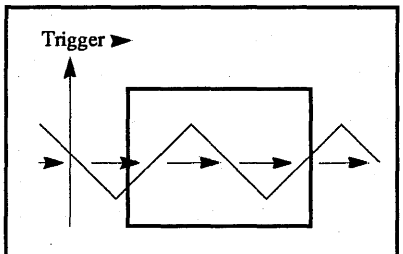
Data appears to slide across the screen when either Trigger Time button is pressed.

NOTE: Depress and hold the LIVE button while depressing the Trigger Time button to fine adjust the movement of data across the screen.

EXAMPLE 8-19

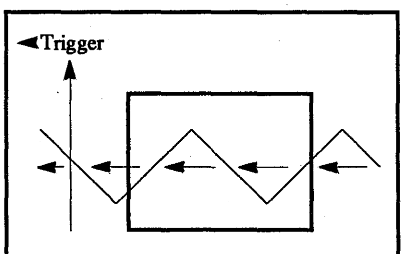
Figure 8-38: Data slides from left to right across the screen when the Trigger Time (>) button is pressed.

Figure 8-39: Data slides from right to left across the screen when the Trigger Time (<) button is pressed.



Data slides right when the (>) button is pressed.

Figure 8-38



Data slides left when the (<) button is pressed.

Figure 8-39

• Mid Signal Trigger Mode

If the Trigger Time (>) button is pressed long enough, the trigger time (T=0) coordinate will enter into the display area, causing the 4180 to enter the Mid Signal Trigger display mode automatically. The Mid Signal Trigger display mode is present when Trigger Time (>) button lights. The numerics will be prefixed with a negative (-) sign when decoding pre-trigger data.

• Delayed Sweep Mode

If the Trigger Time (<) button is pressed long enough, the 4180 will enter into the Delayed Sweep mode. A Delayed Sweep display is present when the Trigger Time (<) button lights.

• Returning to the Normal Sweep Mode

To quickly return the trigger to the left edge of the screen (unexpanded display), press both Trigger Time buttons simultaneously and then press the Live button. The Normal Sweep mode is present when both of the Trigger Time buttons are off.

EXAMPLE 8-20

Figure 8-40: The upper display contains only post-trigger data (Normal Sweep mode). After pressing the Trigger Time (>) button, the lower display now contains both pre-trigger and post-trigger data (Mid Signal Trigger mode).

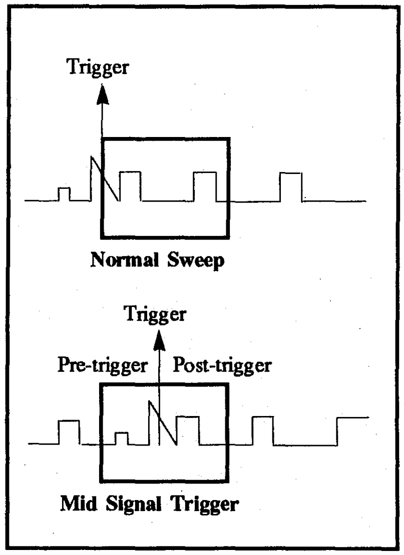


Figure 8-40

THE REMOTE CONTROL CONNECTOR

The remote control connector allows certain functions of the plug-in to be controlled from a remote station. Figure 8-41 identifies the function of each pin.

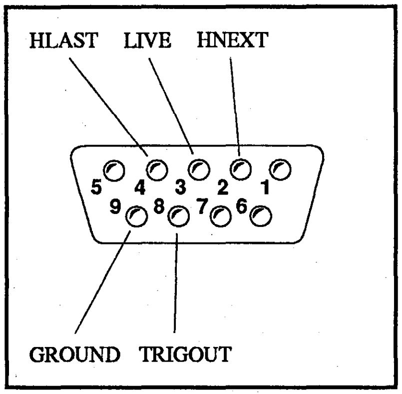


Figure 8-41

HLAST, LIVE, HNEXT

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.

TRIGOUT

Activates when either channel receives a valid trigger.

The output normally rests at +3 VDC (TTL 1) and drops to 0 VDC (TTL 0) when a valid trigger occurs. It returns to +3 VDC when the sweep ends.

THE EXTERNAL CLOCK IN CONNECTOR

The External Clock In connector inputs the signals used to advance the memory to its next address when the Time Per Point is set to either EXTERNAL I or EXTERNAL II.

The External Clock In signal should normally rest at less than 0.4 VDC (TTL 0) and raise to more than 3 VDC (TTL 1) each time the memory is to advance one address.

THE PROBE POWER CONNECTOR

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

Figure 8-42 identifies the connector's voltage polarities and ground.

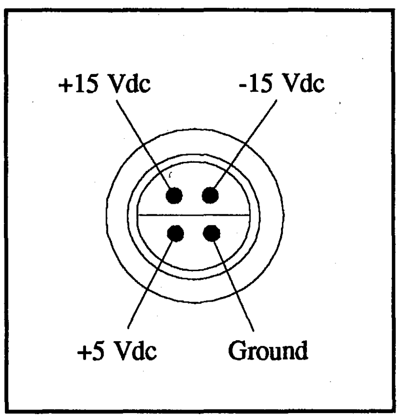


Figure 8-42

THE COMPENSATION POINT

A square wave signal appears on the screen when the optional X10 and X100 test probes are touched to the Compensation point.

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

IMPORTANT: The Time Per Point must be 500 nSec/point.

EXAMPLE 8-21

Figure 8-43 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.

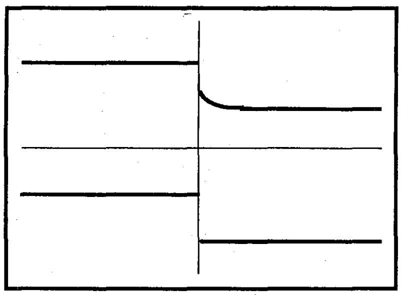


Figure 8-43

THE FUNCTION BUTTON

The FUNCTION button, when illuminated, will execute the function selected from the following list. Use the procedure at the right to select and execute a function.

NOTE: The plug-in defaults to the Virtual Averaging function when power is applied initially to the plug-in.

IMPORTANT: The plug-in must be in the LIVE mode and the FUNCTION button must be illuminated to execute the selected function. If the FUNCTION button is not illuminated, the plug-in will operate normally unless the Max/Min function is selected (see Note 1).

NOTE 1: If the Max/Min function is selected, the plug-in's Data Resolution is divided by two. This is done to prevent Time Shifting when entering or exiting the Max/Min function.

SELECTING & EXECUTING A FUNCTION

NOTE: Placing the plug-in into the SETUP mode allows the 4180 to step to the next function each time the FUNCTION button is depressed.

Stepping Through the Functions

#1. Place the plug-in into the HOLD LAST mode (HOLD LAST LED on only).

#2. Enter the SETUP mode:
  a. Depress and hold HOLD LAST.
  b. Depress and hold HOLD NEXT.
  c. Release HOLD LAST.
  d. Release HOLD NEXT.

  NOTE: All three Storage LEDs should be illuminated and the current Function title should appear.

#3. Tap the FUNCTION button until the desired function appears on the screen.

  NOTE: When selecting one of the OPTIONS (Version 1.1 or above), use the cursor Up/Down buttons to select the desired option and the Left/Right buttons to toggle the selected option.

#4. Press the LIVE or HOLD LAST button to exit the SETUP mode and execute the selected function.

NOTE: The plug-in executes the selected function only if the FUNCTION button is illuminated while in the Live mode.

Combining Functions with Trigger View Mode

All functions are inhibited in the trigger VIEW MODE (page 8-19) except for Exponential Averaging (page 8-34).

AVERAGE FUNCTIONS

Select Virtual Averaging, Exponential Averaging, or Summation Averaging (page 8-45) 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.

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

Values captured during the first two sweeps are averaged and the result is stored in memory. The "new" values captured during the third sweep are averaged with the "old" stored values and the memory is updated once again. This process of averaging "new" and "old" values and then updating the memory repeats with each successive sweep.

NOTE: The maximum number of sweeps for averaging is 2^{15} or 32,768. The plug-in will start a new average upon the Maximum Sweep Count.

Virtual Averaging

Virtual averaging 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.

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

Equation 8-3

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	K=2	K=4	K=8	K=16

Table 8-6

The term "K" is computed from Equation 8-4. The result is rounded off to the nearest, lower power of two.

$$K = 2^{[\text{INT}(\text{LOG}_2(\text{Sweep} \times 1.5))]}$$

Equation 8-4

Exponential Averaging

The value of K in Equation 8-3 is always equal to 4 when exponential averaging is selected. This forces the display to respond quickly to any changes in the signal.

NOTE: The effects of exponential averaging will not be evident until the first six sweeps have been completed.

Exponential Averaging is the only function that is not inhibited in the trigger View Mode (page 8-19). Exponential Averaging must be activated after entering the View Mode by depressing the plug-in's FUNCTION button.

EXAMPLE 8-22

This example illustrates the Virtual Averaging mode.

Figure 8-44: First sweep sampled at 1V1, 1V2, ... 1Vx.

Figure 8-45: Second sweep sampled at 2V1, 2V2, ... 2Vx.

Figure 8-46: 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 8-47: The resulting waveform display captured after several sweeps with Average turned on.

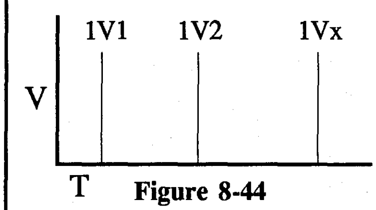


Figure 8-44

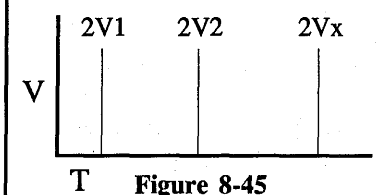


Figure 8-45

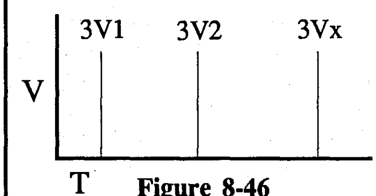


Figure 8-46

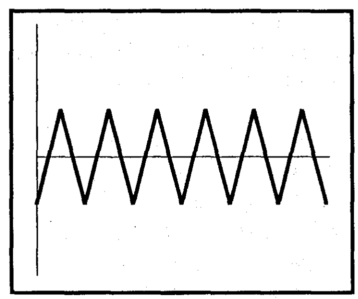


Figure 8-47

FOURIER TRANSFORM

The FOURIER TRANSFORM mode displays the spectrum of an incoming signal for examination of its frequency content. The oscilloscope uses 512 time points to calculate a 256-point spectrum.

Signal Acquisition

When running in the Fourier Transform mode, select a suitable Time Per Point setting to obtain a meaningful FFT display.

Generally, the Time Per Point setting is much slower than that which would normally be used when examining signals with the voltage vs. time display. Trial and error (or Table 8-7, page 8-37) may be used to select a Time Per Point, but if the incoming signal contains significant frequencies above 1/2 the digitizing rate, aliasing will distort the results (see page 8-38, Aliasing and the Nyquist Frequency).

In the interest of speed, the fast Fourier transform is performed on the first 512 points of the incoming time-related signal. Be certain that the frequencies of interest are contained in the initial portion of the signal.

EXAMPLE 8-23

If a short, repetitive burst is under examination, the burst must be located in 512 points centered on the cursor. See Figure 8-48.

To see the time domain signal which will be used for the FFT calculation, put your cursor at the 256th point on the waveform and apply expansion until 512 points are displayed (Figure 8-48).

Figure 8-49 shows the expanded display of the first 512 points in Figure 8-48.

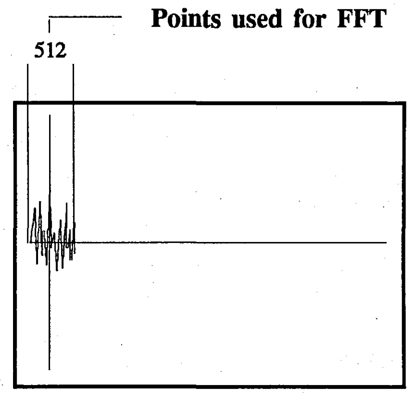


Figure 8-48

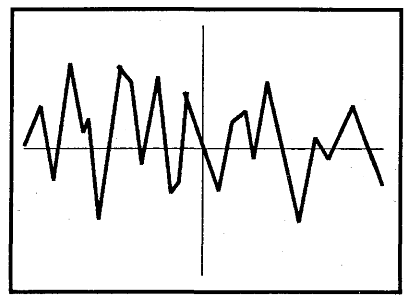


Figure 8-49

APPROXIMATE VALUES			
Time Per Point	Digitizing Rate (Max)	Display Frequency Spectrum	Display Resolution (Interval between Points)
5 nS	200 MHz	0 - 100 MHz	400 kHz
10 nS	100 MHz	0 - 50 MHz	200 kHz
20 nS	50 MHz	0 - 25 MHz	100 kHz
50 nS	20 MHz	0 - 10 MHz	50 kHz
100 nS	10 MHz	0 - 5 MHz	20 kHz
200 nS	5 MHz	0 - 2.5 MHz	10 kHz
500 nS	2 MHz	0 - 1 MHz	4 kHz
1 µS	1 MHz	0 - 500 kHz	2 kHz
2 µS	500 kHz	0 - 250 kHz	1 kHz
5 µS	200 kHz	0 - 100 kHz	400 Hz
10 µS	100 kHz	0 - 50 kHz	200 Hz
20 µS	50 kHz	0 - 25 kHz	100 Hz
50 µS	20 kHz	0 - 10 kHz	40 Hz
100 µS	10 kHz	0 - 5 kHz	20 Hz
200 µS	5 kHz	0 - 2.5 kHz	10 Hz
500 µS	2 kHz	0 - 1 kHz	4 Hz
1 mS	1 kHz	0 - 500 Hz	2 Hz
2 mS	500 Hz	0 - 250 Hz	1 Hz
5 mS	200 Hz	0 - 100 Hz	0.4 Hz
10 mS	100 Hz	0 - 50 Hz	0.2 Hz
20 mS	50 Hz	0 - 25 Hz	0.1 Hz
50 mS	20 Hz	0 - 10 Hz	0.04 Hz
100 mS	10 Hz	0 - 5 Hz	0.02 Hz
200 mS	5 Hz	0 - 2.5 Hz	0.01 Hz
500 mS	2 Hz	0 - 1 Hz	0.004 Hz
1S	1 Hz	0 - 0.5 Hz	0.002 Hz

Table 8-7

$$\text{Maximum Digitizing Rate} = \frac{1}{\text{Time Per Point Setting}}$$

$$\text{Displayed Frequency Spectrum} = \frac{\text{Maximum Digitizing Rate}}{2}$$

$$\text{Display Resolution} = \frac{\text{Displayed Frequency Spectrum}}{250}$$

Aliasing and the Nyquist Frequency

Aliasing occurs if a waveform is undersampled. Undersampling occurs when the sampling rate is less than twice the maximum frequency contained in the signal being sampled.

Figure 8-50 illustrates an 80 Hz sine wave sampled at 100 Hz. Notice that the apparent frequency, or "alias" is 20 Hz, a much lower frequency than that of the actual waveform. From Figure 8-51, it is clear that a sampling rate of exactly twice the sine wave frequency will not define the signal either.

Sampling theory requires a sampling rate of slightly more than twice the signal frequency for recognition of the signal. The 80 Hz signal, then, requires a sampling rate of slightly more than 160 Hz.

In the frequency domain, aliasing of this sort causes a "folding back" of frequencies, and distorts both the amplitude and phase information of the Fourier transform. Frequency folding can be visualized as an accordian-like graph (Figure 8-52).

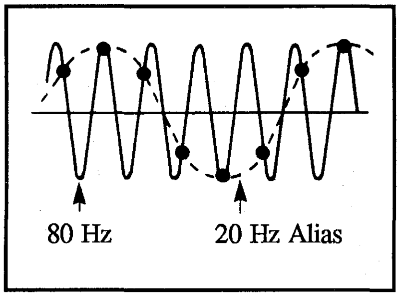
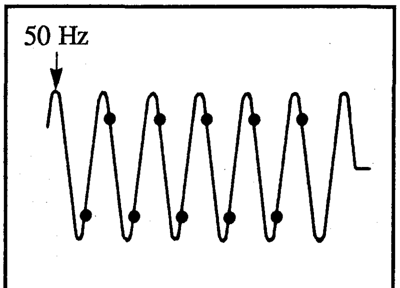


Figure 8-50



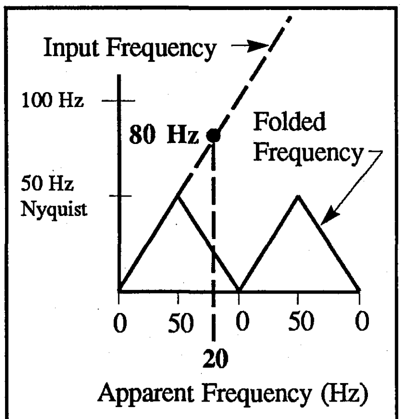
Sampling at 100 Hz
Nyquist Frequency = 50 Hz

Figure 8-51

With the 100 Hz sampling rate in Figure 8-50, any frequency component higher than 50 Hz will be folded back to appear as a lower frequency. Thus the 80 Hz sine wave appears as an aliased 20 Hz. The point at which folding begins to occur is the Nyquist frequency, or 1/2 the sampling frequency.

If frequencies above Nyquist are present to a significant degree in a signal, the frequency spectrum will be distorted. One must either use a higher sampling rate, or filter out the unwanted high frequencies. Thus, if one is using a 100 kHz rate (10 microseconds/point), the signal's frequencies above 50 kHz should be eliminated or at least greatly reduced with a 50 kHz low pass filter.

In the case of the example in Figure 8-50, a higher sampling rate (e.g., 200 Hz) would be adequate to avoid frequency folding. However, for complex signals, one cannot always be certain which high frequencies are present, so filtering is necessary.



Folding Diagram for Fs = 100 Hz

Figure 8-52

FFT Mathematics

After acquisition of 512 time-domain data points, the 4180 applies a Hanning window function to the data. In comparison with FFT's using a simpler box window, the Hanning window widens the main frequency lobe, reduces the "side lobes" caused by truncation, and widens the frequency band at 1/2 peak amplitude.

$$X_{(t)} = \frac{1 - \cos \frac{2t}{T}}{2} \quad 0<t<T$$

Equation 8-6

The Fast Fourier Transform algorithm used for the frequency calculation is the Cooley-Tukey and Sande-Tukey base 4 twiddle factor algorithm. For a complete description of this algorithm, and of FFT's in general, refer to <u>THE FAST FOURIER TRANSFORM</u> by E. Oran Brigham, Prentice Hall, NJ, 1974.

Notes for Users of Disk Drives, Plotters, and Computers

A. Disk Drives

Storing and recalling FFT spectra on the 4094's disk drives may be done in the same manner as time domain waveforms.

B. Plotters

If you try to plot the FFT display using the 4094's pushbutton plot function, the plot will execute with the standard 4094 plot format. It will be labeled in volts and time rather than RMS volts and Hertz. The numerics are correct, but must be "understood" as RMS volts and Hertz.

C. Computers

Results of the Fourier Transform mode may be output to a computer over the interfaces, but special care must be taken.

Use Table 8-9 to select the correct waveform number and step number in the "D" command. Table 8-9 also shows the normalizing set number to be used when retrieving normalizing with the "N" command. Normalization is usually received in a time and volts format, but it must be "understood" that in this application it is received in Hertz and volts (RMS) for the Fourier Transform display.

See the Input/Output instructions (section 13 of this manual) for full information on interfacing.

Please contact the application engineers at Nicolet if you have further questions concerning computer interfacing.

Number of Channels	Channel Identifier	Waveform Number	Step Number	Normset Number
1	Any	1	2	0
2	A	1	2	0
2	B	2	2	1
4	1A	1	2	0
4	2A	2	2	1
4	1B	3	2	2
4	2B	4	2	3

Note: Assume that the mainframe MEMORY GROUP switch was in "ALL" when the data was captured.

Table 8-9

SAMPLE PROGRAM

The following sample program inputs data and normalizing to a computer (HP BASIC) if one FFT was acquired with the mainframe MEMORY switch in the ALL position.

10 OUTPUT 714;"C,4,2,13,10"	Set record separators to CR/LF
20 ENTER 714; E	Read error code.
30 DIM D(248)	Dimension data array.
40 OUTPUT 714; "D,0,1,0,248,2"	Data is output in ASCII for waveform #1, starting at the first point and giving 248 (**see Note 1**) values. A step of 2 assures that these are calculated values.
50 ENTER 714; E	Read the error code.
60 FOR I=1 TO 248 70 ENTER 714; D(I) 80 DISP D(I) 90 NEXT I	Loop to input individual data point values..
100 ENTER 714; E	Read error code.
110 DIM N(7)	Dimension normalizing array.
120 OUTPUT 714; "N,0"	Request normalizing information for waveform 1.
130 ENTER 714; E	Read error code.
140 FOR J=1 TO 7 150 ENTER 714; N(J) 160 DISP N(J) 170 NEXT J	Loop to input normalizing information.
180 ENTER 714; E	Read error code.
190 END	End of program.

NOTE 1: Although a 256-point FFT is calculated, 248 values are displayed on the screen.

THE MAX/MIN FUNCTION

The MAX/MIN function displays two data points per sample period.

NOTE: Two display screen data points are allotted for each sample period when the MAX/MIN function is selected. The first point records the maximum voltage sampled during that sample period. The second point records the minimum voltage sampled during the same sample period.

Table 8-10 (single channel) and Table 8-11 (multiple channels) illustrate the pattern used to display the results on the screen when the SAVE function is turned off.

ONE CHANNEL	SAMPLE PERIOD			
	1st	2nd	3rd	4th
Channel A Turned ON	A a ● ●	A a ● ●	A a ● ●	A a — etc. ● ●
Channel B Turned ON	B b ● ●	B b ● ●	B b ● ●	B b — etc. ● ●

Single Channel (SAVE turned off)
Table 8-10

TWO CHANNELS	SAMPLE PERIOD			
	1st	2nd	3rd	4th
Channels A & B Turned ON	A B a b ● ● ● ●	A B a b ● ● ● ●	A B a b ● ● ● ●	A B a b — etc. ● ● ● ●

Multiple Channels (SAVE turned off)
Table 8-11

A = Maximum Value, channel A

a = Minimum Value, channel A

B = Maximum Value, channel B

b = Minimum Value, channel B

THE A+B FUNCTION

IMPORTANT: Both SAVE modes will be turned off automatically and any data recorded by them will be lost when the A+B function is executed. In addition, both channels are forced on (if not already on) when the A+B function is executed.

Three waveforms are displayed when waveform A and waveform B are added together.
#1. Waveform A
#2. Waveform B
#3. Result of A + B

NOTE: The time resolution is halved due to the use of every other pair of points to store the result.

To ensure that both channels capture data with identical Volts Full Scale ranges -

#1. The channel B Volts Full Scale selector copies the channel A Volts Full Scale range automatically when the A+B function is executed initially.

#2. If the Volts Full Scale range is changed on one channel, the other channel will duplicate the voltage change automatically while the A+B function is being executed.

The resulting waveform is centered vertically on the screen and identified with the letter "R" (Result) by the Plug-in/Channel Identifier when it is being decoded by the numerics.

Figure 8-53 illustrates the pattern that will be used to display the two original waveforms and the result of adding channel A and channel B.

SAMPLE PERIOD				
1st	**1st**	**3rd**	**3rd**	**5th**
A B • •	R R • •	A B • •	R R • •	A B ... etc. • •

Figure 8-53

A = Channel A voltage
B = Channel B voltage
R = Channel A + Channel B voltage

THE A-B FUNCTION

IMPORTANT: Both SAVE modes will be turned off automatically and any data recorded by them will be lost when the A-B function is executed. In addition, both channels are forced on (if not already on) when the A+B function is executed.

Subtracting waveform B from waveform A results in a three waveform display.
#1. Waveform A
#2. Waveform B
#3. Result of A - B

NOTE: The time resolution is halved due to the use of every other pair of points to store the result.

To ensure that both channels capture data with identical Volts Full Scale ranges -

#1. The channel B Volts Full Scale selector copies the channel A Volts Full Scale range automatically when the A-B function is executed initially.

#2. If the Volts Full Scale range is changed on one channel, the other channel will duplicate the voltage change automatically while the A-B function is being executed.

The resulting waveform is centered vertically on the screen and identified with the letter "R" (Result) by the Plug-in/Channel Identifier when it is being decoded by the numerics.

Figure 8-54 illustrates the pattern that will be used to display the two original waveforms and the result of subtracting channel B from channel A.

SAMPLE PERIOD				
1st	**1st**	**3rd**	**3rd**	**5th**
A B • •	R R • •	A B • •	R R • •	A B ... etc. • •

Figure 8-54

A = Channel A voltage
B = Channel B voltage
R = Channel A - Channel B voltage

THE A*B FUNCTION

IMPORTANT: Both SAVE modes will be turned off automatically and any data recorded by them will be lost when the A*B function is executed. In addition, both channels are forced on (if not already on) when the A*B function is executed.

Multiplying waveform A by waveform B results in a three waveform display -
#1. Waveform A
#2. Waveform B
#3. Result of A x B

NOTE: The time resolution is halved due to the use of every other pair of points to store the result.

The resulting waveform is centered vertically on the screen and identified with the letter "R" (Result) by the Plug-in/Channel Identifier when it is being decoded by the numerics.

Figure 8-55 illustrates the pattern that will be used to display the two original waveforms and the result of multiplying channel A by channel B.

SAMPLE PERIOD				
1st	1st	3rd	3rd	5th
A B ● ●	R R ● ●	A B ● ●	R R ● ●	A B ... etc. ● ●

Figure 8-55

A = Channel A voltage
B = Channel B voltage
R = Channel A x Channel B voltage

THE A/B FUNCTION

IMPORTANT: Both SAVE modes will be turned off automatically and any data recorded by them will be lost when the A/B function is executed. In addition, both channels are forced on (if not already on) when the A/B function is executed.

Dividing waveform A by waveform B results in a three waveform display -
#1. Waveform A
#2. Waveform B
#3. Result of A/B

NOTE: The time resolution is halved due to the use of every other pair of points to store the result.

The resulting waveform is centered vertically on the screen and identified with the letter "R" (Result) by the Plug-in/Channel Identifier when it is being decoded by the numerics.

Figure 8-56 illustrates the pattern that will be used to display the two original waveforms and the result of dividing channel A by channel B.

SAMPLE PERIOD				
1st	1st	3rd	3rd	5th
A B ● ●	R R ● ●	A B ● ●	R R ● ●	A B ... etc. ● ●

Figure 8-56

A = Channel A voltage
B = Channel B voltage
R = Channel A/Channel B

SUMMATION AVERAGING

Sweeps are added and stored in a 32 bit accumulator memory.

The normalized average is displayed on the screen when either the plug-in is put into the Hold Mode (Live and Hold Next off, Hold Last on) or the Summation Dump count has been reached. At this point, the Summation Average will be displayed on the screen and a new Summation Average will start. A sweep counter shows the number of sweeps collected.

To change the Summation Dump Count:

#1. Enter the Setup Mode.

#2. Select Summation Averaging.

#3. Use the mainframe Cursor (Left/Right) buttons to select the digit and the (Up/Down) buttons to increment/decrement the selected digit.

A dump count of 0 will execute one sweep.

Executing Hold Next will not go into Hold until the Dump Count has beeen reached.

CHANNEL A/B DATA INVERSION

NOTE: Available on 4180 plug-in versions 1.1 or above only. This option can also be used any of the other functions.

Data captured using the 4180 plug-in and a Model 4094C mainframe can be multiplied by a -1 (voltage coordinates only) to invert the stored data.

IMPORTANT: The collected sweep is inverted around *digital zero* (screen vertical center), 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 capturing the signal.

To Invert a Data Group:

#1. Enter the SETUP mode:
  a. Depress and hold HOLD LAST.
  b. Depress and hold HOLD NEXT.
  c. Release HOLD LAST.
  d. Release HOLD NEXT.

  NOTE: All three Storage LEDs should be illuminated.

#2. Pulse the FUNCTION button until **OPTIONS: +A +B** appears on the screen.

#3. Press the cursor Up or Down button until the desired channel is selected.

#4. Press the cursor Left or Right button until the desired sign appears (+ = noninversion, - = inversion).

#5. If applicable, use the FUNCTION button to select the desired function (e.g., Virtual Averaging, A*B, etc.).

#6. Press the LIVE or HOLD LAST button to exit the SETUP mode.

MINIMUM TRIGGER UNCERTAINTY

NOTE: Available on 4180 plug-in versions 1.1 or above only. This option can be also be used with any of the other functions.

Minimum Trigger Uncertainty OFF

When the Minimum Trigger Jitter option is turned off, the 4180 compensates for the Trigger to Sweep Start Delay by collecting the appropriate number of pre-trigger data points before the actual sweep begins.

The proper trigger time zero (T=0) point will appear at the left edge of the screen if no other delays are in effect.

NOTE: The Trigger Time button LEDs will indicate a delay or pre-trigger condition only if trigger time zero (T=0) is not located at the left edge of the screen.

Minimum Trigger Jitter ON

When the Minimum Trigger Jitter option is turned on, the 4180 compensates for the Trigger to Sweep Start Delay by adjusting the screen normalization. This will show the proper normalization with respect to the waveform.

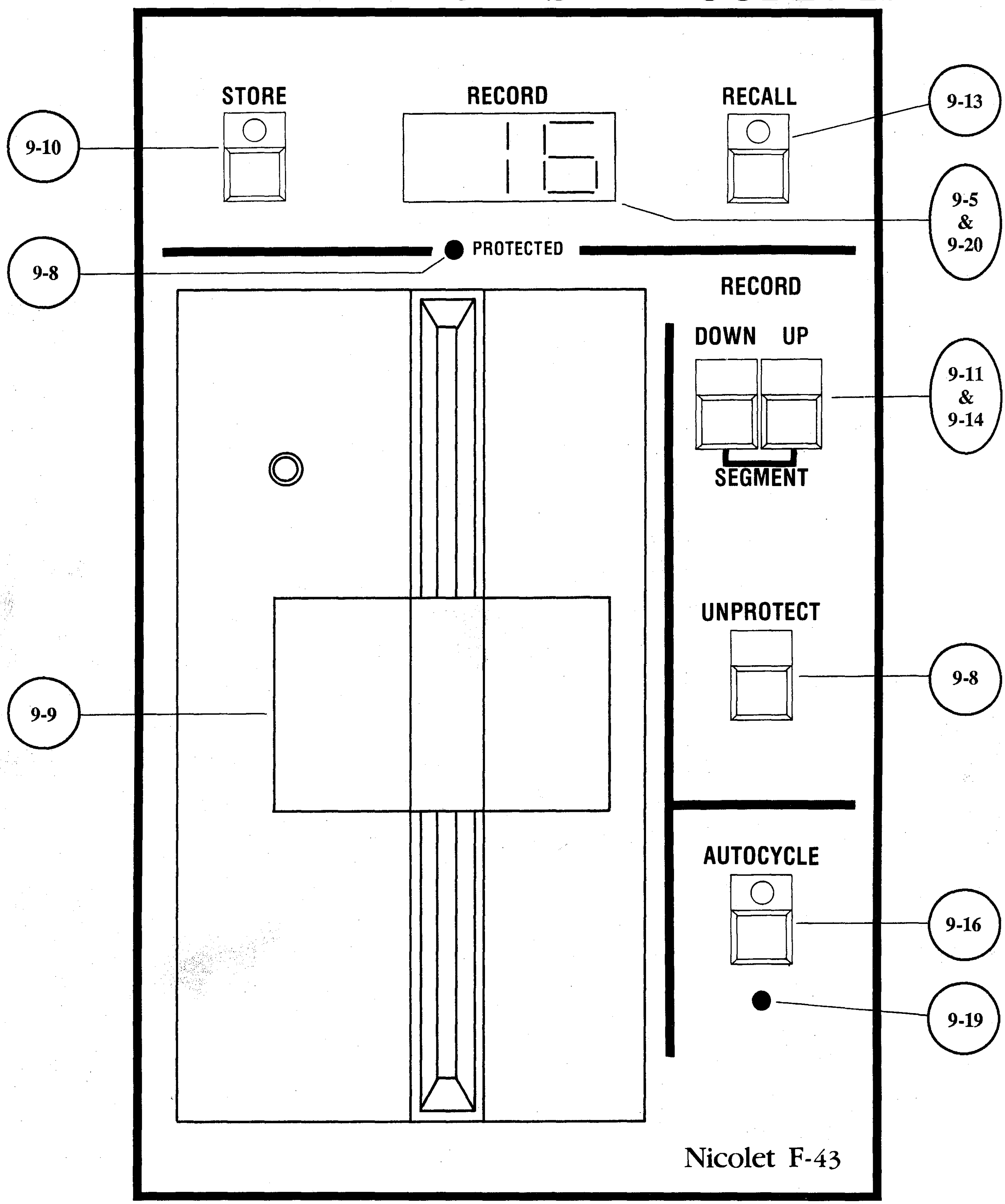
Trigger time zero (T=0) will not necessarily be at the left edge of the screen with the Trigger Time delays zeroed.

Master/Slave and Minimum Trigger Jitter

If a 4180 is used as the Master plug-in and another 4180 is used as a Slave plug-in, both of the preceding discussions concerning Minimum Trigger Jitter ON/OFF remain valid.

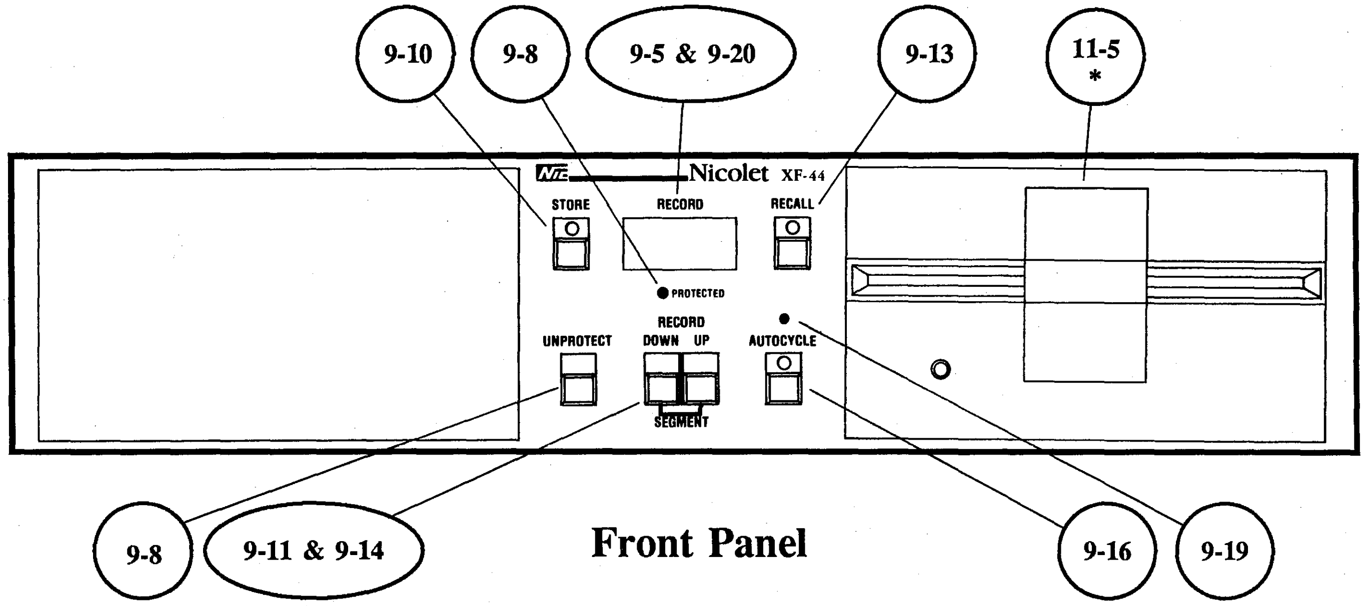
If a 4562, 4851, 4175, or 4570 is used as the Master plug-in, then the 4180 Slave plug-in will not compensate for the Trigger to Sweep Start Delay.

F-43 DISK RECORDER

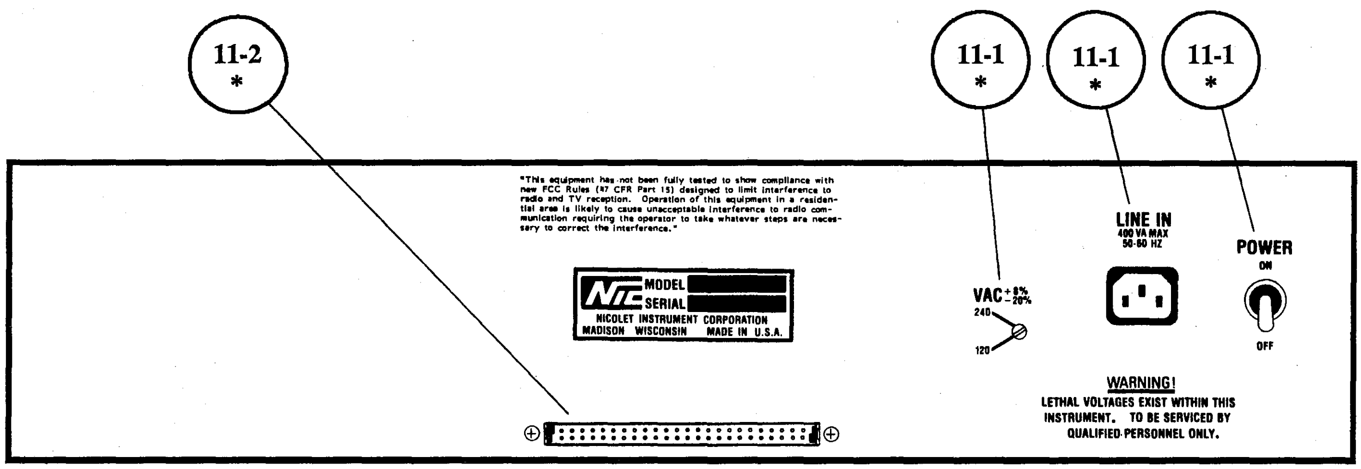


NOTE: The operation of the XF-44/1 is identical to that of the Model F-43. See the next page for the XF-44/1 configuration.

XF-44 DISK RECORDER



Front Panel



Rear Panel

(*) Refer to Tab 11 (Dual Disk Recorders) for description of operation.

INTRODUCTION

The Disk Recorder stores data on the floppy diskette for later recall.

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.

IMPORTANT: Only double-sided, double-density, 96 TPI, soft-sectored diskettes may be used with the 4094 Disk Recorder.

FORMAT ROUTINE

Divides floppy diskettes purchased from different suppliers into the twenty individual records required by the Series 4094 oscillosope.

DATA STORE METHODS

Data can be stored by any of the following methods.

Normal Store Routine
Data groups are stored sequentially on identical segments (e.g., H1 of each record) until all twenty records have stored a data group.

Segmented Store Mode
Data groups are stored on each segment (e.g., H1 and H2 of each record) before incrementing to the next record.

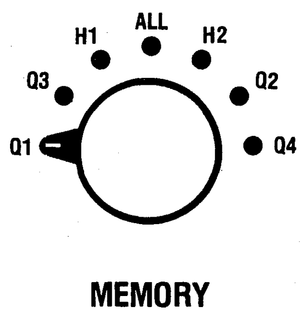
Autocycle Routine
Data groups are stored automatically at the end of a sweep. The oscilloscope will rearm into the Live/Hold Next modes after the data has been stored.

DATA RECALL METHODS

Data can be recalled by either of the following methods.

Normal Recall Routine
Recalls 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.

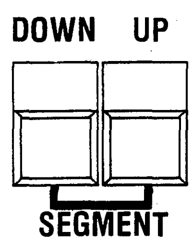
Segmented Recall Mode
Recalls data stored on different tracks (but in identical segments) and displays them on the screen for comparison.



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 front panel.



DOWN BUTTON

Decrements the displayed record and/or segment by a factor of one.

UP BUTTON

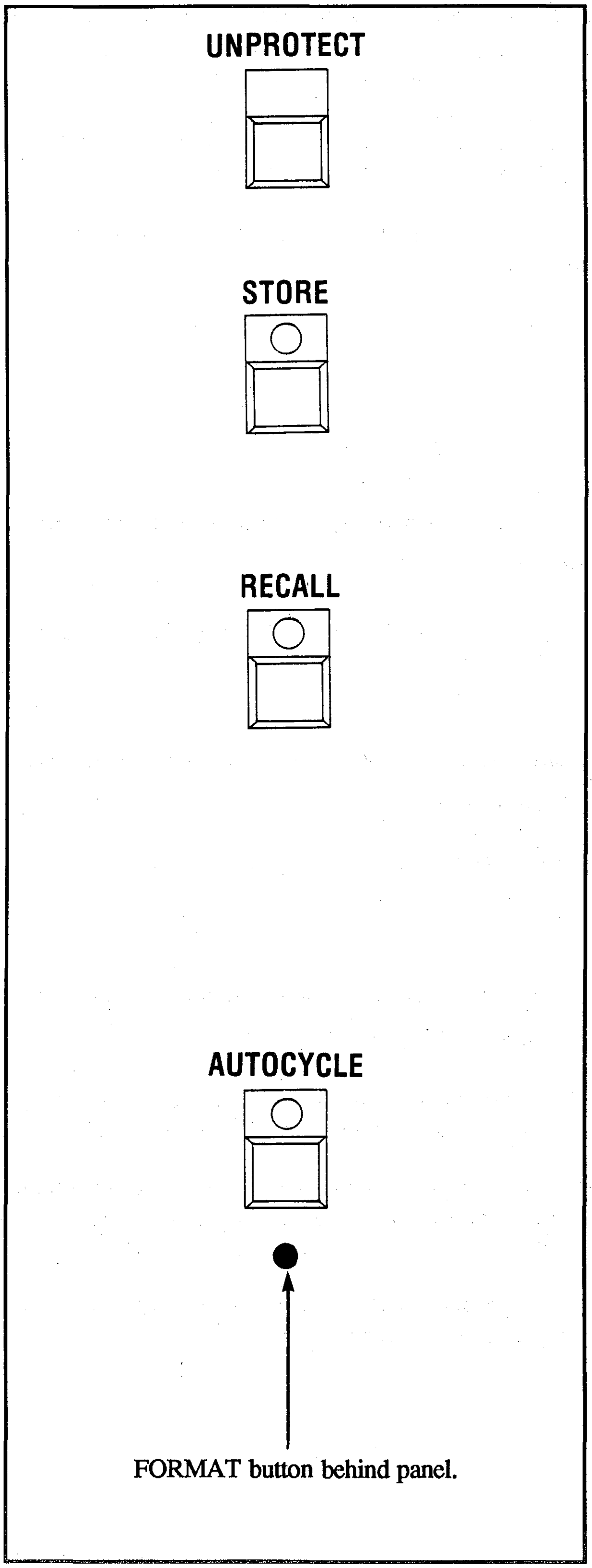
Increments the displayed record and/or segment by a factor of one.

SEGMENT BUTTONS

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 activaed by pressing the UP and DOWN buttons simultaneously.



UNPROTECT BUTTON

Allows previously stored data to be replaced by over-riding the automatic protection feature.

STORE BUTTON

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 button is pressed.

RECALL BUTTON

Transfers data from the diskette to the display memory for viewing on the screen. The LED indicator illuminates during the transfer.

AUTOCYCLE BUTTON

Data automatically transfers from the display memory to the diskette each time the plug-in enters the "Hold Mode" (Live/Hold Next LEDs off, Hold Last LED on). The plug-in rearms into the Live/Hold Next mode after the data has been transferred.

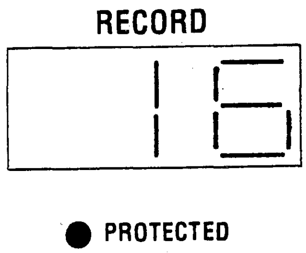
Pressing the AUTOCYCLE button again exits the Autocycle routine and turns of the LED indicator.

FORMAT BUTTON

Divides a new, unformatted diskette into twenty individual records. The STORE button must also be pressed to activate the Format routine.

The FORMAT button is mounted behind the Disk Recorder's front panel. It is operated by inserting a small diameter instrument into the access hole located adjacent to the AUTOCYCLE button.

Pressing the FORMAT button again aborts the Format routine.



NUMERICAL DISPLAY

The following information will appear on the numerical display.

Record Number

All Models

For a Series 4094 diskette, numbers 01 thru 20.

Models 4094, 4094A, 4094B Only

For a 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 when formatting a diskette.

Error Flags
The letter "E" alternates with an error code number.

PROTECTED LED

Alerts the operator, when the LED is illuminated, that the record/segment selected to store data is already storing data.

THE DISKETTE

The Series 4094 diskette is divided into twenty individual records. Each record can store up to (16K) data points of digitized data. It can either be left intact or divided into subgroups called **segments.**

IMPORTANT: Do <u>not</u> use "high density" diskettes - double or quad density diskettes are correct. In addition, a Series 2090 diskette cannot be formatted, nor can it store data on an F-43/XF-44 disk recorder.

4094, 4094A, 4094B Only
A 2090 diskette can be used to recall 2090 oscilloscope data into the 4094 memory.

The position selected on the mainframe MEMORY switch determines whether or not a record will be left intact.

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 mainframe 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.

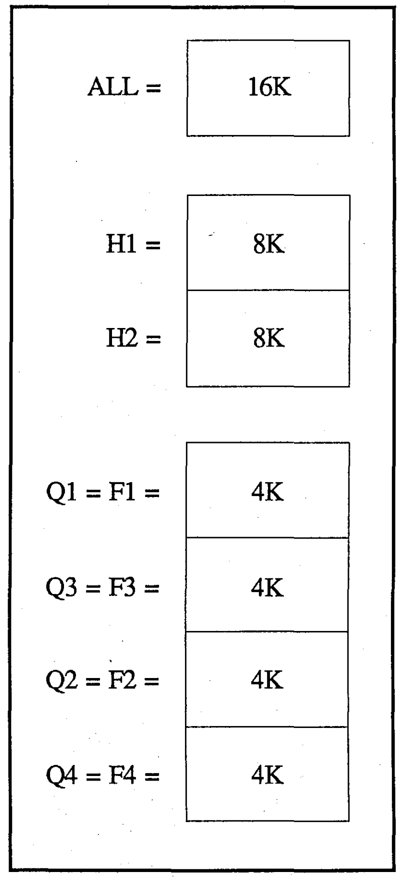


Figure 9-1

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. A protected data group is 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 "wrap-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 PROTECT 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. If it is not removed, the word "Pro" will appear on the numerical display. To clear the word "Pro" from the numerical display, press the UP/DOWN button.

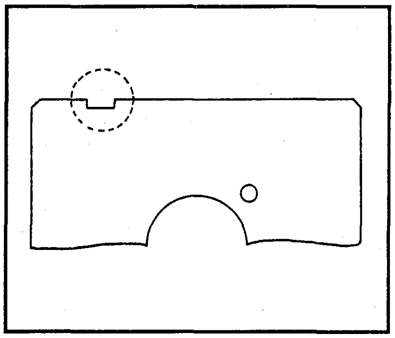


Figure 9-2

LOADING THE DISKETTE

The disk drive energizes automatically 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, or the recorder will not acknowledge the presence of the diskette.

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

a. Power is off.
b. Power is being applied or removed.
c. The drive is not being used.
d. The instrument is being moved.

To insert the diskette:

#1. Open the small door at the front of the disk recorder.

#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.

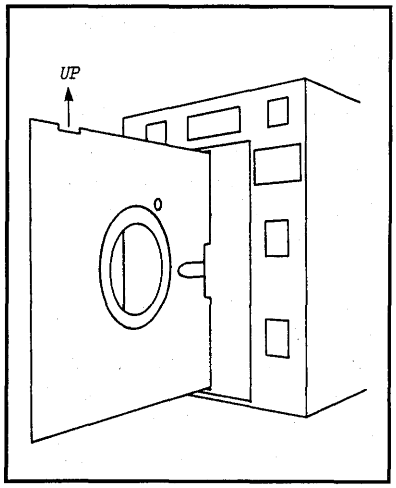


Figure 9-3

STORING DATA ON THE DISKETTE

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 increments to the next record automatically after the previous data group has been stored and the STORE button is pressed again. The "beeper" sounds each time the diskette "wraps-around" from Record 20 to Record 01.

Before a protected data group can be replaced, the UNPROTECT button must be pressed before initiating a Store routine. A protected data group, identified by an illuminated PROTECTED LED, can be by-passed by pressing the UP/DOWN button.

THE NORMAL STORE MODE

The Segmented Store Routine begins on page 9-11.

Selecting a Record to Store Data

A specific record can be selected to store a data group by pressing the UP/DOWN button and observing the numerical display for the desired record number.

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 Procedure

#1. Select the desired segment on the MEMORY switch.

#2. Select the desired record number on the numerical display using the UP/DOWN button.

NOTE: If the PROTECTED LED illuminates, either bypass the record using the UP/DOWN button or press the UNPROTECT button to unprotect the record.

#3. Press the STORE button.
  a. The STORE LED illuminates while data transfers.
  b. The recorder increments the diskette to the 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 store sequence, one data group at a time. Record 20 was manually bypassed with the UP button.

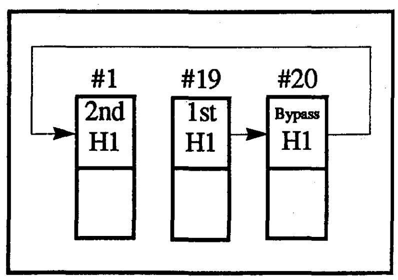


Figure 9-4

THE 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 simultaneously will be the record at which the Segmented mode will start. 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 the Segmented mode is activated.

ALL
Not allowed. Already provided for by the Normal Store routine (page 19-10).

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.

A. Equal Segment Sizes

Only equally sized segments can be selected in the Segmented store mode. For example, 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 when the STORE button is pressed and then be replaced by a Record Number when the button is released.

B. 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. Press both the UP and DOWN buttons simultaneously, then release.

#2. Select a new Segment size on the MEMORY switch.

#3. Press both the UP and DOWN buttons simultaneously, then release.

Segmented Store Procedure

#1. Press the UP/DOWN button until the desired Record number appears on the numerical display.

#2. Using the MEMORY switch, selected whether the record will divide into "halves" (H1 or H2), or into "quarters" (Q1, Q2, Q3, or Q4).

#3. Press both the UP and DOWN buttons simultaneously and observe the numerical display to verify the selected Record Number.

#4. Press the UP or DOWN button until the Segment that is to store the first data group appears on the numerical display.

NOTE: If the PROTECTED LED illuminates, either bypass the Record/Segment or press the UNPROTECT button.

#5. Press the STORE button.
  a. The STORE LED illuminates during data transfer.

  b. The disk recorder increments to the next Segment/Record.

Example 9-3

Assume that the MEMORY switch was in the H1 position when the Segmented mode was 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.

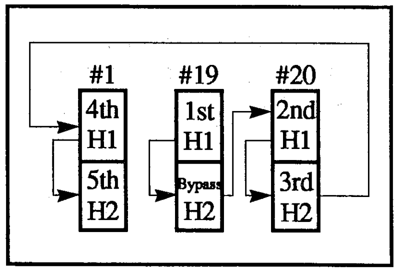


Figure 9-5

RECALLING DATA FOR DISPLAY

Data transfers from the diskette to the display memory each time the RECALL button is pressed.

IMPORTANT: The plug-in must be in the Hold Mode when recalling data from the diskette, or the word "Err" will appear on the numerical display when the RECALL button is pressed.

The disk recorder increments to the next record automatically after the RECALL button is pressed. The "beeper" sounds each time the diskette "wraps-around" from Record 20 to Record 01.

A record can be bypassed by pressing the UP or DOWN button. The operator can scan through the diskette by pressing and holding in the RECALL button.

THE NORMAL RECALL ROUTINE

The Segmented Recall mode begins on page 9-14.

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 by pressing the UP/DOWN button and observing the numerical display for the desired record number.

Scanning the Diskette

The operator can elect to scan the entire diskette for a specific display by pressing and holding in the RECALL button.

Superimposing Data from Different Records

The operator can also elect to recall data from different records, but NOT from identical segments (e.g., recalling data from Segment H1 on more than one record is not allowed) 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 to recall one-fourth of each data group and store each one in a different display memory subsection.

#1.	Numerical Display:	01
#2.	MEMORY switch:	Q1
#3.	Press RECALL.	
#4.	Numerical Display:	03
#5.	MEMORY switch:	Q3
#6.	Press RECALL.	
#7.	Numerical Display:	07
#8.	MEMORY switch:	Q2
#9.	Press RECALL.	
#10.	Numerical Display:	09
#11.	MEMORY switch:	Q4
#12.	Press RECALL.	
#13.	MEMORY switch:	ALL

The operator can now view all four (4K) data groups superimposed on the screen.

THE SEGMENTED RECALL MODE

Allows the recorder to mix data groups 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 again.

Selecting a Record to Recall Data

The Record Number displayed on the numerical display while holding in both the UP and DOWN buttons simultaneously will be the record at which the Segmented mode will start. 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 the "halves" or "quarters" of a record. Which of these two sizes will be selected is determined by the position of the MEMORY switch at the time 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 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", recalling 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.

A. Mixing Segment Sizes

The operator can select different size Segments for recall 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. Press both the UP and DOWN buttons simultaneously, then release.

#2. Select a new Segment size on the MEMORY switch.

#3. Press both the UP and DOWN buttons simultaneously, then release.

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 displayed on the numerical display. The recalled data can consist of either a single (8K) data group, 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 the the "H1" position selected on the MEMORY switch, it will be necessary to perform the three step procedure listed above.

Segmented Recall Procedure

#1. Using the MEMORY switch, select the desired Segment size and the display memory subsection that will store the first recalled data group.

#2. Press the UP/DOWN button until the desired Record Number appears on the numerical display.

#3. Press both the UP and DOWN buttons simultaneously to enter the Segmented mode.

#4. Press the UP or DOWN button until the Segment that is to recall the first data group appears on the numerical display.

#5. Press the RECALL button.

#6. Press both the UP and DOWN buttons simultaneously to exit the Segmented mode.

#7. Using the MEMORY switch, select which Segment size (typically the same size as selected in Step #1) and which display memory subsection will store the next recalled data group.

#8. Repeat steps #2 through #7 until all of the desired data groups have been recalled.

#9. Press both the UP and DOWN buttons simultaneously to exit the Segmented mode.

#10. Place the MEMORY switch to ALL.
   a. The recalled data groups are displayed super-imposed on the display screen.

Example 9-7

Assume that four (16K) data groups (each stored on F1 of Records #1, #3, #7, and #9) are to be compared on the screen.

#1. MEMORY switch: Q1

#2. Numerical Display: 01

#3. UP/DOWN: Press both simultaneously and release.

#4. Numerical Display: 01*/F1

#5. Press RECALL.

#6. MEMORY switch: Q3

#7. Numerical Display: 03*/F1

#8. Press RECALL.

#9. MEMORY switch: Q2

#10. Numerical Display: 07*/F1

#11. Press RECALL.

#12. MEMORY switch: Q4

#13. Numerical Display: 03*/F1

#14. Press RECALL.

#15. MEMORY switch: ALL

#16. UP/DOWN: Press both simultaneously and release.

(*) The Record Number can be verified by exiting the Segmented mode. If incorrect, press the UP or DOWN button until the correct Record Number appears and then reactivate the Segmented mode.

AUTOCYCLE ROUTINE

Data is automatically captured 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 "wrap-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 or the word "Pro" will appear on the numerical display when the AUTOCYCLE button is pressed.

#1. Display the Record Number on the numerical display that is to store the first data group.

#2. Place the MEMORY switch to ALL.

#3. Press and hold in the UNPROTECT button until each record (up to and including Record #20) is unprotected.

#4. Repeat step #1.

Selecting the Segment Sizes

The position of the MEMORY switch at the time that the Autocycle routine is activated will determine whether each record will store one, two, or four data groups.

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.

Activating the Autocycle Routine

The Autocycle Routine is activated by pressing the AUTOCYCLE button.

IMPORTANT: Previously captured data must be stored on the diskette (if it is to be saved) **before** activating the Autocycle routine. Otherwise, it will be replaced by the first Autocycle sweep.

Deactivating the Autocyle 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 either of the following situations occur:

a. Record #20 has stored (16K) words of data.

b. Any of the disk recorder's buttons are pressed and held until the AUTOCYLE LED turns off.

The operator can identify on which RecordSegment the Autocycle routine was aborted by the following procedure.

#1. Place the MEMORY switch to ALL.

#2. Press the UP button until the first unprotected record appears on the numerical display.

#3. Decrement the numerical display one count by pressing the DOWN button once.

#4. Switch the MEMORY switch between each of its positions while observing the PROTECTED LED.

NOTE: If the LED remains illuminated for each position in step #4, the next higher 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. The plug-in enters into the Live/Hold Next mode.

#2. A valid trigger occurs, initiating a sweep.

#3. The plug-in enters into the 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 in this example).

   b. The numerical display increments to the next Record Number.

#4. Steps #1 through #3 repeat until Record #20 stores a data group, after which the following two events occur.
   a. The recorder exits the Autocycle routine.

   b. Record #05 reappears on the numerical display.

Figure 9-6 illustrates the process of storing successive data groups according to the position selected on the MEMORY switch.

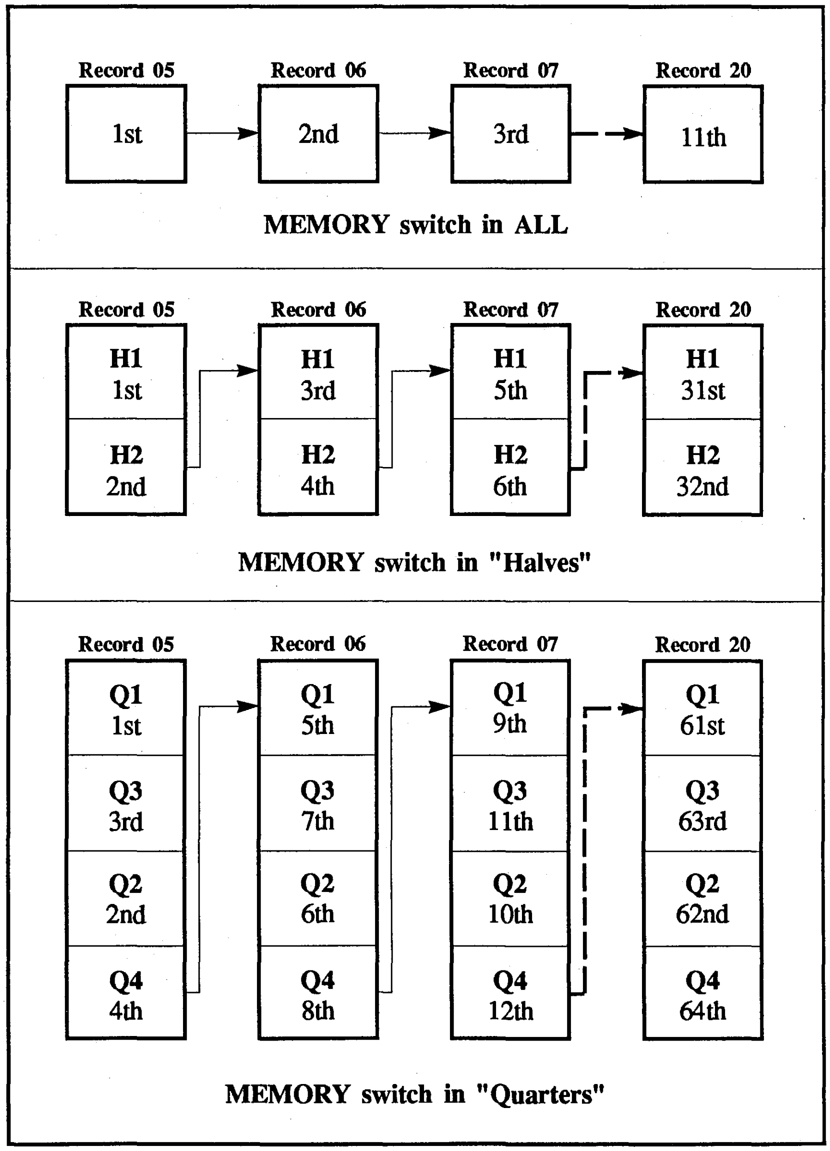


Figure 9-6

FORMAT ROUTINE

IMPORTANT: Only 80 track, 96 TPI, double-sided diskettes can be formatted on the F-43 and XF-44/1 disk recorders. The diskettes shipped with the Series 4094 oscilloscopes have been preformatted at the factory. A series 2090 diskette cannot be formatted on the 4094 system.

Entering the Format Routine

The Format routine divides the diskette into the required twenty records in approximately three minutes.

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 or 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 pressing the STORE button) by pressing any button (including the FORMAT button, but not the STORE button) on the Disk Recorder.

Tab Protected Diskettes

The tab must be removed, or the word "Pro" will appear on the numerical display if an attempt is made 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 cannot be formatted after a second attempt.

Formatting Diskettes

#1. Insert the diskette into the disk recorder.
   a. The 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 to format.
   b. Upon completion, the STORE LED turns off and the word "For" is replaced on the numerical display with 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 - Appears when attempting one of the following:
  a. Storing, Formatting, Copying, Unprotecting, or Autocycling on a tab protected diskette.
  b. Storing or Autocycling on a protected record.

Err - Appears when attempting one of the following:
  a. Recalling data while the plug-in is in the Live mode.
  b. Storing or recalling data (while in the Segment mode) from a larger/smaller segment than was initially selected.
  c. Unprotecting either a 2090 diskette 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 is not a 4094 diskette.

E6 - Either a bad diskette (try again), or the diskette 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 third bay (F-43 Disk Recorder bay).

The plug-ins can be mixed or matched as long as the 4094 Model requirement is met (see Table 10-1).

> **CAUTION:** Only one 4175 can be inserted into the model 4094A or above oscilloscope. It must be located in the left-hand bay. A 4180, 4562, 4851, or 4570 plug-in can be added in the right-hand bay.

Since the mainframe is sharing its capabilities with up to four channels, the following descriptions should be read when operating the 4094 in the dual plug-in mode.

NOTE: The term "**Hold Mode**" will be used to indicate that the Plug-in(s) are in the Hold Last mode (Hold Last LED on, Live LED off).

Table Of Contents	Page

Plug-in Model	Requires 4094 Model	Can be mounted in the following plug-in bays
4175	A or above	Left bay (#1) only.
4180	B or above	Either bay (#1 and/or #2).
4562	A or above	Either bay (#1 and/or #2).
4851	A or above	Either bay (#1 and/or #2).
4570	B or above	Either bay (#1 and/or #2).

Table 10-1

POWERING UP A DUAL PLUG-IN 4094

IMPORTANT: Perform the following sequence when applying power to a two plug-in configured 4094 and the both channels of the third bay (right hand) plug-in are turned off.

#1. Apply power to the 4094.

#2. Press the third bay plug-in's LIVE button.

TURNING THE THIRD BAY PLUG-IN OFF

IMPORTANT: Perform the following sequence when both third bay plug-in channels are turned off while capturing signals in the Normal Trigger Mode and the trace(s) are not to be displayed on the screen.

#1. Turn off both channels of the third bay plug-in.

#2. Press the third bay plug-in's LIVE button.
   a. The third bay plug-in's trace(s) are removed from the screen.

MEMORY ADDRESS ALLOCATION

The number of channels turned on and the position of the MEMORY switch determines the number of addresses allotted to record the input signa(s). See Table 10-2.

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*	7,936	3,968	1,984
3**	3,968	1,984	992
4	3,968	1,984	992

Table 10-2

* Addresses allotted for plug-in with one channel activated.

** Addresses allotted (per channel) for plug-in with two channels activated.

SWEEP TIMES

The sweep times will decrease when multiple channels are activated.

Refer to Table 8-4 under the Plug-ins tab for the appropriate Plug-in and divide the listed sweep times accordingly:

Two channels: Divide by 2
Three or four channels: Divide by 4

MIXING TRIGGER DISPLAYS

The operator can select any combination of Normal, Cursor, and Delayed trigger displays. Each channel operates independently.

THE BUS ARBITRATION DIP SWITCH

NOTE: Refer to page 10-4 for the 4094A and 4094B Bus Arbitration Jumper procedure.

The Bus Arbitration DIP switch must be set according to the location(s) of the plug-ins.

Procedure

> **WARNING:** Remove all power from the oscilloscope before continuing.

#1. Remove the bottom cover from the oscilloscope.

#2. Set the oscilloscope to rest on its first (left hand) plug-in bay.

#3. Remove the three securing screws from the top of the Digital board (Figure 10-1) and carefully swing the board down.

#4. Position the Bus Arbitration DIP switches as required for the plug-in configuration that will be used (see Table 10-1).

#5. Replace and secure the Digital board with the three securing screws.

#6. Replace and secure the bottom cover.

PLUG-IN LOCATION(S)	DIP SWITCH CONFIGURATIONS
Left Bay Only	Position all 8 DIP switches down (CLOSED)
Right Bay Only	Position all 8 DIP switches up (OPEN)
Both Bays	Position all 8 DIP switches up (OPEN)

Table 10-2

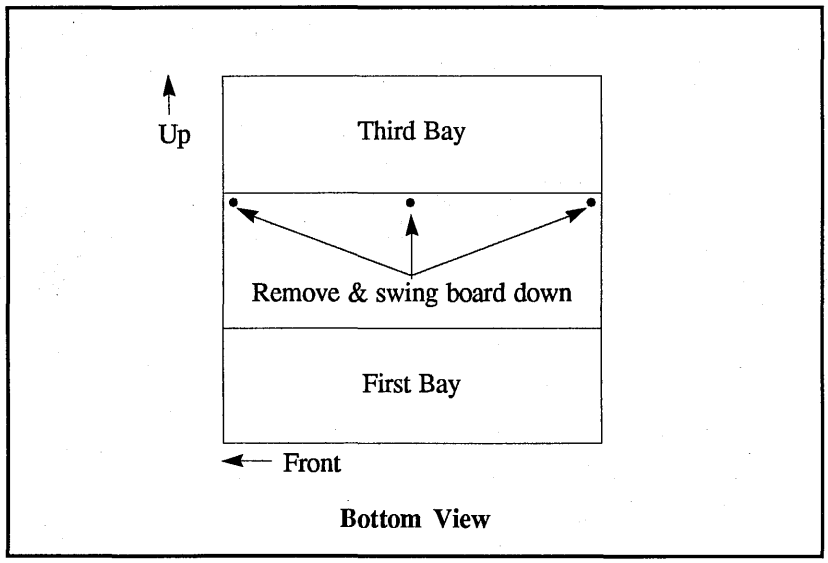


Figure 10-1

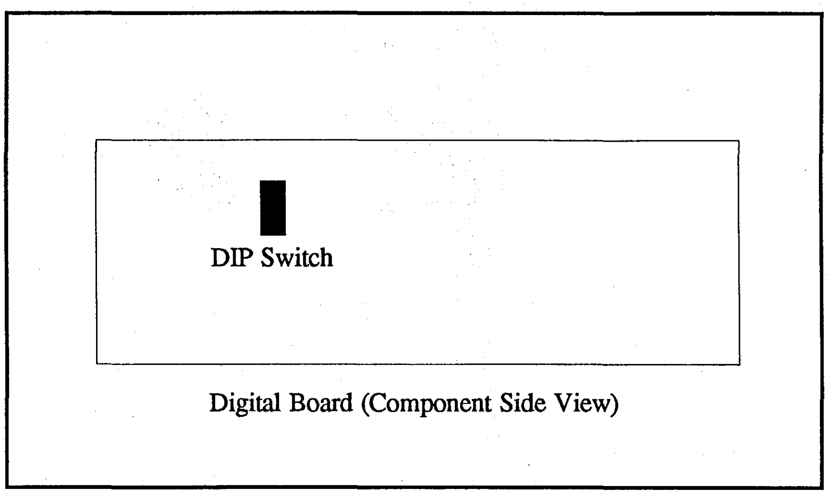


Figure 10-2

THE BUS ARBITRATION JUMPER

NOTE: Refer to page 10-3 for the 4094C and above Bus Arbitration procedure.

If the 4094A or B is to be operated without a third bay plug-in, the Bus Arbitration Jumper (Figure 10-3) must be installed in the third bay Bus Aribitration Cable connector (Figure 10-4).

CAUTION: The jumper must be inserted into the Bus Arbitration Cable connector with the small notch positioned towards the front of the oscilloscope (Figure 10-5). Refer to the 4094 Service Manual for detailed instructions.

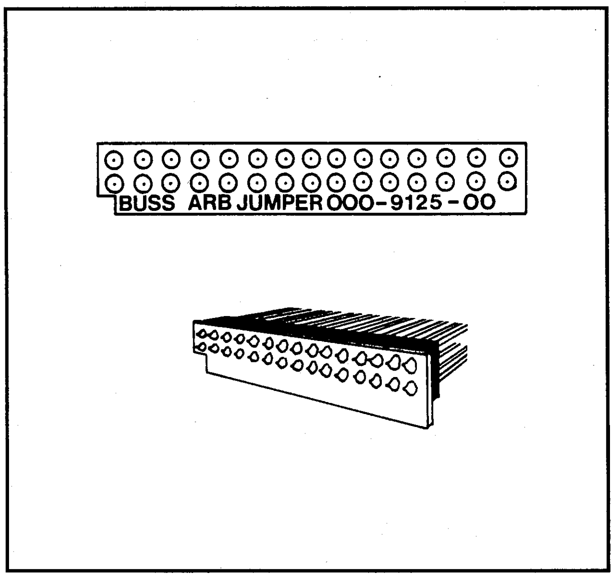


Figure 10-3

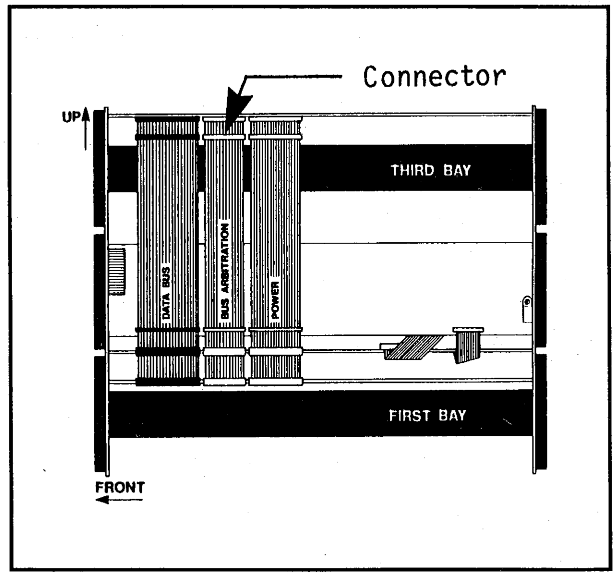


Figure 10-4

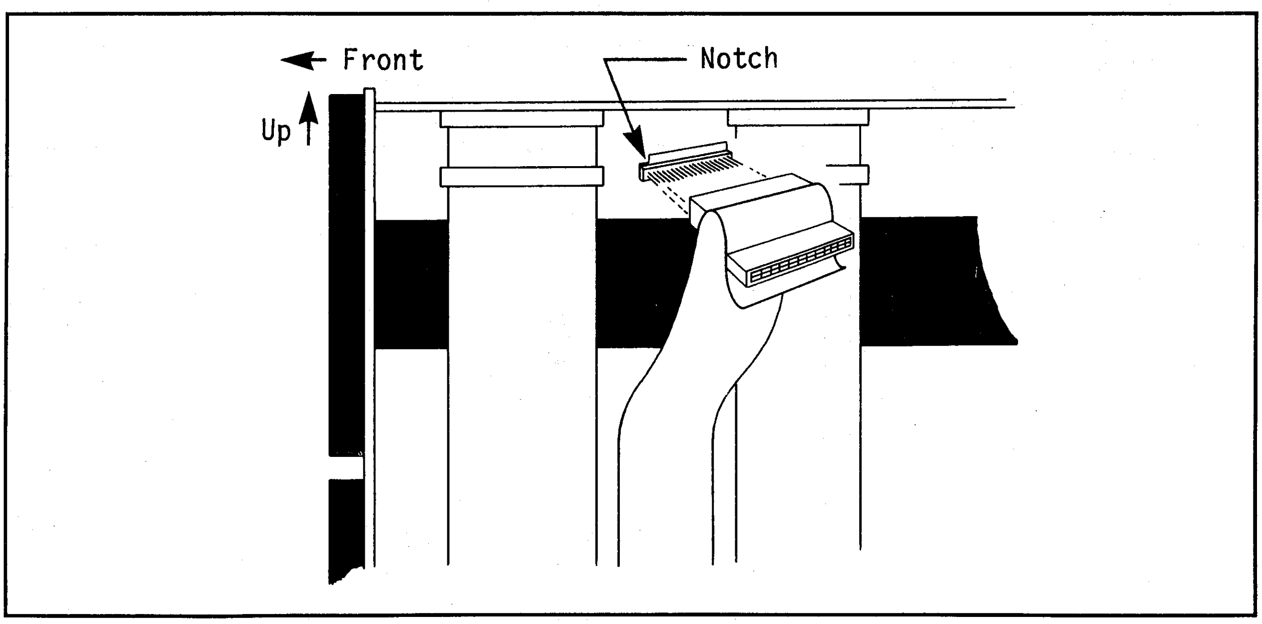


Figure 10-5

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 10-6).

IMPORTANT: Take care to push the connectors in all the way and secure with screws. Intermittent operation can be caused by loose connectors.

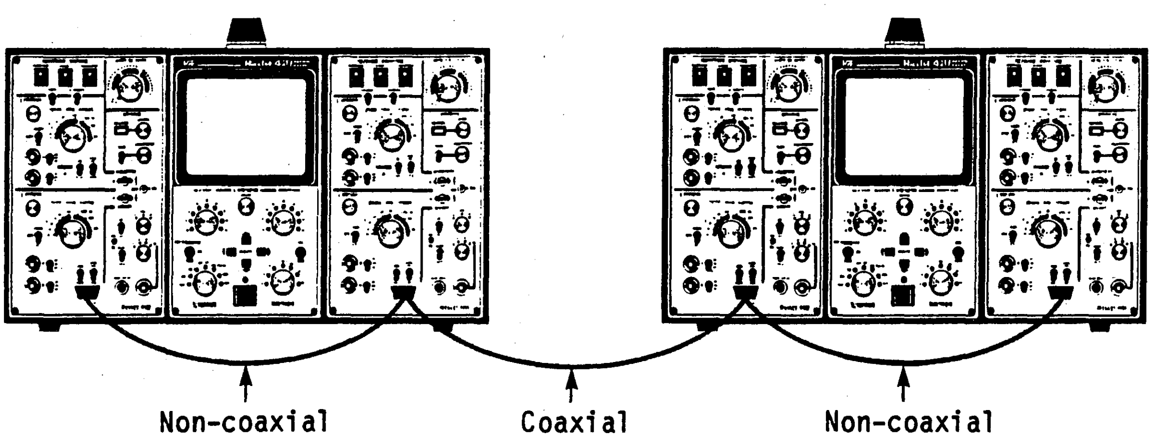


Figure 10-6

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 interchange-able 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 internal metal shielding.

IMPORTANT: Both plug-ins must be armed and waiting for a valid trigger for the master/slave feature to operate properly. If the master plug-in receives a trigger before the slave plug-in is armed, the slave plug-in will either miss the trigger or not trigger at all. Always use the fastest plug-in as the master.

Operation Rules

#1. Any plug-in may be designated the master by turning the SOURCE switch to A, B, or EXT.

#2. Slave plug-ins must have SOURCE switched to "S".

#3. After all plug-ins are correctly configured, press the the LIVE button (on any plug-in) and hold for 2 seconds. Pressing LIVE allows each plug-in to determine the configuration of the connected plug-ins.

#4. Multiple masters are allowed. Each master plug-in controls all slaves to the right, up to the next master (Figure 10-7).

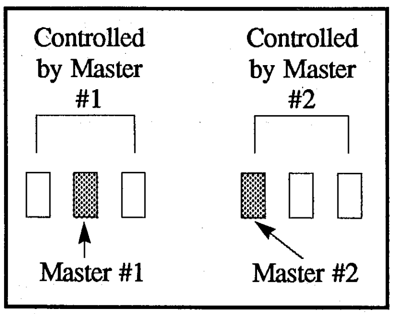


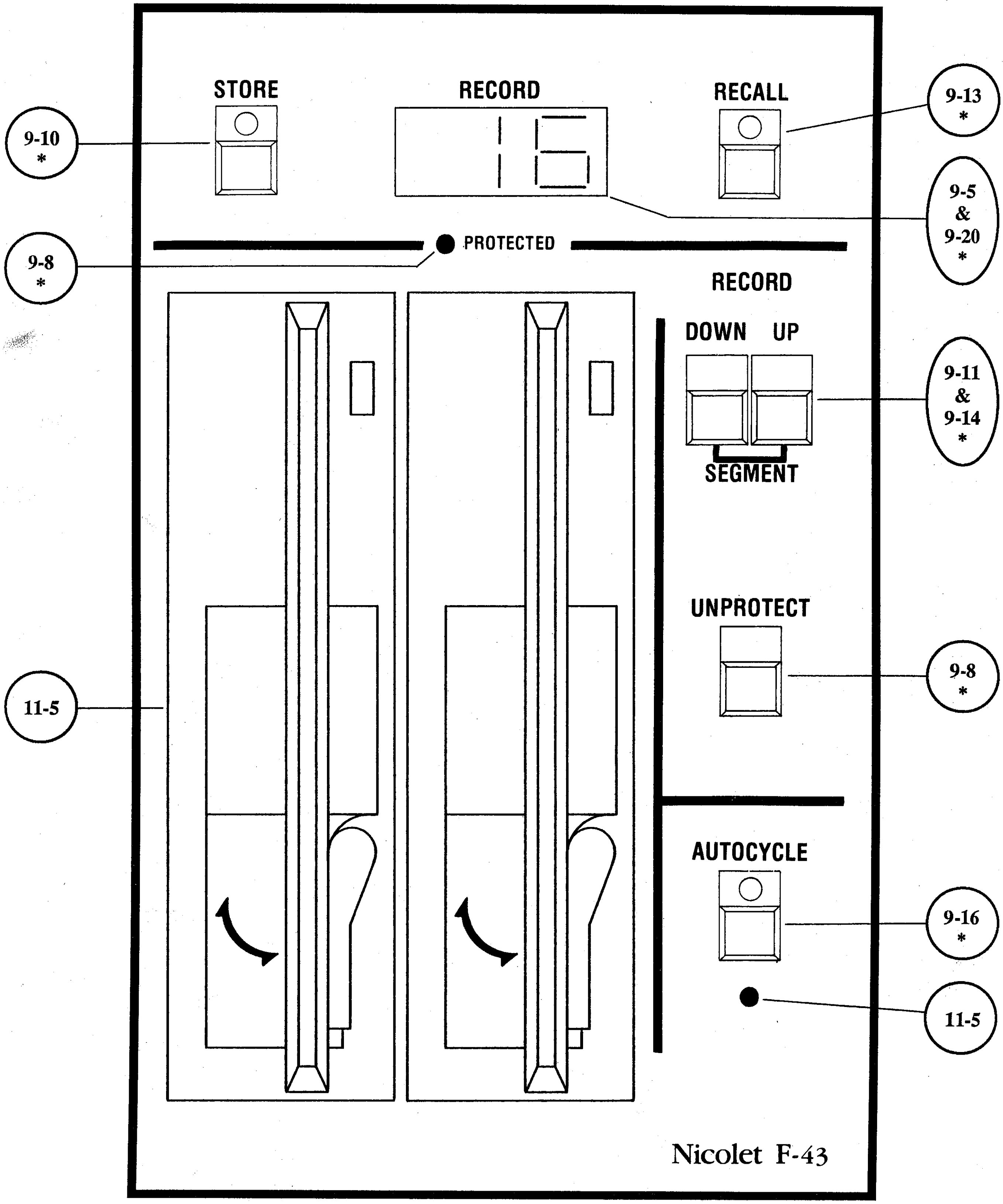
Figure 10-7

#5. Master/Slave AUTOCYCLE is allowed but the maximum repetition rate is limited. If high frequency triggering is input to the master (with all disk recorders in AUTO-CYCLE) the master and slave plug-ins will get out of synchronization due to differences in recording time. Capturing transients while in AUTOCYCLE will work well if the time between triggers is greater than the recording time of the slowest disk recorder.

#6. The trigger circuitry of the master is not affected by data gathering. Anytime the trigger circuitry of the master detects a trigger, all slaves are sent the signal. If the master is set for a slower TIME PER POINT than the slaves, the master/slave combination may appear to get out of synchronization if rapid triggers are sent to the master.

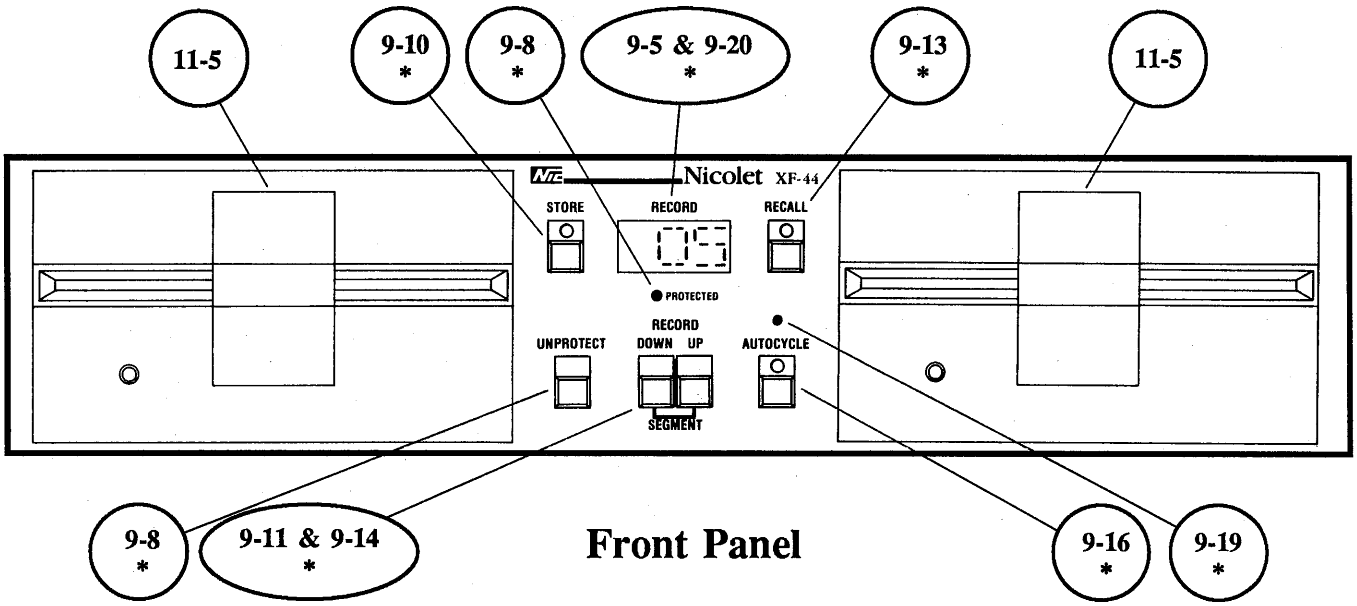
#7. Multiple 4094 oscilloscopes operating together should be plugged into the same power bus. Ground loops can cause erratic behavior if the inter-connected 4094's have different ground voltages.

F-43/2 DISK RECORDER

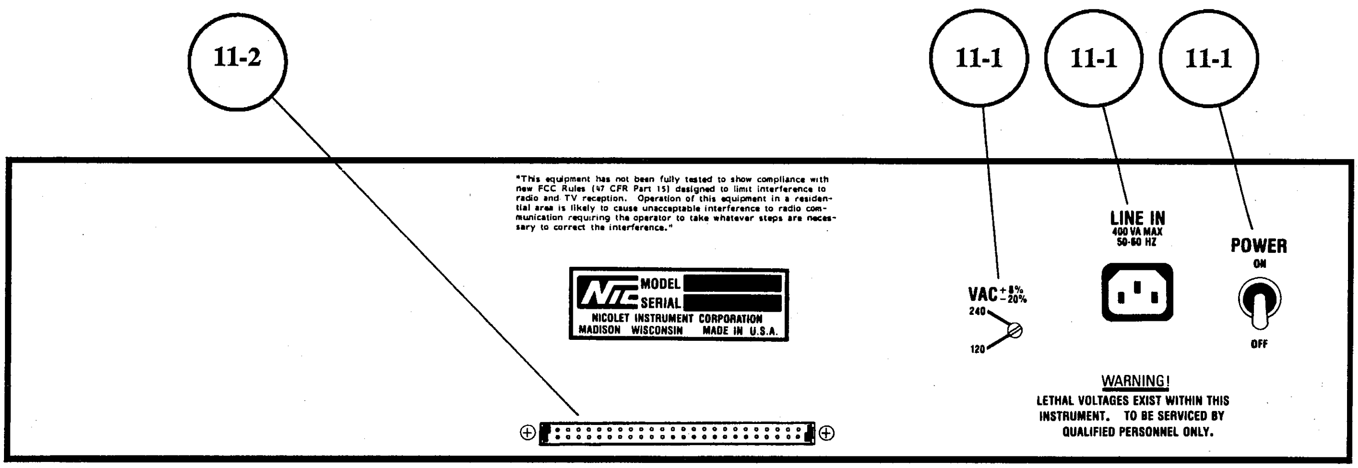


(*) Refer to Tab 9 (Disk Recorder) for description of operation.

XF-44/2 DISK RECORDER



Front Panel



Rear Panel

(*) Refer to Tab 9 (Disk Recorders) for description of operation.

INTRODUCTION

The optional Nicolet F-43/2 and XF-44/2 Dual Disk Recorders are used to record signals captured by the Model 4094 digital oscilloscopes. An important feature of the Dual Disk Recorders is their ability to copy data from one diskette onto another.

The basic operation of the dual disk recorders is essentially identical to that of the F-43/1 and XF-44/1 disk recorders described under tab 9, Disk Recorder.

NOTE: The left-hand drive will be referred to as **DRIVE 0** and the right-hand drive as **DRIVE 1**.

NOTE: The term "Hold Mode" will be used to indicate that the plug-in has exited the Live mode (HOLD LAST LED on, LIVE and HOLD NEXT LEDs off).

> **CAUTION:** To guard against physical damage to the disk heads and/or diskettes, always open the drives' doors when:
> a. Power is off.
> b. Power is applied or removed.
> c. The drive is not being used.
> d. The instrument is being moved.

POWER REQUIRMENTS

A POWER selector is located on the rear panel of the XF-44.

The position of the XF-44's POWER selector must match the setting on the 4094's rear panel voltage selector.

> **CAUTION:** Ensure that the position of the XF-44's POWER selector matches that of the 4094's rear panel voltage selector before applying power to either unit.

For additional information on the POWER selectors, refer to the Power Requirements tab.

The low voltage logic commands between the XF-44 and 4094 are interconnected via the ribbon cable leading between the two instruments. See page 11-2.

The ribbon cable also provides power to a relay inside 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 at the rear of the XF-44 has been provided as a servicing aid. It should always to 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 following the safety rules dictated by their place of employment. Remove all power from the 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. Removing power by any other means may cause erroneous operation.

RIBBON CABLE CONNECTOR

Use the ribbon cable furnished with the XF-44 Disk Recorder and interface the two instruments as illustrated in Figure 11-1.

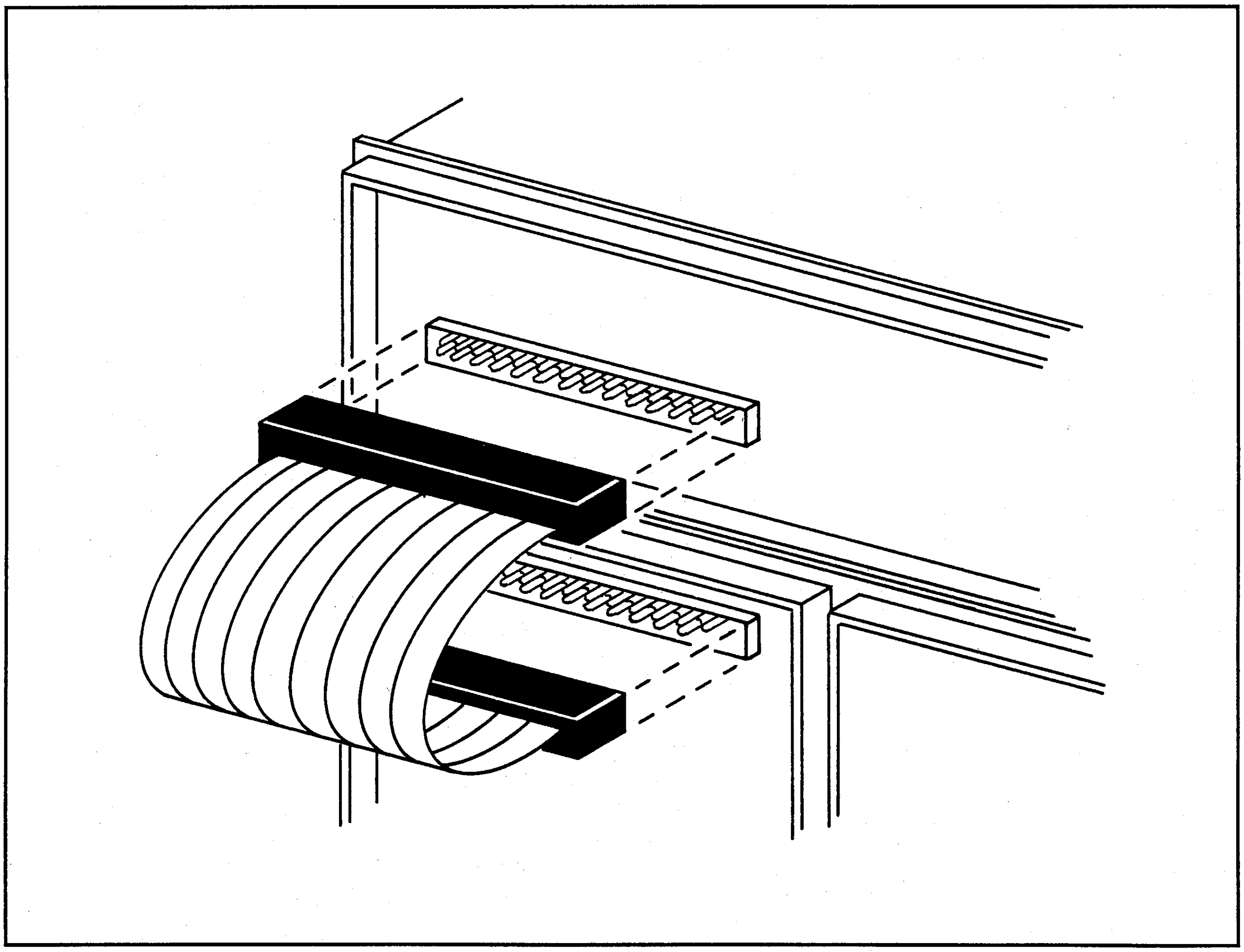


Figure 11-1

LOADING THE DISKETTE(S)

The disk drive(s) energize automatically when the diskette(s) are inserted. Position the diskettes as shown in Figure 11-2.

4094, 4094A, 4094B Only
A Record Number appears on the numerical display if the Series **2090** or **4094** diskettes have been formatted correctly.

4094C Only
A Record Number appears on the numerical display if the Series **4094** diskette has been formatted correctly.

IMPORTANT: The drive's door must be closed within 3 seconds after the diskette has been inserted, or the disk recorder will not recognize the presence of the diskette.

Table 11-1 tabulates which Record Numbers will be displayed corresponding to the type of diskette being used and into which disk drive it is inserted.

NOTE: When loading two diskettes into an F-43/2 or XF-44/2, load one at a time and observe the numerical display for a confirming Record Number before loading the second one. If a Record Number does not appear, the diskette must be formatted.

Type of Diskette	Drive 0	Drive 1
2090 *	1 - 8	1_1 - 1_8
4094	01 - 20	101 - 120

Table 11-1

* Series **2090** diskettes can be used with the Model 4094, 4094A, and 4094B oscilloscopes only.

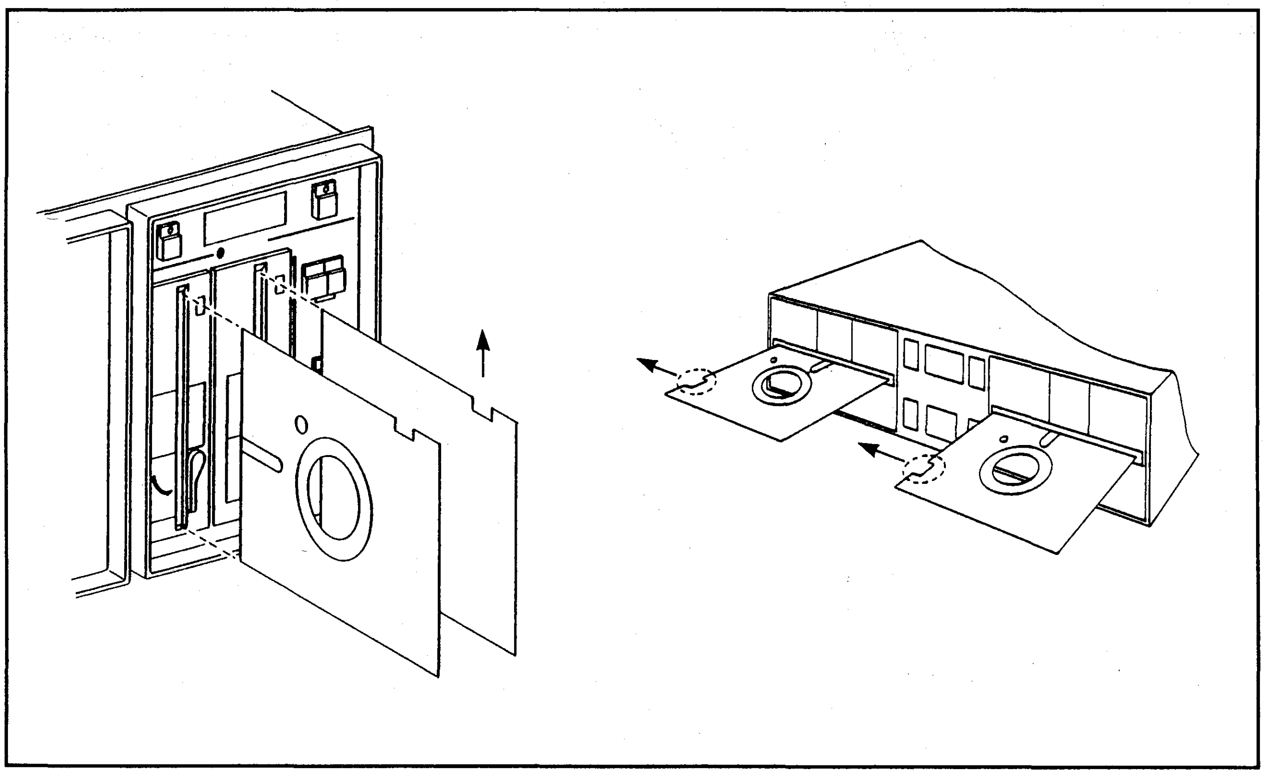


Figure 11-2

NUMERICS DISPLAY

The Numerics Display will display the Record Numbers in the following manner according to the type of diskette being used and into which drive the diskette is placed.

4094, 4094A, 4094B Only	
2090 DISKETTE	
Drive 0:	Records 1 - 8
Drive 1:	Records 1_1 - 1_8

All Models	
4094 DISKETTE	
Drive 0:	Records 01 - 20
Drive 1:	Records 101 - 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 main-frame display memory to the XF-44 for storage on the diskette(s).

AUTOCYCLING THE DISKETTES

The F-43/2 and XF-44/2 can operate as either a single or dual disk drive when using the Auto-cycle 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 not 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, or 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 dual disk drive recorders.

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 one.

Arming the Format Routine

The Format routine is armed by pressing the FORMAT button (accessed via the hole adjacent to the AUTOCYCLE button) with a small diameter instrument. When the word "For" appears on the numerical display, press the STORE button to initiate the Format routine.

NOTE: The Format routine is unarmed automatically 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.

Exiting the Format Routine

Pressing the FORMAT button a second time exits the Format routine.

Errors

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 oprational and the diskette is question cannot be formatted after a second attempt.

COPYING DISKETTES

The dual disk drives allow data to be duplicated from one diskette to another when used in conjunction with the DISKETTE COPY program. See Disk Program tab.

The entire diskette must be copied; individual records cannot be selected for duplication.

Copying Procedure

#1. Insert the Program Diskette into either of the two drives.
   a. A letter "P" and program "number" appear on the the numerical display (e.g., P01, P14, etc.).

#2. Press the UP/DOWN buttons until "PO1" appears on the numerical display.

#3. Press the RECALL button.
   a. The phrase PROGRAM "CATALOG" appears on the status line at the top of the display screen.

#4. Place the FUNCTION switch to "PRGM".

#5. Press the EXECUTE button.
   a. The Catalog Program becomes resident in the Program Memory.

#6. Press the CURSOR UP/DOWN button until the desired Program and Program Number appears on the status line. The Program Number will also appear on the numerical display.

#7. Press the EXECUTE button.
   a. The Catalog Program exits the Program Memory.

#8. Press the RECALL button.
   a. The selected Program becomes resident in the Program Memory.

#9. Remove the Program Diskette.

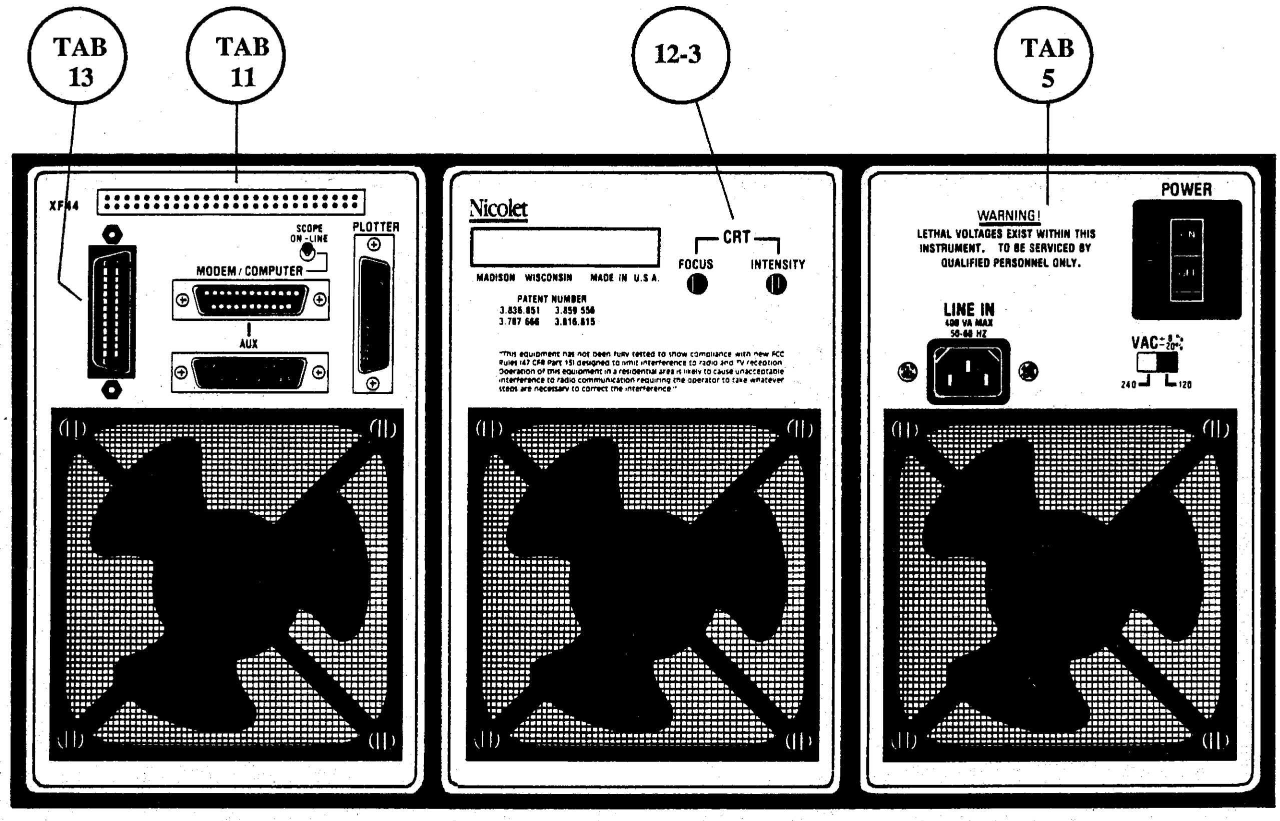
#10. Insert the master diskette (diskette that is to be copied) into DRIVE 0.

#11. Insert the diskette that is to copy the master diskette into DRIVE 1.

#12. Press the EXECUTE button.
   a. The data stored on the master diskette is duplicated on the blank diskette.

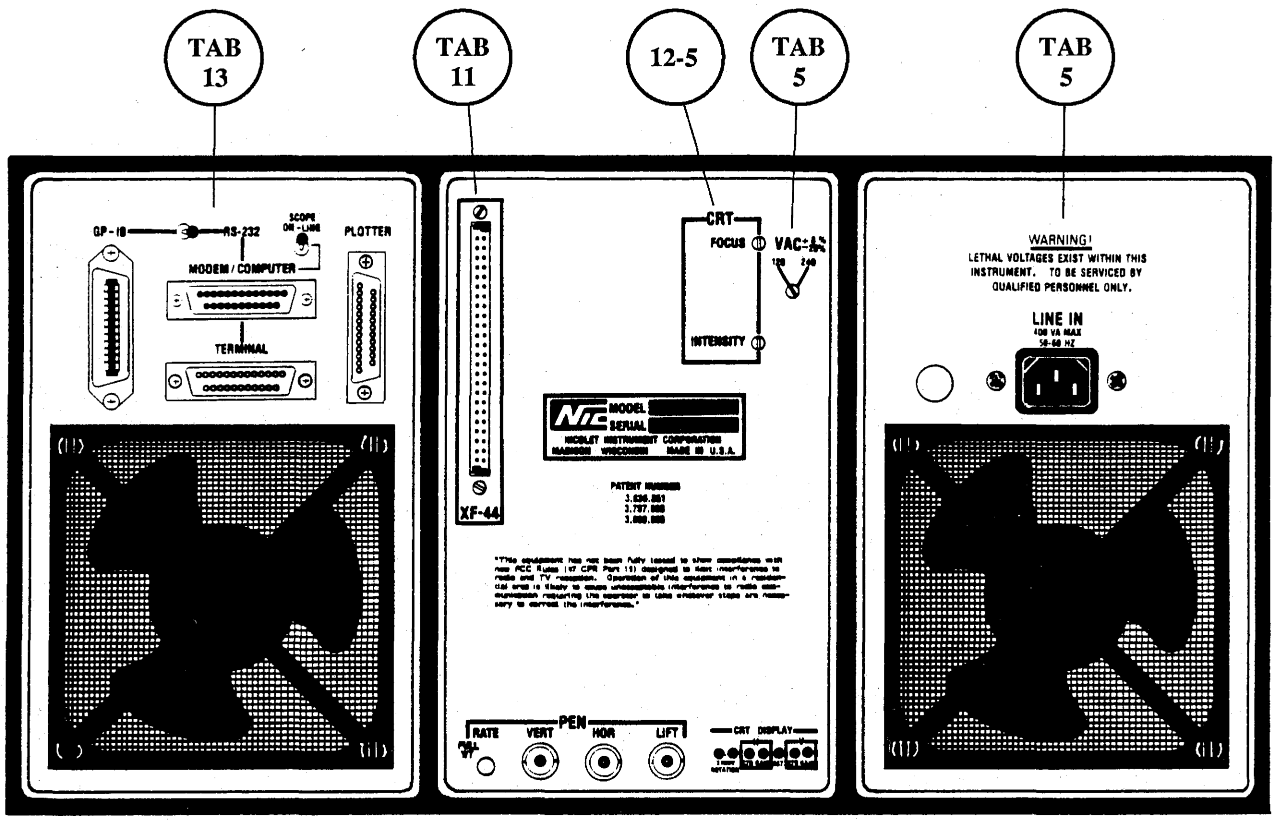
IMPORTANT: The DISKETTE COPY program will remain resident in the Program Memory until either power is removed from the 4094 or the Program is replaced by a different program.

BACK PANEL (4094C)



Refer to the reverse of this page for the 4094A and 4094B.

BACK PANEL (4094A & 4094B)



INTRODUCTION

This section of the manual primarily deals with the CRT display alignment controls and recommended procedures.

NOTE: The 4094C CRT display alignment controls are included in this section, even though most of them have been removed from the rear panel and are now located under the left hand (first bay) cover.

The remaining controls have been described in other sections of this manual.

4094A & 4094B Only

The mainframe back panel contains an XF-44 interface connector, power selector switch, controls for an XY or YT pen recorder, and controls to adjust the CRT display.

The right hand rear panel (bay #3) contains the interface controls.

4094C Only

The mainframe back panel contains the CRT Focus and Intensity controls.

The right hand rear panel (bay #3) contains the interface controls.

The left hand rear panel (bay #1) contains the power controls.

DISPLAY ADJUSTMENTS

Figure 12-1 summarizes the function of each CRT display adjustment control for the 4094C. Refer to pages 12-4 and 12-5 for the 4094A and 4094B oscilloscopes. The following alignment procedure should be followed when aligning the CRT display.

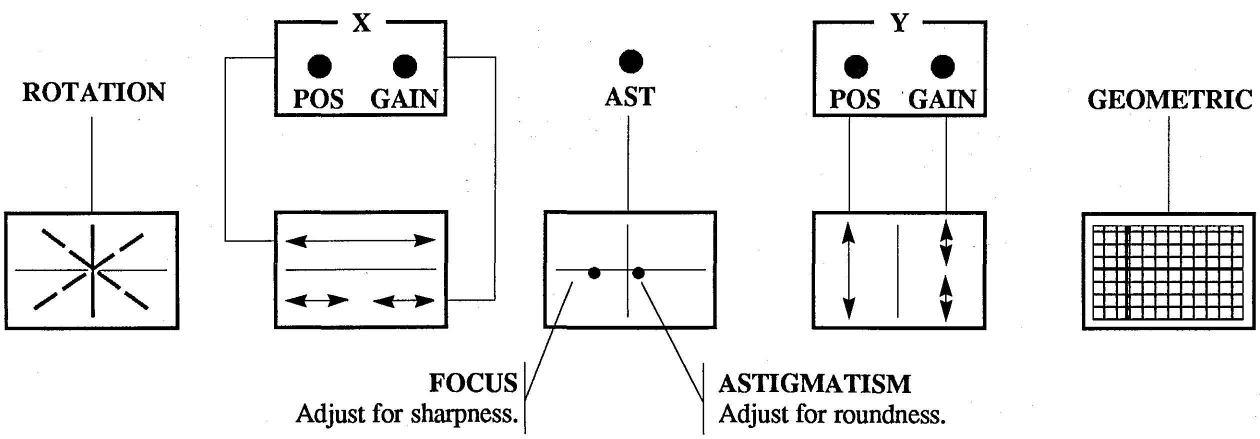
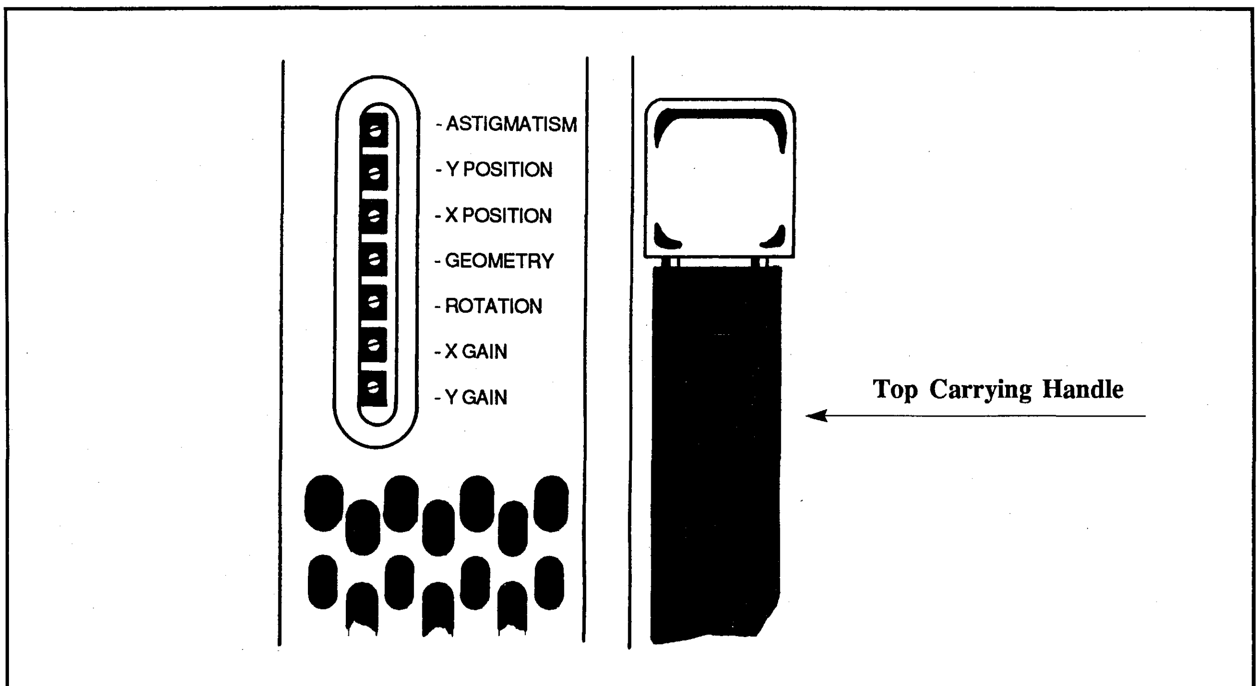


Figure 12-1



4094C CRT Display Alignment Controls
(located under first bay top cover)

Figure 12-2

DISPLAY ALIGNMENT

The CRT display alignment controls are accessed by removing the left hand (first bay) side cover. The adjustment pots are located above the CRT, towards the rear of the 4094C.

Alignment Procedure

It is recommended that the alignment procedure be followed in the sequence listed and perform the alignment only when necessary.

#1. Ground all input BNC's.

#2. Select Auto triggering.

#3. Place the plug-in into the LIVE mode.

#4. Select x2 horizontal and vertical expansion.

#5. **ROTATION:** Pivots the entire display about screen center.
  a. Adjust until the vertical cursor is parallel with the side of the screen.

#6. **X-POSITION:**
Positions the display either left or right.
  a. Adjust until the horizontal cursor is evenly centered on the screen.

#7. **X-GAIN:**
Expands or contracts the entire display.
  a. Adjust until both ends of the horizontal cursor are approximately 3/16" from the sides of the screen.

#8. **Y-POSITION:**
Positions the display either up or down.
  a. Adjust until the vertical cursor is evenly centered on the screen.

#9. **Y-GAIN:**
Expands or contracts the entire display.
  a. Adjust until the vertical cursor is approximately 1/8" from the bottom of the screen.

#10. Repeat steps #8 and #9 until the vertical cursor is approximately 1/4" from the bottom of the screen.

#11. Increase the Horizontal Expansion setting until individual data points can be easily discerned.

#12. Turn on the Autocenter mode.

#13. **ASTIGMATISM:**
Adjusts for round data points.
  a. Adjust until the data point at screen center is round.

#14. **GEOMETRIC:**
This control clears up any geometric distortion, it rarely needs to be used.
  a. Place the display into the GRID mode and observe the display. If no distortion is visible, leave the adjustment alone.

#15. **FOCUS:**
Located on the rear panel. 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:**
Located on the rear panel. Brightens or darkens the display. This control may be adjusted to obtain optimum results when photographing the display.

DISPLAY ADJUSTMENTS

Figure 12-2 summarizes the function of each CRT display adjustment control for the 4094A and 4094B. Refer to pages 12-2 and 12-3 for the 4094C oscilloscope. The following alignment procedure should be followed when aligning the CRT display.

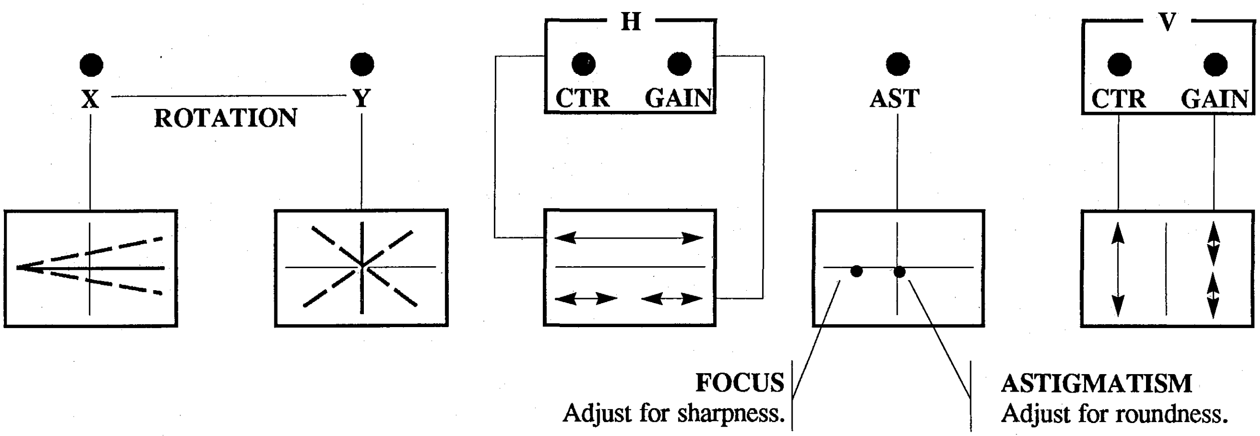


Figure 12-2

DISPLAY ALIGNMENT

The CRT display alignment controls are accessible from the rear panel of the mainframe.

Alignment Procedure

It is recommended that thealignment procedure be followed in the sequence listed and perform the alignment only when necessary.

#1. Ground all input BNC's.

#2. Select Auto triggering.

#3. Place the plug-in into the LIVE mode.

#4. Select x2 horizontal and vertical expansion.

#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:** Pivots the entire display about screen center.
   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 the 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.

#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 setting until individual data points can be easily discerned.

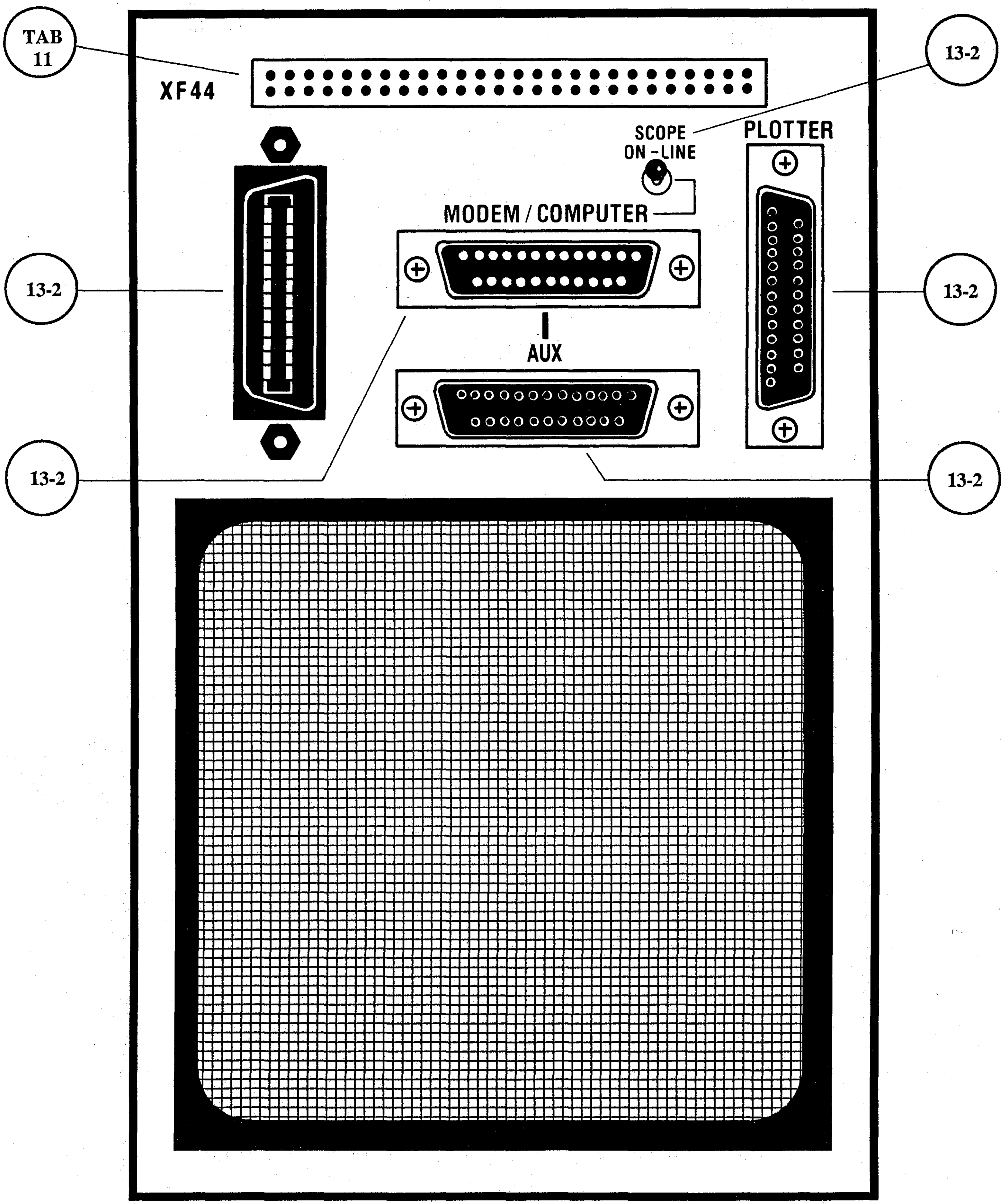
#13. Turn on the Autocenter mode.

#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.

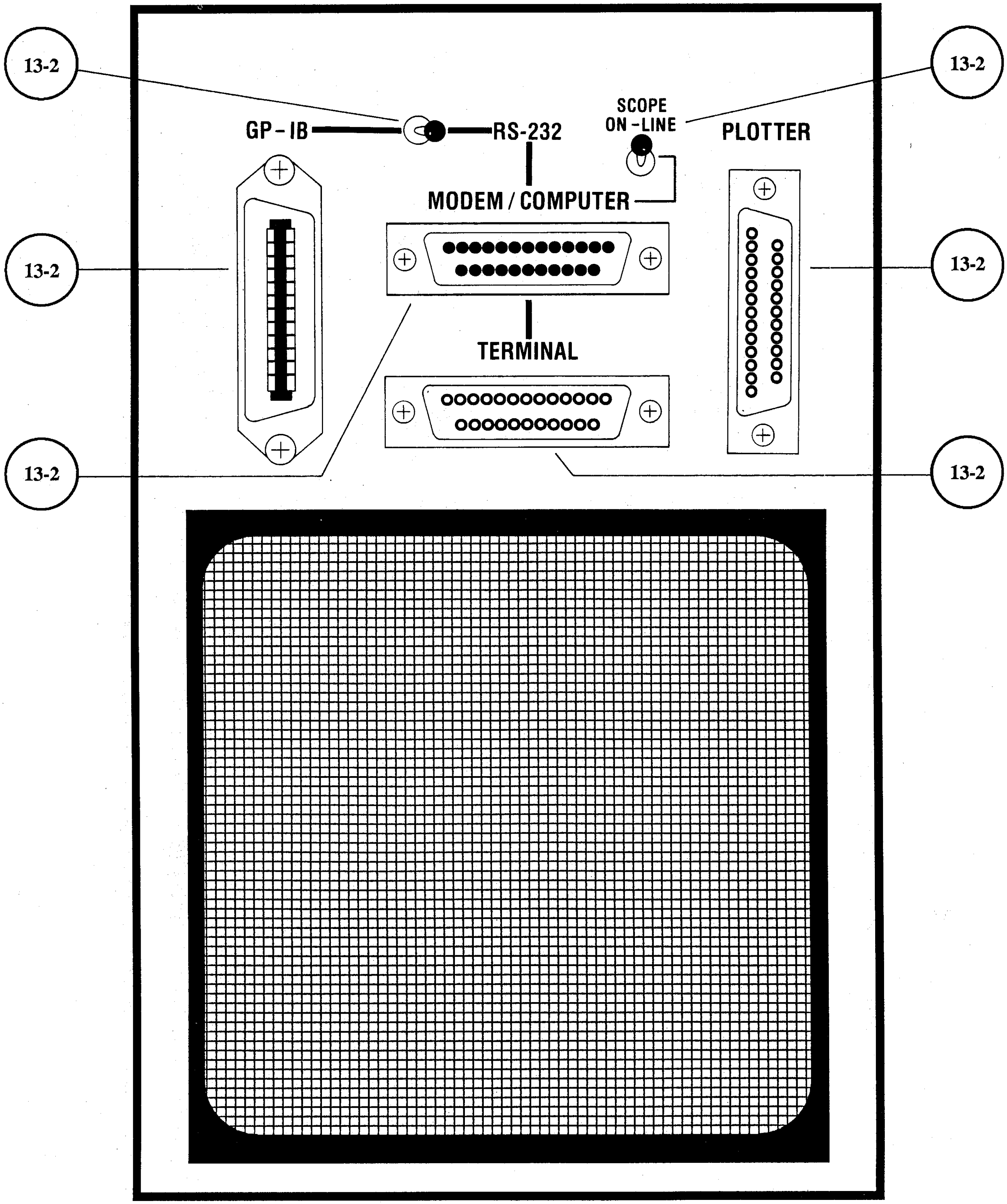
#16. **INTENSITY:** Brightens or darkens the display. This control may be adjusted to obtain optimum results when photographing the display.

I/O PANEL (4094C)



Refer to the reverse of this page for the 4094A and 4094B.

I/O PANEL (4094A & 4094B)

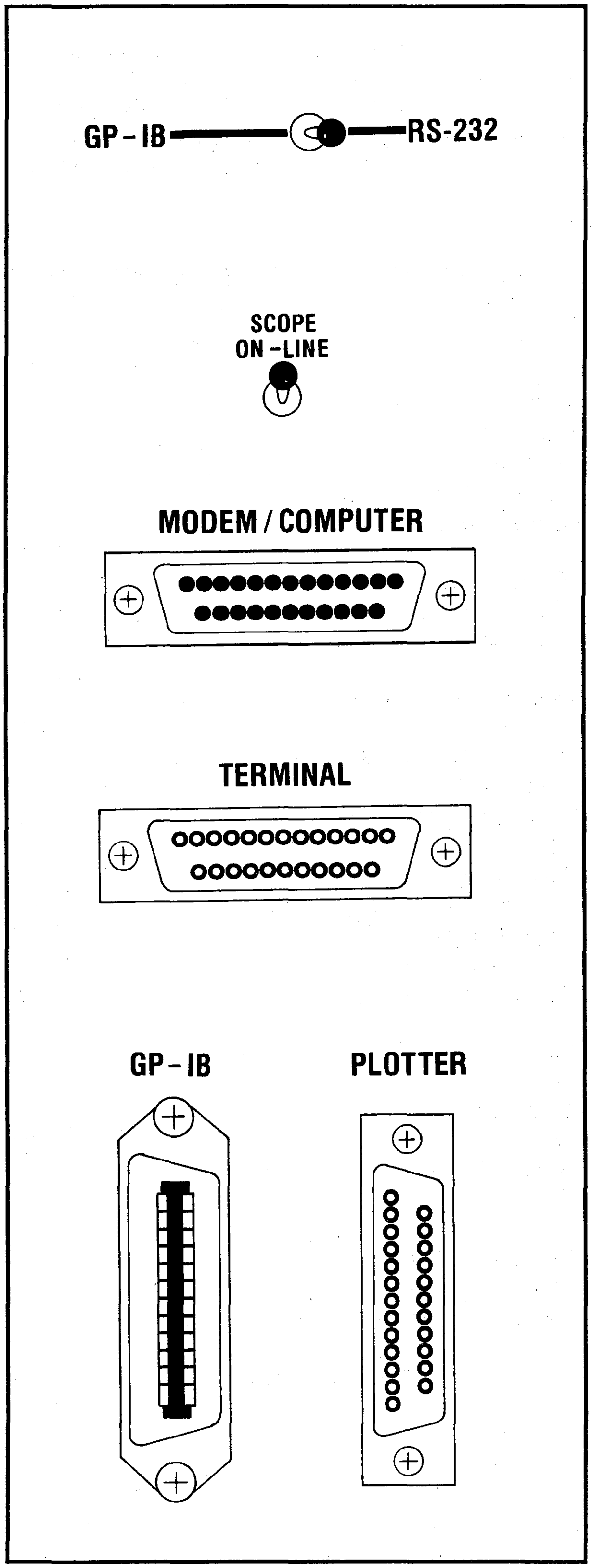


INTRODUCTION

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.

TABLE OF CONTENTS



GPIB/RS-232 SWITCH (4094A & 4094B)

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.

NOTE: The I/O STATUS display is used to select either GPIB or RS-232 on the Model 4094C mainframe, see Tab 7, page 7-27.

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 cannot 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 to the 4094 oscilloscope. Plotters must have an RS232 interface and use HPGL language (Hewlett Packard Graphics Language).

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 communications 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 FREQUENCY: 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), first established in 1975, has been widely accepted as an interfacing standard. Many GPIB compatible measuring instruments and computers are available today.

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 rates.

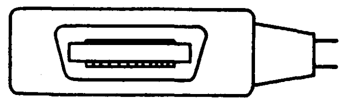
Standard GPIB Cable and Connector	D8 pin 16 (MSB) D7 pin 15 D6 pin 14 Bidirectional D5 pin 13 Data Lines D4 pin 4 D3 pin 3 D2 pin 2 D1 pin 1 (LSB)
	NDAC pin 8 Data Transfer NRFD pin 7 Control Lines
Pins 12, and 18 through 24 are at ground potential.	ATN pin 11 IFC pin 9 General Control SRQ pin 10 Lines REN pin 17 EOI pin 5

Figure 13-1

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 13-8).

The actual computer statement used to send out each "clear" command should be listed in the computer manual.

IMPORTANT: Any "clear" command sent to the 4094 should be followed by a WAIT statement (80 mS) to allow the internal microprocessor to reset the interface.

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.

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.

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.

4094A & 4094B Only

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 (page 13-8) ties together DIP switch settings, GPIB address, listen address, and talk address.

4094C Only

The 4094C uses the I/O Status display to set the GPIB address, rather than using the DIP switch as required by the 4094A and B. Refer to Section 7, page 7-27.

Many computers simplify programing by allowing the programmer to refer to a single GPIB address. The computer will correcly 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.

4094A & 4904B Only

Table 13-1 (page 13-8) 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.

IEEE-488/GPIB FUNCTION SUBSETS

SH1: Source Handshake, complete capability.

T8: Basic Talker and Unaddress if MLA.

L4: Basic Listener and 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.

NOTE: Turn the oscilloscope off before setting the dip switch.

DIP SWITCH					GPIB ADDRESS		LISTEN ADDRESS		TALK ADDRESS	
Sw1B	Sw2B	Sw3B	Sw4B	Sw5B	Decimal	Octal	Decimal	ASCII	Decimal	ASCII
CLOSE	CLOSE	CLOSE	CLOSE	CLOSE	0	0	32	space	64	@
CLOSE	CLOSE	CLOSE	CLOSE	OPEN	1	1	33	!	65	A
CLOSE	CLOSE	CLOSE	OPEN	CLOSE	2	2	34	"	66	B
CLOSE	CLOSE	CLOSE	OPEN	OPEN	3	3	35	#	67	C
CLOSE	CLOSE	OPEN	CLOSE	CLOSE	4	4	36	$	68	D
CLOSE	CLOSE	OPEN	CLOSE	OPEN	5	5	37	%	69	E
CLOSE	CLOSE	OPEN	OPEN	CLOSE	6	6	38	&	70	F
CLOSE	CLOSE	OPEN	OPEN	OPEN	7	7	39	'	71	G
CLOSE	OPEN	CLOSE	CLOSE	CLOSE	8	10	40	(	72	H
CLOSE	OPEN	CLOSE	CLOSE	OPEN	9	11	41	)	73	I
CLOSE	OPEN	CLOSE	OPEN	CLOSE	10	12	42	*	74	J
CLOSE	OPEN	CLOSE	OPEN	OPEN	11	13	43	+	75	K
CLOSE	OPEN	OPEN	CLOSE	CLOSE	12	14	44	,	76	L
CLOSE	OPEN	OPEN	CLOSE	OPEN	13	15	45	-	77	M
CLOSE	OPEN	OPEN	OPEN	CLOSE	14	16	46	.	78	M
CLOSE	OPEN	OPEN	OPEN	OPEN	15	17	47	/	79	O
OPEN	CLOSE	CLOSE	CLOSE	CLOSE	16	20	48	0	80	P
OPEN	CLOSE	CLOSE	CLOSE	OPEN	17	21	49	1	81	Q
OPEN	CLOSE	CLOSE	OPEN	CLOSE	18	22	50	2	82	R
OPEN	CLOSE	CLOSE	OPEN	OPEN	19	23	51	3	83	S
OPEN	CLOSE	OPEN	CLOSE	CLOSE	20	24	52	4	84	T
OPEN	CLOSE	OPEN	CLOSE	OPEN	21	25	53	5	85	U
OPEN	CLOSE	OPEN	OPEN	CLOSE	22	26	54	6	86	V
OPEN	CLOSE	OPEN	OPEN	OPEN	23	27	55	7	87	W
OPEN	OPEN	CLOSE	CLOSE	CLOSE	24	30	56	8	88	X
OPEN	OPEN	CLOSE	CLOSE	OPEN	25	31	57	9	89	Y
OPEN	OPEN	CLOSE	OPEN	CLOSE	26	32	58	:	90	Z
OPEN	OPEN	CLOSE	OPEN	OPEN	27	33	59	;	91	[
OPEN	OPEN	OPEN	CLOSE	CLOSE	28	34	60	<	92	\
OPEN	OPEN	OPEN	CLOSE	OPEN	29	35	61	=	93	]
OPEN	OPEN	OPEN	OPEN	CLOSE	30	36	62	>	94	^
OPEN	OPEN	OPEN	OPEN	OPEN	DO NOT USE		DO NOT USE		DO NOT USE	
Unlisten/Untalk							63	?	95	_

Table 13-1

GENERAL OVERVIEW - RS-232C

The Electronic Industries Association (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.

PHYSICAL LIMITATIONS

#1. The maximum transmission distance is unlimited if telephone lines are utilized. Direct cable linkups 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 19,200 baud.

RS-232 LINE EXPLANATIONS

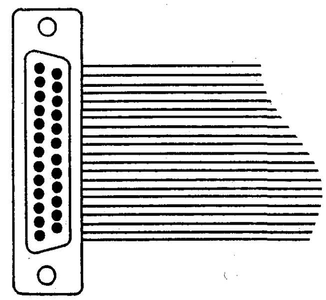
The following are explanations of the RS-232C Lines as they relate to the Nicolet Model 4094 Digital Oscilloscope.

#1. Protective Ground

#2. TDATA: Transmitted Data
Path for outgoing data.

#3. RDATA: Received Data
Path for incoming data.

STANDARD RS-232C CABLE & CONNECTOR



Line 2 - TDATA
Line 3 - RDATA
Line 4 - RTS
Line 5 - CTS
Line 6 - DSR
Line 7 - GND
Line 8 - CD
Line 20 - DTR

Figure 13-2

#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	Ø

Table 13-2

START-UP PROCEDURE

The 4094's baud rate, parity, and number of stop bits must be set to match that of the connected device.

Factory settings are as follows:
a. 300 baud (4094A & B)
   9600 baud (4094C only)
b. no parity check (all models)
c. one stop bit (all models)

4094C Only
Select RS-232 and set the baud rate, parity check, and number of stop bits on the 4094C using the I/O STATUS display (refer to tab 7, page 7-27) and then go to step #4 on page 13-11.

4094A & 4094B Only
Perform steps 1 - 3 to set the baud rate, parity check, and number of stop bits and then continue with step #4.

RS-232C SWITCH

1	2	3	4	5	6	7	8

1 = Baud Rate (BPS)
2 = Baud Rate (BPS)
3 = Baud Rate (BPS)
4 = Baud Rate (BPS)

5 = Plotter Baud Rate
(not discussed here)

6 = Odd/Even Parity

7 = Parity ON/OFF

8 = Stop Bits

Figure 13-3

The above settings may be changed with the 8 segment DIP switch located on the large circuit board visible when the 4094A or B right side cover is removed. After turning the oscilloscope OFF, remove the right side cover and use the following information to set the switch

#1. Set the baud rate (bits per of the connected device as tabulated second) to match the baud rate in the 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 (use only 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

Switch 8	
Open	Two Stop Bits
Closed	One Stop Bit

Table 13-6

Baud Rate	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

#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.

NOTE: Replace the side cover after setting switches 1 through 8.

#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 (4094A & 4094B) or AUX (4094C) connector is unaffected by this switch.

4094A & 4094B Only

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.

4094A & 4094B Only

The TERMINAL connector allows both the 4094 and a computer terminal to communicate with 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.

4094C Only

The AUX connector on the 4094C is for factory use only.

Direct connection of the MODEM/ COMPUTER port to computer terminals, teletypes, and nonterminal 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 (page 13-12).

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.

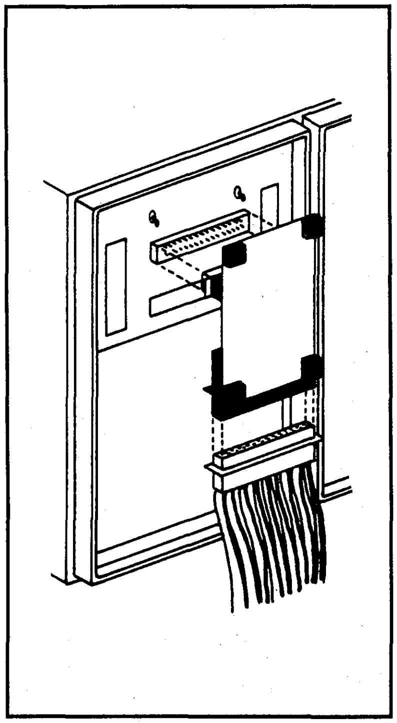


Figure 13-4

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.

The 4094A and 4094B require two ASCII characters (the 4094C requires only one) 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.

4094A, 4094B & 4094C

Character 1 - SOH (CNTL A, two keys pressed simultaneously).

4094A & 4094B Only

Character 2 - RS-232C address (see Table 13-7, page 13-13).

4094A & 4094B Only

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 the Table 13-7 (page 13-13) 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 on the 4094A and 4094B.

SOH is enough on the 4094C. Only one character is required.

NOTE: SOH and the address will not be displayed on the 4094 screen.

NOTE: See Table 13-1, page 13-8 and 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 **Q**, DC3 will appear as **S**.

#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.

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

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 page 13-32.

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.

Basic Interface Commands	Page
Input/Output Data	
W - Waveform Parameters	13-15
D - Data I/O	13-16
Input/Output Normalization Data	
N - Normalization I/O	13-20
Disk Recorder Operation	
S - Store on Disk	13-25
R - Recall from Disk	13-26
U - Unprotect Disk	13-27
A - Autocycle to Disk	13-28
Waveform Acquisition	
H - Live, Hold Next	13-29
Display Titling	
T - Title I/O	13-30

Basic Interface Commands	Page
Status	
L - Live and Disk Status	13-31
Delimiters/Control Characters	
C - Change Deliminters/Control	13-32
Beep	
B - Audio Beep	13-33
RS-232C Deactivate	
Q - Deactivate Interface	13-33
Error Code Numbers	13-34
Advanced Interfacing Commands	13-35

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 (pages 13-16 and 13-20, respectively) cover the uses of the waveform specifications.

Transmission Sequence:

#1. 4094 input
  W
  Command del. (page 13-32),

#2. 4094 output
  Error code for command (00-31).
  Error delimiter (page 13-32).

#3. 4094 output
  a. Total number of waveforms (01-32).
  Record sep. (page 13-32).

  b. End of File delimiter (page 13-32).

#4. 4094 output
  a. Waveform number (01-32).
  Record sep. (page 13-58).

  b. Number of data points (+b0496 to +15872).
  Record sep. (page 13-58).

  NOTE: b = space

  c. Normalizing set number (00-31).
  Record sep. (page 13-32).

  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 13-32).

  e. Channel number (see Table 13-8).
  Record sep. (page 13-32).

  f. Retain reference (1 = RR on, 0 = RR off).
  Record sep. (page 13-32).

  g. Title number (see Table 13-9).
  Record sep. (page 13-32).

  NOTE: The title number also represents the memory group in which the data is stored: i.e., Q1, H2, etc.

  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 #3a gives the total number of waveforms.

#5. 4094 output.
  Error code (00-31).
  Error delimiter (page 13-58).

Channel #	Input Location	
	Plug-in	Channel
0	1	A
1	1	B
2	2	A
3	2	B

Table 13-8

Title #	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 Number, Starting Point., Total Points, Step
(Any non-numeric character can be used to separate numeric values.)

Purpose:

Initiate data transfers, specify data parameters, and format.

Specifications:

#1. **Data Format**
See Table 13-10.

#2. **Waveform Number**
See **W** command (page 13-15). Use of Waveform Number = 0 will access all of memory rather than individual waveforms.

#3. **Starting Point**
The first data point on the waveform which is to be transferred (0-15871).

#4. **Total Points**
The total number of data points to be transferred from the waveform (1-15872). If Total Points 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.

Mode	Data Format
0	Output in ASCII (Recorder Separator, EOF)
2	Output in printable binary (EOF)
4 (4094A & B)	Output in binary (no Record Separator or EOF) (High byte, low byte)
6 (4094C)	Output in binary (no Record Separator or EOF) (Low byte, high byte)
1	Input in ASCII (Record Separator, EOF)
3	Input in printable binary (EOF)
5 (4094A & B)	Input in binary (No Record Separator or EOF) (High byte, low byte)
7 (4094C)	Input in binary (no Record Separator or EOF) (Low byte, high byte)

Table 13-10

Transmission Sequence

#1. 4094 Input
D, Mode, Waveform Number, Starting Point, Total Points, Step.
Command delimiter (page 13-32).

#2. 4094 Output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 Input or Output
Data values (see Data Formats in next column).
Record separator (page 13-32).

Note: I/O of standard binary data values cannot include record separator delimiters.

#4. 4094 Input or Output
End of File (EOF) delimiter (page 13-32).

Note: I/O of standard binary data values cannot include EOF delimiters.

#5. 4094 Output
Error code for data transmission (00-31).
Error delimiter. (page 13-3).

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, page 13-20). 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.

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 13-53.

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 above indicates the correct sign 1 = negative number, 0 = positive number.

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. See Examples 13-2 and 13-3.

```
(0000100) (4096) + (0000111) (64) + (0001001) = 0000100000111001001
(0001111) (4096) + (0110101) (64) + (0111110) = 0001111110101111110
```

Example 13-1

```
   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.

```
 0001111110101111110
+11110000000000000000 add -65536
 --------------------
 11111111110101111110 = 642
 |__________________|
     20 bit word
```

Example 13-3

D

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 in the order selected by the D command (see page 13-16, Table 13-10) The high byte is places 2^{15} through 2^8 and the low byte is 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).

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 (see Example 13-5).

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 13-7).

Computer word length = 20 bits

1111111100010110 = 4094 data

└──── bit 2^{15}

──── extend sign bits

11111111111100010110

└──── 20 bit word ────┘

Example 13-4

Computer word length = 20 bits

1111111100010110 = - 4094 data

+11110000000000000000 add - 65536

11111111111100010110

└──── 20 bit word ────┘

Example 13-5

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.

Transmission Sequence:

#1. 4094 input
N, Norm. Set No., (Norm. Step required to send normalization to the 4094).
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error del. (page 13-32).

#3. 4094 input or output
a. Waveform validity, (see page 13-21).
Record sep. (page 13-32).

b. Sweep size index, (see page 13-21).
Record sep. (page 13-32).

c. Channel no., (see page 13-22).
Record sep. (page 13-32).

d. Display characters, (see page 13-22).
Record sep. (page 13-32).

e. Vnorm, (see page 13-22).
Record sep. (page 13-32).

f. Hnorm, (see page 13-23).
Record sep. (page 13-32).

g. Vzero, (see page 13-23).
Record sep. (page 13-32).

h. Hzero (upper), (see page 13-23).
Record sep. (page 13-32).

i. Hzero (lower), (see page 13-23).
Record sep. (page 13-32).

j. Reset Norm. Vzero, (see page 13-23).
Record sep. (page 13-32).

k. Reset Norm. Hzero, (see page 13-23).
Record sep. (page 13-32).

l. End of File (EOF) delimiter (page 13-32).

#4. 4094 output
Error code for normalization transmission (00-31).
Error del. (page 13-32)

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 setup mode.
2	Data is derived from trigger VIEW.
3	Data is derived from simultaneous trigger VIEW and Setup mode.
6	Data is derived from the external trigger input while in trigger VIEW.
7	Data is derived from simultaneous Setup mode, trigger VIEW, and external trigger input.

Table 13-11

#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 points/2^{SSI} = points in the 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

N

#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

#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 and 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 13-24 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

#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 13-24 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 13-24 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 13-24 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 waveform. 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.

#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.

N

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.

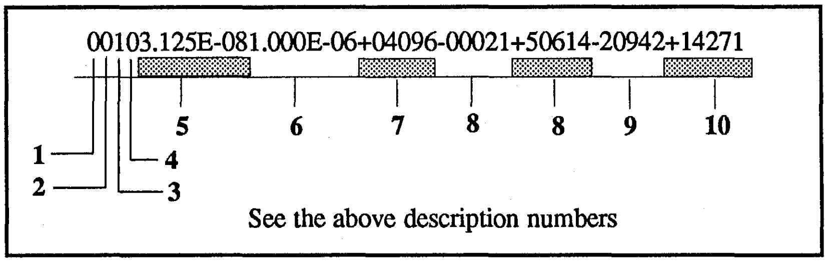
TIME for given data pt. = (Data point location - Total Hzero) Hnorm.

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.



Example 13-8

TIME at point 1063 = $(1063-(65536(-21)+50614))(1 \times 10^{-6})$ Sec.

VOLTAGE at point 1063 = $(422-4096)(3.125 \times 10^{-8})$ Volts

RESET TIME at point 1063 = $(1063-14271)(1 \times 10^{-6})$ Sec.

RESET VOLTAGE at point 1063 = $(422+20942)(3.125 \times 10^{-8})$ Volts

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 Number**
0 = single disk drive or left hand drive on dual disk recorder.
1 = right hand disk drive on dual disk recorder.

#2. **Record Number**
The record number (1-20) on which data is to be 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:

#1. 4094 input
S, Drive number, Record number, Memory Section. Command del. (page 13-32).

#2. 4094 output
Error code for command and disk recorder (00-93).
Error delimiter (page 13-32).

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

DISK RECORDER OPERATION

Command Format:

R, Drive Number, Record Number, 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 Number**
0 = single disk drive or left hand drive on dual disk recorder.
1 = right hand disk drive on dual disk recorder.

#2. **Record Number**
Corresponds to the record number (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 Recorded
0	ALL
1	Q1
2	Q2
3	Q3
4	Q4
5	H1
6	H2

Table 13-15

Transmission Sequence:

#1. 4094 input
R, Drive Number, Record Number, Memory Section.
Command del. (page 13-32).

#2. 4094 output
Error code for command and disk recorder (00-93)
Error delimiter (page 13-32).

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.

DISK RECORDER OPERATION

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 Number**
0 = single disk drive or left hand drive on dual disk recorder.
1 = right hand drive on dual disk recorder.

#2. **Record Number**
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:

#1. 4094 input
U, Drive No., Record No., Memory Section.
Command del. (page 13-32).

#2. 4094 output
Error code for command and disk recorder (00-93).
Error delimiter (page 13-32).

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

DISK RECORDER OPERATION

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 AUTO-CYCLE mode of operation.

Specifications:

#1. **Drive Number**
0 = single disk drive or left hand drive on dual disk recorder.
1 = right hand drive on dual disk recorder.

#2. **Recorder Number**
The record number (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:

#1. 4094 input
Z1
Command del. (page 13-32)

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).
Z1 is used to turn on computer control. This is required before the autocycle command can be used. Z1 is covered under Advanced Interfacing Commands, beginning on page 13-35.

#3. 4094 input
A, Drive No., Record No., Memory Section.
Command del. (page 13-32).

#4. 4094 output
Error code for command and disk recorder (00-93).
Error delimiter (page 13-32).

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.

#5. 4094 input
ZØ
Command del. (page 13-32).

#6. 4094 output
Error code for command (00-31)
Error delimiter (page 13-32).
ZØ is used to turn off computer control.

WAVEFORM ACQUISITON

Command Format:

H, Mode, Plug-in Number (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 Number**
0 = all plug-ins,
1 = plug-in on left,
2 = plug-in on right.

Transmission Sequence:

#1. 4094 input
Z1
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).
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 (page 13-35).

#3. 4094 input
H, Mode, Plug-in Number
Command delimiter (see page 13-32).

#4. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#5. 4094 input
ZØ
Command del. (page 13-32).

#6. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).
ZØ is used to turn off Computer Control.

T

DISPLAY TITLING

Command Format:

T, I/O, Title Number (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.

IMPORTANT: Turn the FUNCTION switch away from the PRGM position when outputting or inputting titles. (They are not visible because the title line is used for disk loaded programs when the switch is in the PRGM position.

Specifications:

#1. **I/O**
Indicates the direction of title transfer.

I/O	Direction
0	4094 output
1	4094 input

Table 13-20

#2. **Title Number**
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

Transmission Sequence:

#1. 4094 input
T, I/O, Title No.
Command delimiter (see page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 input or output
32 character title.
End of File (EOF) delimiter (page 13-32).

#4. 4094 output
Error code for title (00-31).
Error delimiter (page 13-32).

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 = A). See Table 13-37, page 13-54.

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.

STATUS

Command Format:

L, Status Number

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 wave-form 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 Number**
Specifies the information to be returned by the 4094.

Status No.	Status Returned
0	LIVE status: 0 = All plug-ins in HOLD LAST. 1 = At least one plug-in is 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

Transmission Sequence:

#1. 4094 input
L, Status Number
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 output
LIVE status (0 or 1).
Record sep. (page 13-32).
End Of File. (page 13-32).
(Command **L,Ø** results in transmission #3.)

#4. a. LIVE status (0 or 1).
Record sep. (page 13-32).

b. Drive 0 diskette status (0-4).
Record sep. (page 13-32).

c. Drive 1 diskette status (0-4).
Record sep. (page 13-32).

d. End Of File (EOF) delimiter, (page 13-32).
(Command **L,1** results in transmission 4 only.)

#5. Error code for status transmission.
Error delimiter (page 13-32).

C

DELIMITER/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 13-53.

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.

Transmission Sequence:

#1. 4094 input
C, Address, Character.
Command del. (page 13-32)

OR

C, Address, Count,
Character 1, Character 2,
Character 3
Command del. (page 13-32)

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32)

4094C Only

For 4094C models with disk drives, the error codes (other than 00) appear on the disk LED display.

Address	Control Function	Default Character	Maximum Number of Characters
0	End of File (EOF) delimiter (*)	No EOF	3
4	Record Separator delimter	No Record separator	3
8	Error delimiter	Carriage 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 millisecond	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 13-8)	1 number (000-127)

Table 13-24

BEEP

Command Format:

B

Purpose:

Causes the 4094 to make one audio frequency beep.

Transmission Sequence:

#1. 4094 input
B
Command del. (page 13-32).

#2. 4094 output
Error code for commands (00-31).
Error delimiter (page 13-32).

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:

#1. 4094 input
Q
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

ERROR CODE NUMBERS

NOTE: Disk recorder error numbers are located under Tab 9.

Note 1: For Error Code Number 20, 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 placed into ALL would be partially destroyed by a later waveform placed into H2. The mixed data error alerts the programmer to the fact that normalization data for the ALL waveform does not take the missing points into account.

4094C Only

For 4094C models with disk drives, the error codes (other than 00) appear on the disk LED display.

Error Code Numbers	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-Bus down.

Table 13-25

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 varies for the different plug-ins available. Refer to the appropriate page for the plug-in in use.

4562: page 13-37**a**
4851: page 13-37**a**
4570: page 13-37**b**
4180: page 13-37**c**
4175: page 13-37**d**

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:

#1. 4094 input
Z Mode
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

P

4562 & 4851 PLUG-IN FRONT PANEL MANIPULATION

IMPORTANT: The 4562 and 4851 plug-in Front Panel Manipulation descriptions begin on this page. See page 13-37**b** for the 4570 plug-in, page 13-37**c** for the 4180 plug-in, and page 13-37**d** for the 4570 plug-in.

Command Format:

#1. To input to 4094:
P, Address, Setting, Mask

#2. 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 13-39a).

#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.

Table 13-27a shows settings which directly place numeric values into internal 4094 control locations. Masks are not needed for Table 13-27a.

P

#3. **Mask**
A number which indicates the control to be changed.

Settings made using Table 13-26a, (page 13-39a) 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.

Transmission Sequence:

A. To READ Plug-in Settings (Computer Control on or off):

#1. 4094 input
P, Address
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31)
Error delimiter (page 13-32).

#3. 4094 output
Setting number (0-65535)
Record sep. (page 13-32).

#4. 4094 output
End of File (EOF) delimiter (page 13-32).

#5. 4094 output
Error code (00-31).
Error delimiter (page 13-32).

B. To INPUT Plug-in Settings (Computer Control must be on):

#1. 4094 input
Z1
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 input
P, Address, Setting, Mask
Command del. (page 13-32).

#4. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

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.

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	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 et'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	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	Note 2	Same as for Addresses 0 and 32.															
3	35	Note 2	Same as for Addresses 1 and 33.															

(*) Read Only.
NOTE 1: Read only to see actual siwtch positions.
NOTE 2: Read/Write to Access settings used by the 4094. Computer control must be ON to set a value.
ADDITIONAL NOTE: Tables 13-28a and 13-29a (page 13-41a) contain clarifications of A1-A4, B1-B4, and T1-T5.

Table 13-26a

Address for Plug-in Below #1	#2	QUANTITY	SETTING
4	36	Sweep average count	00000 through 21800 (Read only)
5	37	Not Used	Not used
6 (Write only)	38 (Write only)	Channel B Trigger Delay (Low order)	See Notes 1, 2 and 3 (Page 13-40a)
7 (Write Only)	39 (Write only)	Channel B Trigger Delay (High order)	See Notes 1, 2 and 3 (Page 13-40a)
8 (Write Only)	40 (Write only)	Channel A Trigger Delay (Low order)	See Notes 1, 2 and 3 (Page 13-40a)
9 (Write Only)	41 (Write only)	Channel A Trigger Delay (High order)	See Notes 1, 2 and 3 (Page 13-40a)

Table 13-27a

P

NOTE 1: Use the following equations to compute trigger delay settings.

#1. To position the trigger to any point on the screen:

a. Trigger Delay (high order) = 0

b. $$\text{Trigger Delay (low order)} = \frac{|\text{Trigger Pt. Time}|}{\text{Time Per Point}} = \text{Number of data points to the right.}$$

#2. To position the trigger left of screen:

a. $$\text{If } \frac{|\text{Delay Trigger Time}|}{\text{Time Per Point}} \leq 65535\text{, then Trigger Delay (high order)} = 65535$$

$$\text{Trigger Delay (low order)} = 65536 - \frac{|\text{Delay Trigger Time}|}{\text{Time Per Point}}$$

b. $$\text{If } \frac{|\text{Delay Trigger Time}|}{\text{Time Per Point}} > 65535\text{, then divide } \frac{|\text{Delay Trigger Time}|}{\text{Time Per Point}} \text{ by } 65536$$

Separate the answer into whole and fractional portions,
(e.g., 1.6249 = 1 and 0.6249).
65535 - Whole portion = Trigger Delay (high order).
65536 - (Fraction portion x 65536) = Trigger Delay (low order).

NOTE 2: The decimal arithmetic in Note 1 is one way of correctly working with 32 bit 2's complement 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 in Table 13-26a, address 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.

P

MODEL 4562	MODEL 4851	A1/B1	A2/B3	A3/B3	A4/B4
±100 mV	-	1	1	0	1
±200 mV	±100 mV	1	1	0	0
±400 mV	±200 mV	1	1	1	0
±1 V	±400 mV	0	1	0	1
±2 V	±1 V	0	1	0	0
±4 V	±2 V	0	1	1	0
±10 V	± 4V	1	0	0	1
±20 V	±10 V	1	0	0	0
±40 V	±20 V	1	0	1	0
-	±40 V	0	0	0	1

Table 13-28a

NOTE: Front panel voltage range settings represented by A1-A4 and B1-B4 should only be read. New settings cannot be made via computer interfaces.

TIME PER POINT		T1	T2	T3	T4	T5
Model 4562	Model 4851					
0.5 µS	10.0 µS	0	1	1	1	1
1.0	20.0	1	0	1	1	1
2.0	50.0	0	0	1	1	1
5.0	100.0	1	1	0	1	1
10.0	200.0	0	1	0	1	1
20.0	500.0	1	0	0	1	1
50.0	1.0 mS	0	0	0	1	1
100.0	2.0	1	1	1	0	1
200.0	5.0	0	1	1	0	1
500.0	10.0	1	0	1	0	1
1.0 mS	20.0	0	0	1	0	1
2.0	50.0	1	1	0	0	1
5.0	100.0	0	1	0	0	1
10.0	200.0	1	0	0	0	1
20.0	500.0	0	0	0	0	1
50.0	1.0 S	1	1	1	1	0
100.0	2.0	0	1	1	1	0
200.0	5.0	1	0	1	1	0
500.0	10.0	0	0	1	1	0
1.0 S	20.0	1	1	0	1	0
2.0	50.0	0	1	0	1	0
5.0	100.0	1	0	0	1	0
10.0	200.0	0	0	0	1	0
20.0	500.0	1	1	1	0	0
50.0	1000.0	0	1	1	0	0
100.0	2000.0	1	0	1	0	0
200.0	5000.0	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.

4570 PLUG-IN FRONT PANEL MANIPULATION

IMPORTANT: Pages 13-37b through 13-44b describes the Plug-in Front Panel Manipulations for the **4570** plug-in only.

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. **P** Command Input Error (read only):
   Warns if an illegal **P** command has been input.

Definition of Terms

CONTROL - Front panel control such as TRG VIEW. When TRG VIEW is turned on, the 4570 will go into the Trigger View mode.

ADDRESS - A number (4-56) which defines the quantity to be read or changed. See Tables 13-26b and 13-27b (pages 13-40b and 13-41b).

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 13-41b).

MASK - Only used to change the controls listed in Table 13-26b (page 13-40b). 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 13-40b) as the control to be changed.

P

Example #1

The command to put the 4570 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.

Example #2

To read the settings at address #14, use the following procedure:

#1. Input P,14
NOTE: See TRANSMISSION SEQUENCE (page 13-39b) for needed Error and Delimiter checking.

#2. The 4094 will return a number such as 37952. 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 32768.) 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 Function ON.)

#4. Subtract the setting from the returned 4094 number (see Figure 13-1b).

#5. Use the remaining number to repeat Steps #3 and #4.

37952	Original 4094 Output
- 32768	Function on
5184	Remaining Number
- 4096	Slave triggered
1088	Remaining Number
- 1024	CHE on
64	Remaining Number
- 64	Trig AC coup (AC coupling)
0	

Figure 13-1b

NOTE: The above four controls are turned on and all other controls on address #14 are turned off.

Transmission Sequence:

A. To READ Plug-in Settings (Computer Control on or off):

#1. 4094 input
P, Address
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 output
Setting number (0-65535).
Record sep. (page 13-32).

#4. 4094 output
End of File (EOF) delimiter (page 13-32).

#5. 4094 output
Error code (00-31).
Error delimiter (page 13-32).

B. To INPUT Plug-in Settings (Computer Control must be on):

#1. 4094 input
Z1
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 input
P, Address, Setting, Mask
Command del. (page 13-32).

#4. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

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 13-41b.

P

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 mutally 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.

Address for Plug-in Number		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															
#1	#2	N/A	N/A	0	N/A	N/A	N/A	N/A	0	N/A	0	0	0	N/A	N/A	N/A	0
13	45	Trig Auto	Trig Norm	Trig View										Trig (+) Slpe	Trig Dual Slpe	Trig (-) Slpe	
14	46	Int Trig ChA	Int Trig ChB	Not Used	Not Used	Trig Ext	Trig DC Coup	Trig AC Coup	Not Used	Not Used	Trig Hi F Rej	ChE On	Trig Lo F Rej	Trig Slave			Func On
15	47	ChB +DC Coup	ChB +AC Coup	ChB +GND			ChB -DC Coup	ChB -AC Coup	ChB -GND	Not Used	ChB Fltr	ChB On	ChB Save Ref				
16	48	ChA +DC Coup	ChA +AC Coup	ChA +GND			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	28762			32768
		NOTE: Masks are required for the above addresses.															

Table 13-26b

4570 Only

P

NOTE: Masks are not used for the addresses in Table 13-27b.

Address for Plug-in Below		QUANTITY	SETTING
#1	#2		
4	36	Sweep average count	00000 through 21800 (Read only)
5	37	Function select	0 - 7 only
6	38	Channel B Trigger Delay (Low order)	See Notes 3 and 4 (Page 13-42b)
7	39	Channel B Trigger Delay (High order)	See Notes 3 and 4 (Page 13-42b)
8	40	Channel A Trigger Delay (Low order)	See Notes 3 and 4 (Page 13-42b)
9	41	Channel A Trigger Delay (High order)	See Notes 3 and 4 (Page 13-42b)
10	42	Lower Trigger Threshold	-00128 to 00127 (See Notes 1 and 2, page 13-42b).
11	43	Upper Trigger Threshold	-00128 to 00127 (See Notes 1 and 2, page 13-42b).
12	44	Sweep Average Abort Count	00000 through 21800
18	50	Time Per Point	00005 to 00031 (See Table 13-30b, page 13-43b)
20	52	Channel B Position	-00128 to 00127 (See Note 1, page 13-43b)
21	53	Channel A Position	-00128 to 00127 (See Note 1, page 13-42b).
23	55	Channel B Volts Full Scale	00000 to 00008 (See Table 13-29b, page 13-43b)
24	56	Channel A Volts Full Scale	00000 to 00008 (See Table 13-29b, page 13-43b)

Table 13-27b

4570 Only

NOTE 1: Levels above vertical screen center are represented by numbers 0 - 127 (0 represents screen center and 127 represents the top of the screen). Levels below vertical screen center are represented by the numbers 65535 to 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.

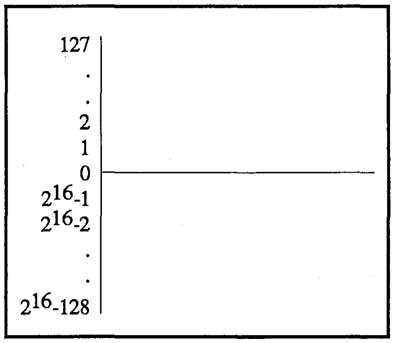


Figure 13-2b

NOTE 3: The decimal arithmetic in Note 4 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 4.

NOTE 4: Use the following equations to compute trigger delay settings.

#1. To position the trigger to any point on the screen:

a. Trigger Delay (high order) = 0

b. Trigger Delay (low order) = $\dfrac{|\text{Trigger Pt. Time}|}{\text{Time Per Point}}$ = Number of data points to the right.

#2. 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 - (Fraction portion x 65536) = Trigger Delay (low order).

P

SETTING	VOLTS FULL SCALE
0	±100 mV
1	±200 mV
2	±400 mV
3	±1 V
4	±2 V
5	±4 V
6	±10 V
7	±20 V
8	±40 V

Table 13-29b

SETTING	TIME PER POINT
5	100 nS
6	200 nS
7	500 nS
8	1 µS
9	2 µS
10	5 µS
11	10 µS
12	20 µS
13	50 µS
14	100 µS
15	200 µS
16	500 µS
17	1 mS
18	2 mS
19	5 mS
20	10 mS
21	20 mS
22	50 mS
23	100 mS
24	200 mS
25	500 mS
26	1 S
27	2 S
28	5 S
29	10 S
30	EXT I
31	EXT II

Table 13-30b

P

4180 PLUG-IN FRONT PANEL MANIPULATION

IMPORTANT: Pages 13-37c through 13-45c describe the Plug-in Front Panel Manipulations for the **4180** plug-in only.

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 by using the "Z1" command. The plug-in settings will remain at their new positions after computer control is turned off, "Z0". 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. **P** Command Input Error (read only):
   Warns if an illegal **P** command has been input.

Definition of Terms

CONTROL - Front panel control such as TRG VIEW. When TRG VIEW is turned on, the 4180 will go into the Trigger View mode.

ADDRESS - A number (3-25) which defines the front panel control to be read or changed. See Tables 13-26c and 13-27c (pages 13-40c and 13-41c).

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 Tables 13-26c and 13-27c, pages 13-40c and 13-41c).

MASK - Only used to change the controls listed in Table 13-26c (page 13-40c). 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 13-26c, page 13-40c) as the control to be changed.

4180 Only

P

Example #1

The command to put the 4180 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 13-26c (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.

Example #2

To read the settings at address #14, use the following procedure:

#1. Input P,14
NOTE: See TRANS-MISSION SEQUENCE (page 13-39c) for needed Error and Delimiter checking.

#2. The 4094 will return a number such as 36912. Record this number as in Figure 13-1c.

#3. From Table 13-26c, 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 32768.) Record this setting underneath the first number recorded in Step #2 (see Figure 13-1c). 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 Function On.)

#4. Subtract the setting from the returned 4094 number (see Figure 13-1c).

#5. Use the remaining number to repeat Steps #3 and #4.

36912	Original 4094 Output
- 32768	Function On
4144	Remaining Number
-4096	Slave triggered
48	Remaining Number
- 32	Trig DC coupling
16	Remaining Number
- 16	External Trigger
0	

Figure 13-1c

NOTE: The above four controls are turned on and all other controls on address #14 are turned off.

Transmission Sequence:

A. To READ Plug-in Settings (Computer Control on or off):

#1. 4094 input
P, Address
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 output
Setting number (0-65535).
Record sep. (page 13-32).

#4. 4094 output
End of File (EOF) delimiter (page 13-32).

#5. 4094 output
Error code (00-31).
Error delimiter (page 13-32).

B. To INPUT Plug-in Settings (Computer Control must be on):

#1. 4094 input
Z1
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 input
P, Address, Setting, Mask
Command del. (page 13-32).

#4. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

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 13-27c on page 13-41c.

P

NOTE: Some settings have an alternate switch position. For example, the alternate switch position for Auto trigger is Normal trigger.

Use P, 13, 1, 3 to turn auto trigger on. Normal trigger will automatically turn off.

Use P, 13, 0, 3 to turn normal trigger on. Auto trigger will automatically turn off.

Address for Plug-in Number		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 OR SELECT ALTERNATE															
#1	#2	0	0	0	N/A	0	0	N/A	N/A	N/A	0	0	0	0	N/A	0	0
13	45	Auto / Norm		Trig View							Min Trig Jitter	B Data Invert	A Data Invert	+SL / DU		-SL / DU	
14	46	IntA / IntB			Not Used	External Trigger/ Internal Trigger	Tdc / Tac		Not Used	Not Used	Trig Hi F Rej		Trig Lo F Rej	SL / EX			Func On
15	47	ChBdc / ChBac		ChB +GND							ChB Fltr	ChB On	ChB Save Ref				
16	48	ChAdc / ChAac		ChA +GND							ChA Fltr	ChA On	ChA Save Ref				
Mask		3		4	24		96		128	256	512	1024	2048	28762			32768
		NOTE: Masks are required for the above addresses.															

Table 13-26c

NOTE: Minimum Trigger Jitter, Channel B Data Invert, and Channel A Data Invert are available on Version 1.1 or above only.

4180 Only

P

NOTE: Masks are not used for the addresses in Table 13-27c.

Address for Plug-in Below		QUANTITY	SETTING
#1	#2		
4	36	Sweep average count	00000 through 21800 (Read only)
5	37	Function select	0 - 8 only (See Table 13-30c, Page 13-44c)
8	40	Channel A/B Trigger Delay (Low order)	See Notes 3 & 4 (Page 13-42c)
9	41	Channel A/B Trigger Delay (High order)	See Notes 3 & 4 (Page 13-42c)
10	42	Lower Sensitivity Threshold	2^{16}-100 to 00100 (See Notes 1 & 2, page 13-42c)
11	43	Upper Sensitivity Threshold	2^{16}-100 to 00100 (See Notes 1 & 2, page 13-42c)
12	44	Sweep Average Abort Count	00000 through 21800
18	50	Time Per Point	00005 to 00031 (See Table 13-32c, page 13-45c)
19	51	Interpolate	See Note 5 and Table 13-28c, (Page 13-44c)
20	52	Channel B Position	2^{16}-100 to 00100 (See Note 1, page 13-42c).
21	53	Channel A Position	2^{16}-100 to 00100 (See Note 1, page 13-42c).
22	54	Summation Dump Count	00000 to 32767
23	55	Channel B Volts Full Scale	00000 to 00008 (See Table 13-29c, page 13-44c)
24	56	Channel A Volts Full Scale	00000 to 00008 (See Table 13-29c, page 13-44c)
25	57	Dead Time Reduction	1 = On, 0 = Off

Table 13-27c

NOTE: When Dead Time Reduction is turned On, the 4180 front panel status is not checked between sweeps. This eliminates approximately 200mS of dead time between sweeps.

4180 Only

P

NOTE 1: Levels above vertical screen center are represented by percentages 0 - 100 (0 represents screen center and 100 represents the top of the screen). Levels below vertical screen center are represented by the numbers 65535 to 65436. 65535 (2^{16}-1) represents the first percent below screen center, and 65436 (2^{16}-100) represents the bottom of the screen (see Figure 13-2c).

NOTE 2: The upper trigger threshold should always be equal to or greater than the lower trigger threshold.

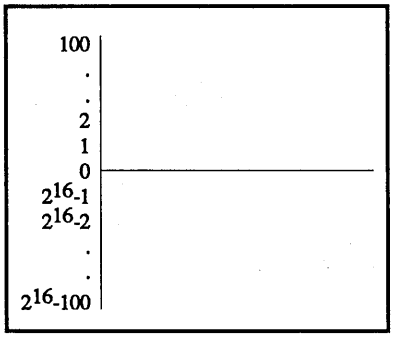


Figure 13-2c

NOTE 3: The decimal arithmetic in Note 4 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 4.

NOTE 4: Use the following equations to compute trigger delay settings.

#1. To position the trigger to any point on the screen:

a. Trigger Delay (high order) = 0

b. $\text{Trigger Delay (low order)} = \dfrac{|\text{Trigger Pt. Time}|}{\text{Time Per Point}}$ = Number of data points to the right.

#2. 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

$\text{Trigger Delay (low order)} = 65536 - \dfrac{|\text{Delay Trigger Time}|}{\text{Time Per Point}}$

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 - (Fraction portion x 65536) = Trigger Delay (low order).

See Example #3 and Example #4 on page 13-43c.

4180 Only

EXAMPLE #3

Time per Point = 1µS
Delay trigger time desired = 50mS

a. Trigger Delay (high order) = 65535

b. Trigger Delay (low order) = $65536 - \frac{|50mS|}{1\mu S} = 15536$

Commands are: P, 8, 15536
P, 9, 65535.

EXAMPLE #4

Time per Point = 1µS
Delay trigger time desired = 2 Seconds

$\frac{2S}{1\mu S} = 2^{E6}$, therefore $\frac{2^{E6}}{65536} = 30.517578$

a. Trigger Delay (high order) = 65535 - 30 = 65505

b. Trigger Delay (low order) = 65536 - (0.517578 x 65536) ≈ 31,616

Commands are: P, 8, 31616
P, 9, 65505.

P

SETTING	APPARENT SAMPLING RATE
0	No interpolation. 5 nS per point true sampling.
1	2.5 nS per point
2	1.25 nS per point
3	625 pS per point
4	312.5 pS per point

Table 13-28c

SETTING	VOLTS FULL SCALE
0	±100 mV
1	±200 mV
2	±400 mV
3	±1 V
4	±2 V
5	±4 V
6	±10 V
7	±20 V
8	±40 V

Table 13-29c

NOTE 5: Interpolation mode extends the apparent sampling rate up to 312.5 pico-seconds per point by using a cubic spline curve fit algorithm.

The 4180 must be in the 5 nano-second Time Per Point setting to use the interpolation mode. See Table 13-32c.

SETTING	FUNCTION
0	Virtual Averaging
1	Exponential Averaging
2	Fourier Transform
3	Max/Min
4	A + B
5	A - B
6	A * B
7	A / B
8	Summation Averaging

Table 13-30c

NOTE 6: Function must be turned on to use the functions in Table 13-30c.

SETTING	TIME PER POINT
1	5 nS
2	10 nS
3	20 nS
4	50 nS
5	100 nS
6	200 nS
7	500 nS
8	1 µS
9	2 µS
10	5 µS
11	10 µS
12	20 µS
13	50 µS
14	100 µS
15	200 µS
16	500 µS
17	1 mS
18	2 mS
19	5 mS
20	10 mS
21	20 mS
22	50 mS
23	100 mS
24	200 mS
25	500 mS
26	1 S
27	2 S
28	5 S
29	10 S
30	EXT I
31	EXT II

Table 13-32c

4175 PLUG-IN FRONT PANEL MANIPULATION

IMPORTANT: Pages 13-37d through 13-46d describes the Plug-in Front Panel Manipulations for the **4175** plug-in only.

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.

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 13-26d and 13-27d (pages 13-40d and 13-41d).

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 13-27d, page 13-41d).

MASK - Only used to change the controls listed in Table 13-26d (page 13-40d). 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 13-26d, page 13-40d) as the control to be changed.

P

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 13-26d (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.

Example #2

To read the settings at address #14, use the following procedure:

#1. Input P,14
NOTE: See TRANSMISSION SEQUENCE (page 13-42d) for needed Error and Delimiter checking.

#2. The 4094 will return a number such as 8234. Record this number as in Figure 13-1d.

#3. From Table 13-26d, 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 13-1d). 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 13-1d).

#5. Use the remaining number to repeat Steps #3 and #4.

8234	Original 4094 Output
- 8192	Function on
42	Remaining Number
- 32	Slave triggered
10	Remaining Number
- 8	CHE on
2	Remaining Number
- 2	Trig AC coup (AC coupling)
0	

Figure 13-1d

NOTE: The above four controls are turned on and all other controls on address #14 are turned off.

P

Transmission Sequence:

A. To READ Plug-in Settings (Computer Control on or off):

#1. 4094 input
P, Address
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 output
Setting number (0-65535).
Record sep. (page 13-32).

#4. 4094 output
End of File (EOF) delimiter (page 13-32).

#5. 4094 output
Error code (00-31).
Error delimiter (page 13-32).

B. To INPUT Plug-in Settings (Computer Control must be on):

#1. 4094 input
Z1
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 input
P, Address, Setting, Mask
Command del. (page 13-32).

#4. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

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 13-27d on page 13-41d.

P

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 mutally 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.

Address for Plug-in	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															
#1	N/A	N/A	0	N/A	N/A	N/A	N/A	0	N/A	0	0	0	N/A	N/A	N/A	0
13	Trig Auto	Trig Norm	Trig View										Trig (+) Slope	Trig Dual Slope	Trig (-) Slope	
14	Int Trig ChA	Int Trig ChB	Not Used	Trig Int	Trog Ext	Trig DC Coup	Trig AC Coup	Not Used	Not Used	Trig Hi F Rej	Not Used	Trig Lo F Rej	Trog Slave	Trig 1Meg Ohms	Trig 50 Ohms	Avg
15	ChB +DC Coup	ChB +AC Coup	ChB +GND	ChB 1Meg Ohm	ChB -DC Coup	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 Ohms	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	28762			32768
	NOTE: Masks are required for the above addresses.															

Table 13-26d

4175 Only

P

NOTE: Masks are not used for the addresses in Table 13-27d.

Address for Plug-in #1	QUANTITY	SETTING
4	Sweep average count	00000 through 21800 (Read only)
6	Channel B Trigger Delay (Low order)	See Notes 3 and 4 (Page 13-42d)
7	Channel B Trigger Delay (High order)	See Notes 3 and 4 (Page 13-42d)
8	Channel A Trigger Delay (Low order)	See Notes 3 and 4 (Page 13-42d)
9	Channel A Trigger Delay (High order)	See Notes 3 and 4 (Page 13-42d)
10	Lower Trigger Threshold	-00128 to 00127 (See Notes 1 and 2, page 13-42d).
11	Upper Trigger Threshold	-00128 to 00127 (See Notes 1 and 2, page 13-42d).
12	Sweep Average Abort Count	00000 through 21800
18	Time Per Point	00005 to 00031 (See Table 13-30b, page 13-43d)
20	Channel B Position	-00128 to 00127 (See Note 1, page 13-42d)
21	Channel A Position	-00128 to 00127 (See Note 1, page 13-42b).
23	Channel B Volts Full Scale	00000 to 00008 (See Table 13-29d, page 13-43d)
24	Channel A Volts Full Scale	00000 to 00008 (See Table 13-29d, page 13-43d)
28	P Command Error A (Read only)	00000 to 32768 (See Table 13-31d, page 13-44d)
29	P Command Error B (Read only)	00000 to 00016 (See Table 13-32d, page 13-45d)
30	Over-voltage Error (Read only)	00000 to 00007 (See Table 13-28d, page 13-42d)

Table 13-27d

4175 Only

P

Setting	Over-Voltage Detected
0	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, Channel A and Channel B

Table 13-28d

NOTE 1: Levels above vertical screen center are represented by numbers 0 - 127 (0 represents screen center and 127 represents the top of the screen). Levels below vertical screen center are represented by the numbers 65535 to 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 13-2d).

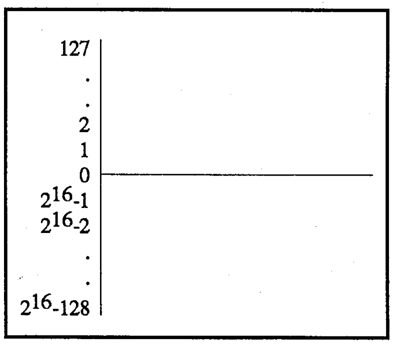


Figure 13-2d

NOTE 2: The upper trigger threshold should always be equal to or greater than the lower trigger threshold.

NOTE 3: The decimal arithmetic in Note 4 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 4.

NOTE 4: Use the following equations to compute trigger delay settings.

#1. To position the trigger to any point on the screen:

a. Trigger Delay (high order) = 0

b. Trigger Delay (low order) = $\dfrac{|\text{Trigger Pt. Time}|}{\text{Time Per Point}}$ = Number of data points to the right.

#2. 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 - (Fraction portion x 65536) = Trigger Delay (low order).

P

SETTING	VOLTS FULL SCALE
0	±100 mV
1	±200 mV
2	±400 mV
3	±1 V
4	±2 V
5	±4 V
6	±10 V
7	±20 V
8	±40 V

Table 13-29d

SETTING	TIME PER POINT
0	2 nS
1	5 nS
2	10 nS
3	20 nS
4	50 nS
5	100 nS
6	200 nS
7	500 nS
8	1 µS
9	2 µS
10	5 µS
11	10 µS
12	20 µS
13	50 µS
14	100 µS
15	200 µS
16	500 µS
17	1 mS
18	2 mS
19	5 mS
20	10 mS
21	20 mS
22	50 mS
23	100 mS
24	200 mS
25	500 mS
26	1 S
27	2 S
28	5 S
29	10 S
30	EXT I
31	EXT II

Table 13-30d

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 Timer Per Point setting (only 0-31 allowed)
16384	Illegal Channel A Volts Full Scale setting (only 0-8 allowed).
32768	Illegal Channel B Volts Full Scale setting (only 0-8 allowed).

Table 13-31d

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 A input 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 13-32d

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 13-31, (page 13-49).

#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 nonmutually 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 nonmutually 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 (e.g., x16 and x256 together) will lead to unpredictable results. Table 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.

M

Transmission Sequence:

A. To READ mainframe settings (Computer Control on or off):

#1. 4094 input
M, Address
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 output
Setting number (0-65535).
Record sep. (page 13-32).

#4. 4094 output
End Of File (EOF) delimiter (page 13-32).

#5. 4094 output
Error code (00-31).
Error delimiter (page 13-32).

B. To INPUT mainframe setting (Computer Control must be on):

#1. 4094 input
Z1
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

#3. 4094 input
M, Address, Setting, Mask
Command del. (page 13-32).

#4. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

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.

M

Address	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. Expansion	Off	X2	X4	X8	X16	X32	X64	X128	X256	
1		Hor. Expansion	Off	X2	X4	X8	X16	X32	X64	X128	X256	
2		Cursor Control, Execute	Cursor Left	Cursor Right	Cursor Up	Cursor Down	Exec	Y/T	Auto Center	Zero	X256	
3		Not Used										
4		Function Switch	Prgm	Invert IO Stat	Sub Grid	Data Move	Reset	Grid Erase	Pen Plot			See Note 1
5		Memory Switch	Q1	Q3	H1	All	H2	Q2	Q4			
6	Read/Write to influence scope behavior - Computer Control must be turned ON.	Vert. Expansion	Off	X2	X4	X8	X16	X32	X64	X128	X256	
7		Hor. Expansion	Off	X2	X4	X8	X16	X32	X64	X128	X256	
8		Cursor Control, Execute	Do not use (Cursor position keys). See Table 13-31.				Exec	Y/T				
9		Not Used										
10		Function Switch	Prgm	Invert IO Stat	Sub Grid	Data Move	Reset	Grid Erase	Pen Plot			See Note 1
11		Memory Switch	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	XY Vertical Cursor	32768 through 65535 (for -32768 through -1), 0 through 32767
#13	XY Horizontal Cursor	32768 through 65535 (for -32768 through -1), 0 through 32767
#14	YT Vertical Cursor	49664 through 65535 (0 + 49664 through 15871 + 49664)
#15	YT Horizontal Cursor	32768 through 65535 (for -32768 through -1), 0 through 32767

Table 13-31

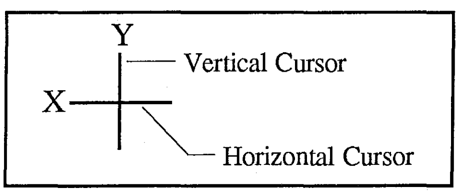


Figure 13-5

The "vertical" cursor indicates X-axis values. The "horizontal" cursor indicates Y-axis values.

NOTE 1: The top settings in the outlined boxes are for the 4094A and 4094B. The bottom settings are for the 4094C.

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 through 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.

#1. Data Terminal Equipment:
  a. line 2 = transmit
  b. line 3 = receive

#2. 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:

#1. GPIB 4094 input
  J
  Command del. (page 13-32).

#2. GPIB 4094 output
  Error code for command (00-31).
  Error delimiter (page 13-32).

  Bidirectional GPIB/Plotter Port communications are now possible.

#3. GPIB 4094 input
  Device Clear, Selected Device Clear, or Interface Clear. A computer manual must be consulted to determine the correct command to issue the necessary clear.

MODEM/COMPUTER and PLOTTER PORT PARAMETERS

Command Format:

K, Port, Mode, Baud Rate Number

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 inter-connection (see command **J**), it is best to first use the **K** command to ensure that the PLOTTER port is set up as needed. The pre-programmed 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	1.5
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 setup 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 Number**
A number which specifies the baud rate (bits per second) of the transmissions. See Table 13-35.

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:

#1. 4094 input
K, Port, Mode, Baud Rate No.
Command del. (page 13-32).

#2. 4094 output
Error code for command (00-31).
Error delimiter (page 13-32).

ASCII CODE CHART

BITS 2^3	2^2	2^1	2^0	2^6 0 2^5 0 2^4 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	DEL	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 TRANSLATED INTO 4094 DISPLAY CHARACTERS

BITS 2^6				0	0	0	0	1	1	1	1
2^5				0	0	1	1	0	0	1	1
2^4				0	1	0	1	0	1	0	1
2^3	2^2	2^1	2^0								
0	0	0	0	@	P	space	0	@	P	space	0
0	0	0	1	A	Q	!	1	A	Q	!	1
0	0	1	0	B	R	"	2	B	R	"	2
0	0	1	1	C	S	#	3	C	S	#	3
0	1	0	0	D	T	$	4	D	T	$	4
0	1	0	1	E	U	%	5	E	U	%	5
0	1	1	0	F	V	&	6	F	V	&	6
0	1	1	1	G	W	'	7	G	W	'	7
1	0	0	0	H	X	(	8	H	X	(	8
1	0	0	1	I	Y	)	9	I	Y	)	9
1	0	1	0	J	Z	*	:	J	Z	*	:
1	0	1	1	K	k	+	;	K	k	+	;
1	1	0	0	L	m	,	<	L	m	,	<
1	1	0	1	M	u	-	=	M	u	-	=
1	1	1	0	N	n	.	>	N	n	.	>
1	1	1	1	O	p	/	?	O	p	/	?

Table 13-37

The 4094 display shows non-printable ASCII characters as underlined ASCII characters (for example, CR = 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 HP and IBM PC sample programs are intended to show basic usage of the Nicolet 4094 digital oscilloscope 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.

Sample HP Programs

The HP-85/HP-87 sample 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.

All of the following programs use a 4094 address of 14 and a computer select code of 7.

The HP sample programs begin on page 13a-3.

Sample IBM PC Programs

The IBM PC sample programs demonstrate the usage of the Nicolet 4094 interfacing commands.

All programs use the 4094's RS-232 interface and the IBM PC Asynchronous Communications Adapter. Connection between the units is via a straight through RS-232 cable and the Null Modem board supplied with the 4094. Only pins 2, 3 and 7 of the cable are required. The programs are written in Personal Computer BASIC, and will run in either version 1.1 or 2.0. The 4094 is set at its factory defaults: address 14, 300 baud, no parity.

Special note on IBM PC programs 5 - 8

These programs transfer up to several hundred characters from the 4094 to the PC. To speed up the programs, the PC's baud rate is set to 9600 rather than 300. The 4094 must also have its baud rate changed to 9600, OR line 10 of the program may be changed from "COM1:9600,..." to "COM1:300,...".

Also, due to the volume of data, the IBM must have a communications buffer established. This is done by bringing up BASIC from DOS with the command "BASIC'C:2048". All of the IBM PC sample programs use a 4094 address ">" on the RS-232 interface.

The IBM PC sample programs begin on page 13b-1.

HP 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".

10 OUTPUT 714; "B"	Computer outputs command **B** as a character string from select code 7 to GPIB address 14 (4094). The 4094 will beep as soon as it receives command **B**.
20 ENTER 714; E	The 4094 command error code is entered into the computer and stored in variable **E.**
30 END	End of program.

HP PROGRAM #2

The 4094 is instructed to recall record number 1 from the disk into the display memory.

10 OUTPUT 714; "R,Ø,1,Ø"	Command **R** is sent out 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 DISP "RECALL COMPLETE"	Computer displays "RECALL COMPLETE".
40 BEEP	Computer beeps.
50 END	End of program.

HP 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.

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.
20 ENTER 714; E	The 4094 command error code is entered into the computer and stored in variable **E**.
30 OUTPUT 714; "H,Ø,Ø"	Command **H** is sent to the 4094.
40 ENTER 714; E	The 4094 command error code is entered.
50 DISP "SWEEP COMPLETE"	Computer displays "SWEEP COMPLETE". The 4094 will now be in HOLD LAST.
60 BEEP	Computer beeps.
70 OUTPUT 714; "ZØ"	Command **Z** is sent to the 4094 to turn off computer control.
80 ENTER 714; E	The 4094 command error code is entered.
90 END	End of program.

HP PROGRAM #4

A check is made of 4094 plug-ins to determine whether they are in LIVE or HOLD LAST.

10 OUTPUT 714; "C,4,2,13,1Ø"	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 (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,Ø"	Command **L** is sent to the 4094 to determine the plug-in status.
40 ENTER 714; E	The 4094 command error code is enter.
50 ENTER 714; S	The plug-in status number is entered.
60 IF S=Ø 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.

HP 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,4,2,13,1Ø"	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 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 "-------" 13Ø0 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=2Ø THEN DISP " MIXED DATA"	Check for mixed data.
16Ø END	End of program.

HP 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.

10 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 data point can be stored separately in a numerical array.
20 ENTER 714; E	The 4094 command error code is entered into the computer and stored in variable **E.**
30 OUTPUT 714; "D,Ø,1,Ø,1Ø,1"	Command **D** is sent to the 4094.
40 ENTER 714; E	The 4094 command error code is entered.
50 DIM D(1Ø)	Dimension array **D** to contain 10 numeric values.
60 FOR I=1 TO 1Ø 70 ENTER 714; D(I) 80 DISP D(I) 90 NEXT I	Lines 60 through 90 enter the ASCII data point values from the 4094 data point values from the 4Ø94 and store them into numeric array **D.**
100 ENTER 714; E	Enter data transmission error code.
110 END	End of program.

HP 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,Ø,4ØØØ,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$ [8ØØ8]	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$.
50 CONTROL 7,16;Ø	Turn off the CR/LF delimiter used inside the computer.
60 TRANSFER 714 TO A$ FHS; COUNT 8ØØØ	Enter 8000 bytes of data from the 4094 into string A$ using the "fast "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.
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,Ø,4ØØØ,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;Ø	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.

HP 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.

10 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).
20 ENTER 714; E	The 4094 command error code is entered into the computer and stored in variable **E.**
30 CONTROL 7,16;Ø	Turn off the CR/LF delimiter inside the computer.
40 DIM B$ [2Ø8]	Dimension character string **B$** to contain 200 characters plus the HP required 8 extra string locations. Each data point transferred in binary will result in two 8 bit characters to be stored.
50 IOBUFFER B$	Declare the buffer used in the IO operation to be **B$.**
60 TRANSFER 714 TO B$ FHS; COUNT 2ØØ	Enter 200 bytes of data from the 4094 into string **B$** using the "fast handshake" transfer mode.
70 CONTROL 7,16;2	Turn the internal computer CR/LF delimiter back on
80 ENTER 714; E	Enter the data transmission error code.
90 J=1	Initialize variable **J.**
100 DIM A(1ØØ)	Dimension array **A** to contain the 100 numeric data point values.
110 FOR I=1 TO 199 STEP 2 120 P=256*NUM(B$ [I])+NUM(B$ [I+1]) -65536*(NUM(B$ [I]) =128) 130 A(J)=P 140 DISP A(J) 150 J=J+1 160 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.**
170 BEEP	Computer beeps.
180 END	End of Program.

HP PROGRAM #9

The 4094 outputs normalization set number Ø 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.

10 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.
20 ENTER 714; E	The 4094 command error code is entered into the computer and stored in variable **E.**
30 OUTPUT 714; "N,Ø"	Command **N** is output to the 4094.
40 ENTER 714; E	Enter the 4094 command error code.
50 DIM N(11)	Dimension numeric array **N** to contain the values in the normalizing set.
60 FOR I=1 TO 11 70 ENTER 714; N(I) 80 DISP N(I) 90 NEXT I	Lines 60 through 90 are used to enter normalizing set values into array **N.**
100 ENTER 714; E	Enter the normalization transmission error.
110 END	End of program.

HP 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.

10 DIM A$ 4Ø	Dimension character string **A$** to contain the 32 character title.
20 DISP "TYPE IN 32 CHARACTER TITLE"	Display message on computer.
30 INPUT A$	Input title from computer keyboard.
40 OUTPUT 714; "T,1,1"	Command **T** is sent to the 4094.
50 ENTER 714; E	Enter the 4094 command error code.
60 CONTROL 7,16;Ø	Turn off the internal computer CR/LF delimiter. Delimiters would add excess characters (CR/LF) to the title.
70 OUTPUT 714 USING "K"; A$	Send the 32 character title into the 4094.
80 CONTROL 7,16; 2	Turn the internal computer delimiter CR/LF back on.
90 ENTER 714; E	Enter the title transmission error code.
100 END	End of program.

HP PROGRAM #11

Plug-in front panel controls can be set via computer interfaces. This program sets the time per point to 500 nsec per point (**Model 4562**) or 10 µsec per point (**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,3,6144Ø,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; "ZØ"	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.

HP 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 13-28a on page 13-41a for the meanings of A1-A4.

10 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
20 ENTER 714; E	Enter the 4094 command error code.
30 OUTPUT 714; "P,1"	Command **P** is used to request the value related to the plug-in front panel setting.
40 ENTER 714; E	Enter the 4094 command error code.
50 ENTER 714; P	Enter the plug-in front panel setting value.
60 ENTER 714; E 70 A1=Ø 80 A2=Ø 90 A3=Ø 100 A4=Ø	Enter the transmission error code. Lines 70 through 100 initialize A1 through A4.
110 IF P 32767 THEN P=P-32768	Reduce the size of **P** to within the range allowed to be used with BINAND.
120 IF BINAND (P,1) Ø THEN A1=1 130 IF BINAND (P,2) Ø THEN A2=1 140 IF BINAND (P,4) Ø THEN A3=1 150 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 13-41a.
160 DISP USING "D,X"; A1, A2, A3, A4	Display the values of A1-A4.
170 END	End of Program.

HP 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.
120 PAUSE	Pause during program execution. Press CONT to finish program.
130 OUTPUT 714; "ZØ"	Command **Z** is sent to the 4094 to turn off computer control.
140 ENTER 714; E	Enter the 4094 command error code.
150 END	End of program.

IBM PC 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".

10 OPEN "COM1:3ØØ,S,7,1,LF" as #1	Open the IBM serial port at 300 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">B"	Send CONTROL-A and ">" to activate scope's RS-232 interface. Send "B" command to make scope beep.
30 INPUT #1,E	The 4094 command error code is entered into the computer and stored in variable E.
40 PRINT #1, "Q"	Send "Q" command to deactivate scope.
50 CLOSE	Close the IBM's serial port.
60 END	End of program.

IBM PC PROGRAM #2

The 4094 is instructed to recall record number 1 from disk into the display memory.

10 OPEN "COM1:3ØØ,S,7,1,LF" as #1	Open the IBM serial port at 300 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "R,Ø,1,Ø"	Send recall command to scope.
40 IF LOC(1) < 2 THEN 4Ø	Wait until error code is sent by scope, indicating reacall is finished. LOC(1) is the number of characters in the IBM's input buffer.
50 INPUT #1,E	The 4094 command error code is entered.
60 PRINT "RECALL COMPLETE"	Print message on IBM screen.
70 PRINT #1, "Q"	Send "Q" command to deactivate scope.
80 CLOSE	Close the IBM's serial port.
90 END	End of program.

IBM PC 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 70) 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.

10 OPEN "COM1:3ØØ,S,7,1,LF" as #1	Open the IBM serial port at 300 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "Z1"	Send "Z1" command to scope, to turn on computer control.
40 INPUT #1,E	The 4094 command error code is entered into the computer.
50 PRINT #1, "H,Ø,Ø"	Send HOLD NEXT command to scope.
60 IF LOC(1) < 2 THEN 6Ø	Wait until error code is sent by scope, indicating sweep is finished. LOC(1) is the number of characters in the IBM's input buffer.
70 INPUT #1,E	The 4094 command error code is entered.
80 PRINT "SWEEP COMPLETE"	Print message on IBM screen.
90 PRINT #1, "ZØ"	Send "ZØ" command to scope, to turn off computer control.
100 INPUT #1,E	The 4094 command error code is enter.
110 PRINT #1, "Q"	Send "Q" command to deactivate scope.
120 CLOSE	Close the IBM's serial port.
130 END	End of program.

IBM PC PROGRAM #4

A check is made of 4094 plug-ins to determine whether they are in LIVE or HOLD LAST.

10 OPEN "COM1:3ØØ,S,7,1,LF" as #1	Open the IBM serial port at 300 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "C,4,1,13"	Send C command to scope, to set record separator delimiter (which follows the status reply) to <CR>, CHR$(13), to match PC.
40 INPUT #1,E	Enter 4094 command error code.
50 PRINT #1, "L,Ø"	Send "L,Ø" command to scope, to request plug-in status.
60 INPUT #1,E	Enter the 4094 command error code.
70 INPUT #1,S	Enter the plug-in status number.
80 IF S=Ø THEN PRINT "ALL PLUG-INS IN HOLD"	Check value of status number.
90 IF S=1 THEN PRINT "AT LEAST ONE PLUG-IN IN LIVE"	Check value of status number.
100 INPUT #1,E	Enter error code for status transmission.
110 PRINT #1, "Q"	Send "Q" command to deactivate scope.
120 CLOSE	Close the IBM's serial port.
130 END	End of program.

IBM PC 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.

WARNING: See page 13a-1 for special note on using programs 5 through 8.

10 OPEN "COM1:96ØØ,S,7,1,LF" as #1	Open the IBM serial port at 9600 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "C,4,1,13"	Send C command to scope, to set record separator delimiter (which follows the status replay) to <CR>, CHR$(13), to match PC.
40 INPUT #1,E	Enter 4094 command error code.
50 PRINT #1, "W"	Send "W" command to scope, to request waveform information.
60 INPUT #1,E	Enter 4094 command error code.
70 INPUT #1,W1	Enter the total waveform count into variable W1.
80 DIM W(W1,7)	Dimension array W large enough to contain seven values for each waveform in memory.
90 FOR I=1 TO W1 100 FOR J=1 TO 7 110 INPUT #1, W(I,J) 120 PRINT W(I,J); 130 NEXT J 140 PRINT 150 NEXT I	Lines 90-150 enter the waveform information into array W and display the data.
160 INPUT #1,E	Enter error code for data transmission.
170 PRINT #1, "Q"	Send "Q" command to deactivate scope.
180 CLOSE	Close the IBM's serial port.
190 END	End of program.

IBM PC PROGRAM #6

The 4094 outputs the first ten data points of waveform 1 in ASCII code. The data values are stored in numerical array D. Binary data transmissions (program 7) should be used if transfer time is important.

WARNING: See page 13a-1 for special note on using programs 5 through 8.

10 OPEN "COM1:96ØØ,S,7,1,LF" as #1	Open the IBM serial port at 9600 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "C,8,1,13"	Send C command to scope, to set error delimiter to <CR>, CHR$(13), to match PC. Necessary to insure that PC correctly recognizes the data points; 4094's default is <CR/LF>, which confuses the PC.
40 INPUT #1,E	Enter 4094 command error code.
50 PRINT #1, "C,4,1,13" 60 INPUT #1,E	Send C command to scope, to set record separator delimiter (which follows the status reply) to <CR>, CHR$(13), to match PC.
70 PRINT #1, "D,Ø,1,Ø,1Ø,1" 80 INPUT #1,E	Send "D" command to scope, to request data output of 10 points from waveform 1, in ASCII code.
90 FOR I=1 to 1Ø 100 INPUT #1, D(I) 110 PRINT D(I) 120 NEXT I	Lines 90-120 enter the data point values from the 4094 and store then in numeric array D.
130 INPUT #1,E	Enter error code for data transmission.
140 PRINT #1, "Q"	Send "Q" command to deactivate scope.
150 CLOSE	Close the IBM's serial port.
160 END	End of program.

IBM PC PROGRAM #7

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 program combines the two bytes to form a single numeric value. The 4094 transmits the most significant bits first, where the PC expects the first byte to be the least significant bits. This is corrected in lines 70-90.

WARNING: See 13a-1 for special note on using programs 5 through 8.

10 OPEN "COM1:96ØØ,N,8,1,LF" as #1	Open the IBM serial port at 9600 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "C,8,1,13"	Send C command to scope, to set error delimiter to <CR>, CHR$(13), to match PC. Necessary to insure that PC correctly recognizes the data points; 4094's default is <CR/LF>, which confuses the PC.
40 INPUT #1,E	Enter 4094 command error code.
50 PRINT #1, "D,4,1,Ø,1ØØ,1"	Send "D" command to scope, to request binary output of 100 data points from waveform 1.
60 INPUT #1,E	Enter 4094 command error code.
70 DIM D(1ØØ)	Dimension aray D to receive 100 data values.
80 FOR I=Ø to 99 90 H$ = INPUT$(1,1) 100 L$ = INPUT$(1,1) 110 D(I) = CVI(L$+H$) 120 PRINT D(I); 130 NEXT I	For lines 80-130, set up loop to enter data: ° Read one byte from input buffer #1 (from scope). This is the high byte (most significant bits). ° Read another byte, the least significant bits. ° Combine the two bytes, and use the Convert-to-Integer function to recreate the numeric data values. ° Display the resulting data point.
140 INPUT #1,E	Enter error code for data transmission.
150 PRINT #1, "Q"	Send "Q" command to deactivate scope.
160 CLOSE	Close the IBM's serial port.
170 END	End of program.

IBM PC PROGRAM #8

The 4094 outputs normalization set 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.

WARNING: See page 13a-1 for special notes on using programs 5 through 8.

10 OPEN "COM1:96ØØ,S,7,1,LF" AS #1	Open the IBM serial port at 9600 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "C,4,1,13"	Command C is sent to the scope, to set the record separator delimiter to <CR>, CHR$(13), to match the PC. This allows each item in the norm. set to be entered into an array individually.
40 INPUT #1,E	
50 PRINT #1, "N,Ø"	Send "N" command to scope, to request output of normalization data.
60 INPUT #1,E	Enter 4094 command error code.
70 DIM N(11)	Dimension array N to receive 11 normalizing values.
80 FOR I=1 to 11 90 INPUT #1, N(I) 100 PRINT N(I); 110 NEXT I	Set up loop to enter data.
120 INPUT #1,E	Enter error code for data transmission.
130 PRINT #1, "Q"	Send "Q" command to deactivate scope.
140 CLOSE	Close the IBM's serial port.
150 END	End of program.

IBM PC PROGRAM #9

This program illustrates a method to input titles to the 4094. Titles sent to the 4094 must be exactly 32 characters long.

To view title, switch 4094 FUNCTION switch to PRGM, then INVERT. This will clear the commands and leave only the title.

10 OPEN "COM1:300,S,7,1,LF" AS #1	Open the IBM serial port at 300 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 DIM T$(32)	Dimension string for 32 characters.
40 PRINT "TYPE IN 32 CHARACTER TITLE"	Display message on PC screen.
50 T$ = INPUT$(32)	Read 32 characters from keyboard. (The characters are NOT displayed on the PC's screen.)
60 PRINT #1, "T,1,1"	Command T is sent to the scope, to input a title.
70 INPUT #1,E	Enter 4094 command error code.
80 PRINT #1, T$;	Print T$ without delimiter.
90 INPUT #1,E	Enter error code for title transmission.
100 PRINT #1, "Q"	Send "Q" command to deactivate scope.
110 CLOSE	Close the IBM's serial port.
120 END	End of program.

IBM PC PROGRAM #10

Plug-in front panel controls can be set via computer interfaces. This program sets the time per point to 500 nsec per point (**Model 4562**) or 10 µsec per point (**Model 4851**).

10 OPEN "COM1:3ØØ,S,7,1,LF" as #1	Open the IBM serial port at 300 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "Z1"	Send "Z1" command to scope, to turn on computer control.
40 INPUT #1,E	The 4094 command error code is entered into the computer.
50 PRINT #1, "P,3,6144Ø,63488"	Command P is sent to the 4094 to set the new time base.
60 INPUT #1,E	Enter the 4094 command error code.
70 PRINT "PRESS F5 (cont) TO REVERT BACK TO KNOB SETTING"	Print message on IBM screen.
80 STOP	Wait for CONTINUE command.
90 PRINT #1, "ZØ"	Send "ZØ" command to scope, to turn off computer control.
100 INPUT #1,E	The 4094 command error code is entered.
110 PRINT #1, "Q"	Send "Q" command to deactivate scope.
120 CLOSE	Close the IBM's serial port.
130 END	End of program.

IBM PC PROGRAM #11

Many front panels settings can be read out on the computer interfaces. This program reads the Channel A, plug-in 1 voltage range setting. See page 13-41a of the Operating Manual for the meanings of A1-A4.

10 OPEN "COM1:3ØØ,S,7,1,LF" as #1	Open the IBM serial port at 300 baud, as file number 1.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "C,8,1,13"	Send C command to scope, to set its command delimiter to <CR>, CHR$(13), to match the PC. The 4094's default of <CRLF> can confuse the PC when entering numeric data.
40 INPUT #1,E	Enter 4094 command error code.
50 PRINT #1, "C,4,1,13"	Send C command to scope, to set record separator delimiter (which follows the status reply) to <CR>, CHR$(13), to match PC.
60 INPUT #1,E	Enter 4094 command error code.
70 PRINT #1, "P,1"	Command P is used to request the value related to the plug-in front panel settings.
80 INPUT #1,E	Enter 4094 command error code.
90 INPUT #1,P	Enter the setting value.
100 INPUT #1,E	Enter error code for data transmission.
110 A1=Ø : A2=Ø : A3=Ø : A4=Ø	Initialize A1-A4.
120 IF P> 32767 THEN P=P-32768	Bring P into range of 16-bit logic.
130 IF P AND 1 THEN A1=1	Test first bit of P.
140 IF P AND 2 THEN A2=1	Test second bit of P.
150 IF P AND 4 THEN A3=1	Test third bit of P.
160 IF P AND 8 THEN A4=1	Test fourth bit of P.
170 PRINT A1; A2; A3; A4	Print the four bits, corresponding to A1-A4 in Table 13-28.
180 PRINT #1, "Q"	Send "Q" command to deactivate scope.
190 CLOSE	Close the IBM's serial port.
200 END	End of program.

IBM PC PROGRAM #12

Mainframe front panel controls can be set via computer interfaces. This program allows the horizontal and vertical expansions to be set.

10 OPEN "COM1:3ØØ,S,7,1,LF" as #1	Open the IBM serial port at 300 baud.
20 PRINT #1, CHR$(1) + ">";	Send CONTROL-A and ">" to activate scope's RS-232 interface.
30 PRINT #1, "Z1"	Send "Z1" command to scope, to turn on computer control.
40 INPUT #1,E	The 4094 command error code is entered into the computer.
50 PRINT "TYPE IN DESIRED HORIZONTAL EXPANSION"	Display message on PC screen.
60 INPUT A	Set A equal to desired expansion factor.
70 PRINT #1, "M,7,"; A 80 INPUT #1,E	(Lines 70 and 80) Send command M to scope to set horizontal expansion.
90 PRINT "TYPE IN DESIRED VERTICAL EXPANSION"	Display message on PC screen.
100 INPUT B	Set B equal to desired expansion factor.
110 PRINT #1, "M,6,"; B 120 INPUT #1,E	(Lines 110 and 120) Send command M to scope to set vertical expansion.
130 PRINT "PRESS F5 (cont) TO REVERT TO KNOB SETTINGS"	Display message on PC screen.
140 STOP	Wait for CONTINUE command.
150 PRINT #1, "ZØ" 160 INPUT #1,E	(Lines 150 and 160) Send command "ZØ" to scope to turn off computer control.
170 PRINT #1, "Q"	Send "Q" command to deactivate scope.
180 CLOSE	Close the IBM's serial port.
190 END	End of program.

IBM PC PROGRAM #13

This program is an example of a typical application program. It is considerably more complex than the previous samples, and should not be attempted until some skill is developed with simpler programs.

The first section (lines 30-130) initializes the 4094 for compatibility with the PC.

The program looks at the normalizing set for waveform number 1, to determine how many data points it contains. All of waveform 1 is then transferred to the PC, using a binary data transmission. The volume of data requires that a communications buffer be established in the PC, and that handshaking be used.

When the data transfer is complete, the last section (lines 450-530) allow the data to be stored in binary form on the PC disk drive. The next sample program recalls this data from the disk.

The program requires that PC BASIC be brought up from DOS with the command "BASICC:2048", to create a 2K byte communication buffer.

Due to the speed limitations of the BASIC language, transfer of a full 16K waveform will take several minutes.

10 DEFINT A-Z	Declare all variables integers.
20 DIM N#(11)	Declare N as a double precision array to contain normalizing factors.
30 OPEN "COM1:3ØØ,S,7,1,LF" AS #1	Open PC serial port at 300 baud, as file number 1.
40 PRINT #1, CHR$(1) + ">";	Send CTL-A and ">" to activate scope's RS-232 interface.
50 PRINT #1, "K,Ø,131,52"	Send K command to change scope's baud rate to 9600.
60 CLOSE	Close PC serial port. (This also discards 4094 error code from previous line.)
70 OPEN "COM1:96ØØ,N,8,1" AS #1	Re-open PC port at 9600 baud. Use 8 bits for binary data.
80 PRINT #1, "C,13,13" + CHR$(1Ø)	Send C command to change scope's command delimiter to <CR>, to match PC.
90 INPUT #1,E	Enter 4094 command error code.
100 PRINT #1, "C,8,1,13" 110 INPUT #1,E	(Lines 100 and 110) Send C command to set scope's error delimiter to <CR>.
120 PRINT #1, "C,4,1,13" 130 INPUT #1,E	(Lines 120 and 130) Send C command to set scope's record separator to <CR>.
140 PRINT #1, "N,Ø" 150 INPUT #1,E	(Lines 140 and 150) Send N command to read norm. set for waveform 1. (N-set 0.)
160 FOR I=1 TO 11 170 INPUT #1, N#(I) 180 NEXT I	(Lines 160 - 180) Enter normalizing factors from scope into array N!.

```
190 INPUT #1,E
```

Enter error code for data transmission.

```
200 X = 15872/2^N#(2)
```

Calculate number of data points in waveform 1, using Sweep Size Index (stored in N!(2).)

```
210 DIM D(X)
```

Dimension data array for number of points in waveform 1.

```
220 PRINT "Waveform #1 has"; X; "data points."
230 PRINT "Time per point ="; N#(6)
240 PRINT "Voltage range  ="; N#(5)*32ØØØ
250 PRINT "Transferring data to PC...."
```

(Lines 220 - 250) Display messages on PC screen.

```
260 R=X : I=Ø
```

R is the number of points that remain to be transferred. I is the number transferred so far.

```
270 PRINT #1, "D,4,1,Ø'," + STR$(X) + ",1"
280 INPUT #1,E
```

(Lines 270 and 280) Sent D command to scope, for binary output of X points.

```
290 IF R<1ØØØ THEN 32Ø
```

If less than 1000 points remain, buffer will not overflow and handshaking can be ignored.

```
300 IF LOF(1) > 5Ø THEN 3ØØ
```

Wait for buffer to fill within 50 bytes. LOF(1) is the room left in the input buffer.

```
310 PRINT #1, CHR$(19);
```

Send XOFF, CHR$(19), to scope, to pause data transmission.

```
320 WHILE LOC(1) > 3 :
    H$ = INPUT$(1,1) :
    L$ = INPUT$(1,1) :
    D(I) = CVI(L$+H$) :
    I = I+1 :
    WEND
```

This line combines functions to optimize speed.
While more than 3 bytes remain in input buffer:

- Read one byte int H$
- Read one byte into L$
- Combine the two bytes to form an integer data value (D(I)
- Increment the point count.

At end of line, buffer is near empty and ready to be refilled with the next 2K bytes.

```
330 PRINT "Finished with data point"; I
```

Let user know how it's going.

```
340 R=X-I
```

Calculate number of points yet to be transferred.

```
350 IF R > Ø THEN PRINT #1, CHR$(17);:
    GOTO 29Ø
```

If more points remain, send XON to scope to resume transmitting. Return to line 290 and wait for buffer to fill again.

```
360 INPUT #1,E
```

At this point, all the data has been read and only the last error code is still in the input buffer.

```
380 HZ# = N#(8)*65536! + N#(9)
```

Calculate HZERO from normalizing factors.

```
390 PRINT "FIRST TEN DATA POINTS:"
400 PRINT "Seconds", "Volts"
410 FOR J=Ø TO 9
420 PRINT (J-HZ#)*N#(6), (D(J)-N#(7))*N#(5)
430 NEXT J
440 PRINT
```

(Lines 390 - 440) Display the first ten points, in normalized form.
Seconds = (# of point - Hzero) x (Hnorm).
Volts = (data value - Vzero) x (Vnorm).

```
450 PRINT "If storage to disk is desired,
    type name of file, up to 8 char."
460 PRINT "If not, press <ENTER>."
470 BEEP
```

(Lines 450 - 470) Prompt user for input.

```
480 INPUT T$
```

Read from keyboard.

```
490 IF T$ = "" THEN 54Ø
```

If no input, skip to end.

```
500 NP = VARPTR(N#(1))
```

Find memory address where first element of N! is stored.

```
510 BSAVE T$+".NOR", NP, 88
```

Save 88 bytes (11 double precision values), beginning at address found above, to disk file with ".NOR" suffix.

```
520 DP = VARPTR(D(Ø))
```

Find memory address where waveform data begins.

```
530 BSAVE T$+".DAT", DP, 2*X
```

Save 2X bytes (X integers) to disk file with ".DAT" suffix.

```
540 PRINT "END OF PROGRAM"
550 END
```

(Lines 540 and 550) End of program.

NOTE: Optionally, normalized voltage data may be stored to disk in Data Interchange Format (DIF), usable with most spreadsheet and database programs. However, this consumes substantially more time and disk space.

Replace lines 500 to 550 with the following:

```
500 PRINT

510 PRINT "Normalizing and storing data -
    takes up to several minutes ..."
```

```
520 OPEN T$+".PRN" FOR OUTPUT AS #2
```

Open disk file with user's title and .PRN suffix.

```
530 FOR K=Ø TO X-1 :
  PRINT #2, (D(K)-N#(7))*N#(5) :
  NEXT K
```

For each data point, normalize to a voltage value and send to file.

```
540 CLOSE : PRINT "End of program."
```

Close COM port and disk file.

```
550 BEEP : END
```

End of program.

IBM PC PROGRAM #14

This program recalls the PC disk files created by program 13.

10 DEFINT A-Z	Declare all variables integers.
20 DIM N#(11)	Declare N as a double precision array to contain normalizing factors.
30 PRINT "Type in name of file to retrieve"	Prompt user for input.
40 INPUT T$	Read from keyboard.
50 NP = VARPTR(N#(1))	Find memory address where the first element of N# is stored.
60 BLOAD T$+".NOR", NP	Load file (T$).NOR into memory starting at the above address.
70 X = 15872/2^N#(2)	Calculate number of points in data file, using Sweep Size Index (stored in N#(2).)
80 DIM D(X)	Dimension an array for the data from the disk file.
90 DP = VARPTR(D(Ø))	Fine memory address where array D begins.
100 BLOAD T$+".DAT", DP	Load file (T$).DAT into memory starting at the above address.
110 HZ# = N#(*)*65536! + N#(9)	Calculate Hzero.
120 PRINT "File" + T$ + " contains"; X; "data points"	Display message.
130 PRINT "FIRST TEN DATA PONTS:" 140 PRINT "Seconds", "Volts" 150 FOR J=Ø TO 9 160 PRINT (J-HZZ#)*N#(6), (D(J)-N#(7))*N#(5) 170 NEXT J	(Lines 130 - 170) Display the first ten points, in normalized form. Seconds = (# of point - Hzero) x (Hnorm.) Volts = (data value - Vzero) x (Vnorm.)
180 END	End of program. Waveform data is now stored in integer array D(n). Normalizing factors are stored in array N#(n).

INTRODUCTION

The following special procedures have 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.

NOTE: The term "Hold Mode" will be used in the following discussions to signify that the Plug-in is in the Hold Last mode (LIVE and HOLD NEXT LED's off, HOLD LAST LED on).

Index 14-1

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 positioned properly.

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 accidental loss of data upon the completion of the sweep.

See Table 8-4 in the appropriate plug-in description under the PLUG-INS section (Tab 8) of this manual for approximate sweep times.

TERMINATING SLOW SWEEPS

To terminate a slow sweep:

#1. Hold in the HOLD LAST button.

#2. Momentarily press the LIVE button.

#3. Release 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 which, in turn, may cause 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 positioned properly.

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 capturing data. See the DELAY control description for the appropriate plug-in under the PLUG-INS section (Tab 8) for further discussions.

NOTE: The term (T_0) in Figures 14-1 through 14-8 (pages 14-4 through 14-6) represents the trigger time (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 signals illustrated in the figures were captured while in the External Trigger mode.

Single Plug-in Operation

A single trigger applied to either channel A or B, or to the EXT input BNC will initiate a sweep for both channels. However, the only time that both channels will simultaneously capture data for display is when either:

a. Both channels are operating in the Normal trigger mode, or

b. Both channels are operating in the Cursor (or Delayed) trigger modes and identical delays have been selected.

Therefore, when viewing displays captured with different trigger modes (or identical trigger modes with different delays), it is important to remember that the displayed data groups are displaced in time with respect to each other.

The figures on pages 14-4 and 14-5 illustrate the relationships of the displayed data groups for each of the possible combinations of trigger modes.

Two Plug-in Operation

When employing two plug-ins to capture 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.

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 14-7 (page 14-6) 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 14-8 (page 14-6) illustrates the effect of triggering sweeps on each plug-in with a different trigger.

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.

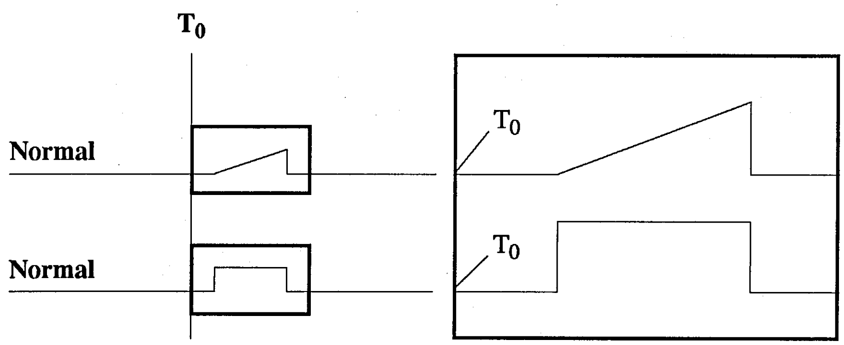


Figure 14-1

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.

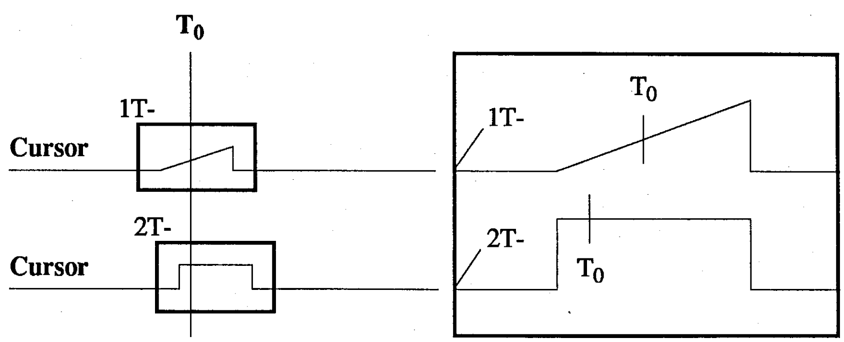


Figure 14-2

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.

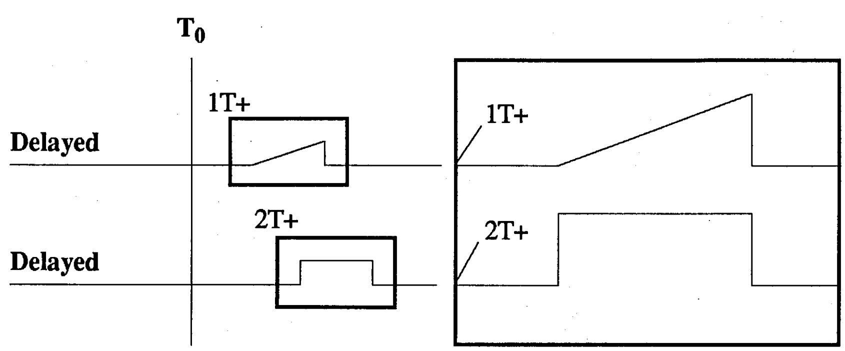


Figure 14-3

MIXING TRIGGER MODES

NORMAL/CURSOR

Extreme left of screen always corresponds to the (T_0) 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.

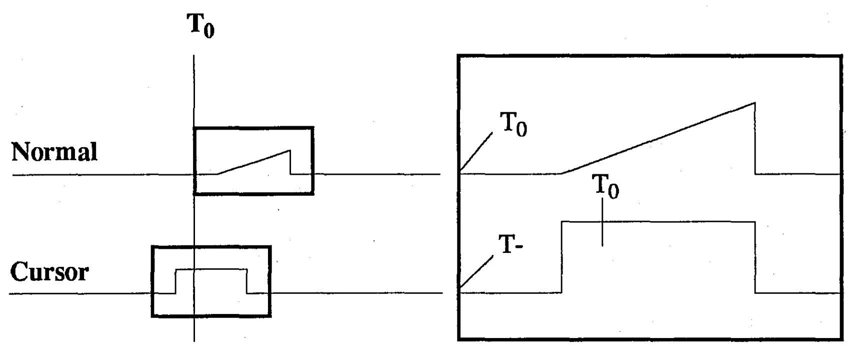


Figure 14-4

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.

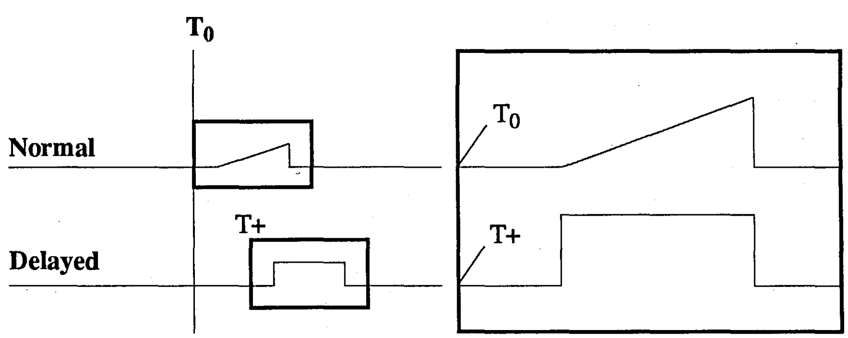


Figure 14-5

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.

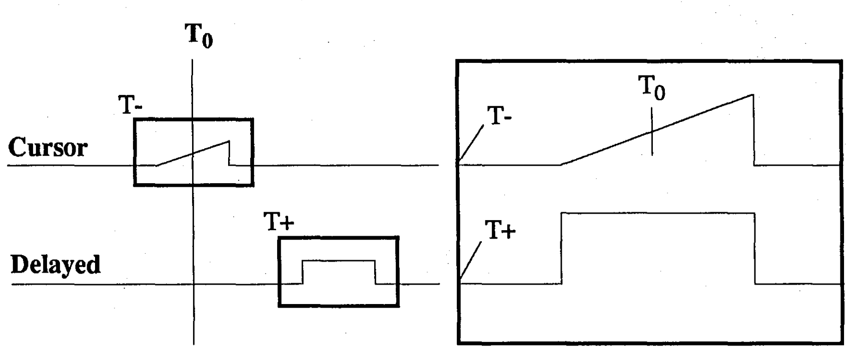


Figure 14-6

COMMON TRIGGERS versus SEPARATE TRIGGERS

COMMON TRIGGERS

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 the screen corresponds to the time at which acquisition began on each individual channel.

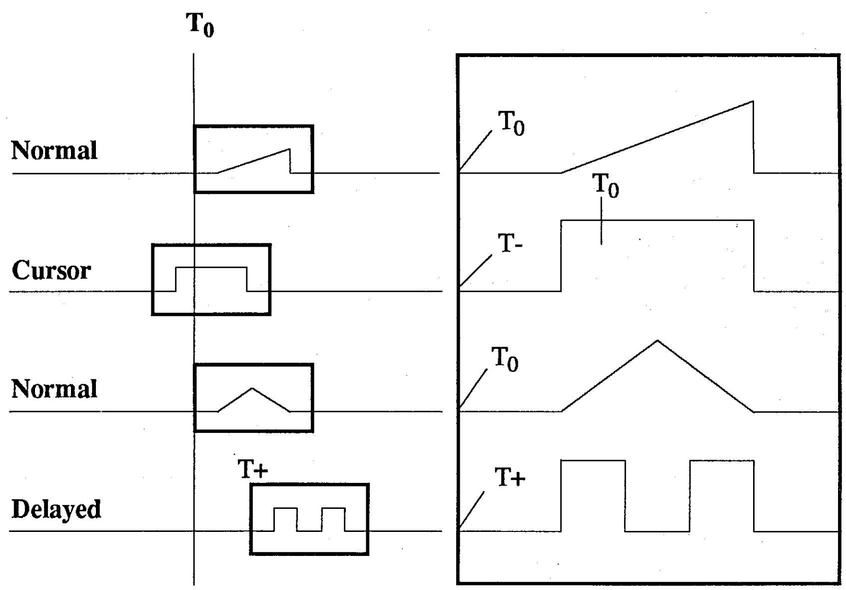


Figure 14-7

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 the screen corresponds to the time at which acquisition began on each individual channel.

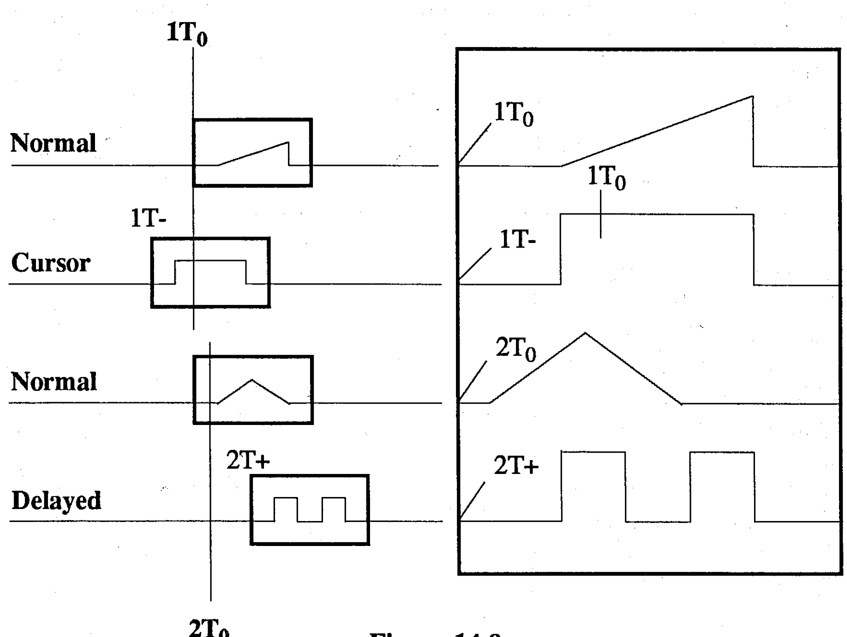


Figure 14-8

SETTING A D.C. TRIGGER LEVEL

The trigger VIEW function 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 trigger sensitivity are visually accurate when performing the "Adjusting the Trigger" procedure located under the Plug-ins tab in this manual. However, the voltage values read by the cursor are only accurate to within approximately 5%.

There are two alternative methods (Continuous Signals on this page and One-Shot Signals on page 14-8) which may be used to set an internal D.C. trigger level.

The Continuous Signals procedure provides an exact D.C. trigger level.

The accuracy of the One-Shot Signals procedure depends on how carefully Step #17 of the procedure 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. Press the LIVE button.

#4. Select AUTO triggering.

#5. Select DC coupling.

#6. Select either "+" or "-" SLOPE triggering.

#7. Set trigger SOURCE to either "A" or "B", whichever channel is being used.

#8. Turn AUTOCENTER on.

#9. Place the mainframe FUNCTION switch to any position but "Numerics Reset".

#10. Turn on trigger VIEW mode.

#11. Adjust the SENSITIVITY as required for trigger sensitivity.

#12. Turn off trigger VIEW mode.

#13. Adjust the trigger POSITION delay until the trigger cursor (small crosshair) is visible.

#14. Position the vertical cursor over the trigger cursor. The Time Numerics should read zero.

#15. Adjust the LEVEL until the voltage numerics decode the required trigger voltage level.

#16. Adjust the trigger POSITION until the delay is set to the 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. Press the LIVE button.

#3. Select AUTO triggering.

#4. Select DC coupling.

#5. Select either "+" or "-" SLOPE triggering.

#6. Set trigger SOURCE to either "A" or "B", whichever channel is being used.

#7. Turn AUTOCENTER on.

#8. Place the FUNCTION switch to any position but "Numerics Reset" or "Grid".

#9. Turn on the VIEW mode.

#10. Adjust the SENSITIVITY as required for trigger sensitivity.

#11. Turn off trigger VIEW mode.

#12. Adjust the trigger POSITION delay until the trigger cursor (small crosshair) is visible.

#13. Position the vertical cursor over the trigger cursor. The Time Numerics should read zero.

#14. Adjust the LEVEL fully clockwise for positive (+) slope triggering, fully counterclockwise for negative (-) slope triggering.

#15. Adjust the channel's POSITION control until the trace is positioned vertically at the screen level where triggers are to occur.

#16. Select the NORMAL trigger mode.

#17. Adjust the LEVEL control very slowly 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. Place the FUNCTION switch to Reset Numerics.

#19. Press the EXECUTE button.

#20. Select the AUTO trigger mode.

#21. Adjust the channel's POSITION control until the voltage numerics decode the opposite sign and the required voltage value appears.

For example, if a trigger level of +500 mV is desired, adjust the POSITION control until the voltage numerics decode -500 mV.

#22. Place the FUNCTION switch to any position <u>but</u> "Reset Numerics".

#23. Adjust the trigger POSITION control for the required delay value.

#24. Select NORMAL triggering.

#25. Apply the input signal and place the adjacent input BNC switch to the "DC" position.

#26. Wait for a valid trigger and resulting waveform display.

4094C Only

INTRODUCTION

> **NOTE:** This section describes the plotter procedures for the Model 4094C digital oscilloscope only. Refer to the following section for the 4094A and 4094B oscilloscopes.

This plotting program labels the horizontal and vertical axes for up to four separate waveforms. The waveforms may be from the Y/T or X/Y display modes.

The waveforms are drawn with solid lines and are identified by separate colors. The vertical axis is labelled in volts (mVolts, uvolts, kvolts, etc.). The horizontal axis is labelled in time (seconds, msec., usec., etc.). Because of the limitless combinations of time and voltage possible, each waveform has its own axes labels. (See example in Figure 1, page 15-6.)

If a title has been added to a waveform, the title is printed at the top of the plot. When two or more titles exist, only the title from the waveform in Q1 is printed.

This Plot Routine is designed for plotters which use the RS232C interface, or Option 001 on plotters such as the HP7470A and HP7440 ColorPro. If you have a plotter with an HPIB or GPIB interface, use the plotting program provided on the Standard Package of programs. This program diskette is supplied with all 4094Cs which have a disk drive.

Requirements

#1. Must use PLOTTER interface on 4094 with special cable.

#2. Plotter must use HPGL Language and Hardware Handshake.

Typical Plotters: HP7470, HP7475, HPColorPro, NIC Sprint.

Digital Plot Features

- Plots up to four plots on a single sheet of paper.
- Provides two plotting modes:
- **Standard Resolution -** Maximum of 1024 points (40 seconds - 2.4 minutes).
- **High Resolution -** All points plotted (up to 7 minutes).
- Selects different colored pens for different waveforms automatically.
- Provides scale information: volts/div. and time/div., etc.
- Scales plot to accomodate various paper dimensions.
- Plots only the waveform indicated by the Plug-in/Channel Identifier.
- Plots vertical and/or horizontal expanded waveforms.
- Plots a title displayed on the display screen's Status Line.

4094C Only

HARDWARE SETUP

Refer to the plotter manual to set up the plotter with the following parameters:

Plotter:

#1. 9600 BAUD, or Bits per Second.

NOTE: Any available Baud rate may be selected. But the plotter Baud rate must MATCH the 4094 plotter out baud rate! To change the plotter's Baud rate, consult your plotter manual. To change the 4094 plotter port Baud rate, refer to page 7-27 (Mainframe tab).

#2. ONE stop bit.

#3. Parity OFF.

#4. U.S. paper size limits.

#5. Hardware Handshake. (On most HP plotters, the power-up default is for Hardware Handshake. On others, this is setup through selection by the operator.)

The plotting program fills 8-1/2 " x 11" paper. To change the size of the plot on your paper, you can select new lower left and upper right limits. See the plotter manual for instructions on how to set these limits.

4094 & Cable

#1. The 4094 plotter BAUD rate is factory preset to 9600, one stop bit, parity off. To check these parameters, turn the FUNCTION switch to I/O STATUS, press EXECUTE, and read the Plotter parameters.

#2. Connect the Cable supplied by Nicolet. Connect the end labelled 4094 to the 4094 plotter port at the back of the 4094. Connect the end labelled PLOTTER to the RS232 port on the plotter. If you do not have this cable, it will be necessary to order one or to build your own cable as diagrammed in Figure 15-1.

The plotter pin #20 to 4094 pin #4 connection is used for hardware handshaking. When the plotter buffer is full, the plotter pulls pin #20 low. This causes the 4094 to see a low voltage on pin #4 (CLEAR TO SEND LINE) and to stop transmitting data. Data transmission resumes when the plotter pulls pin #20 high again.

4094 Pin	Plotter Pin	Function
2	2	Plotter Transmit, 4094 Receive
3	3	4094 Transmit, Plotter Recieve
7	7	Ground
4	20	Hardware Handshaking Lines

Figure 15-1

4094C Only

EXECUTING A PLOT

#1. Turn the 4094 FUNCTION switch to the PLOT position.

#2. Display the desired signal or signals.

#4. Press the HOLD LAST button and wait for the sweep to end.

#5. Press EXECUTE.
The plotter draws a box with tic marks and a title if present. The plotter pauses for you to select a waveform for plotting.

#6. Select a waveform using the cursors or the MEMORY switch and then press EXECUTE. The plotter labels the voltage and time axes and draws the selected waveform.

#7. If you are plotting more than one waveform, select the next waveform to be plotted. You may plot up to 4 separate waveforms sequentially. The program selects different pens for plotting different waveforms if the pens are available.

#8. To EXIT the program before 4 waveforms have been plotted, turn the FUNCTION switch away from the PGRM position.

USEFUL HINTS

#1. The waveform display may be altered between waveforms using the expansion controls and cursor buttons.

#2. To attain zero volts at the center of the plot (no vertical expansion), use the "Centering Zero Volts" program before running the PLOT program.

#3. The "tic" marks on the plot are at same location as the GRID lines. To see the grid lines, turn the FUNCTION switch to GRID before entering the plot program.

4094C Only

STANDARD RESOLUTION PLOTS

A maximum on 1024 data points are plotted for any signal. This requires from 40 seconds to 2.5 minutes.Which of a waveform's data points will be plotted is shown in Table 1.

Example

If the MEMORY switch is in the ALL position, one channel on, the waveform contains 15,872 data points. With HORIZONTAL EXPANSION OFF, every 16th point will be plotted. If two channels are on, each waveform contains 7,936 data points, and every 8th point of a waveform will be plotted.

HIGH RESOLUTION PLOTS

All of the selected waveform's displayed data points are plotted, requiring up to 7 minutes for a full 15,872-point signal.

To execute a high resolution plot, press and hold the EXECUTE button, then toggle the AUTOCENTER switch to the "ZERO" position. This action tells the program to plot every data point on the selected signal.

SAMPLE PLOTS

Refer to page 15-6 for sample plots.

INCREMENTAL SELECTION OF STANDARD PLOT DATA POINTS								
MEMORY SWITCH POSITION	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 15-1

(*) All of the selected waveform's displayed data points are plotted.

4094C Only

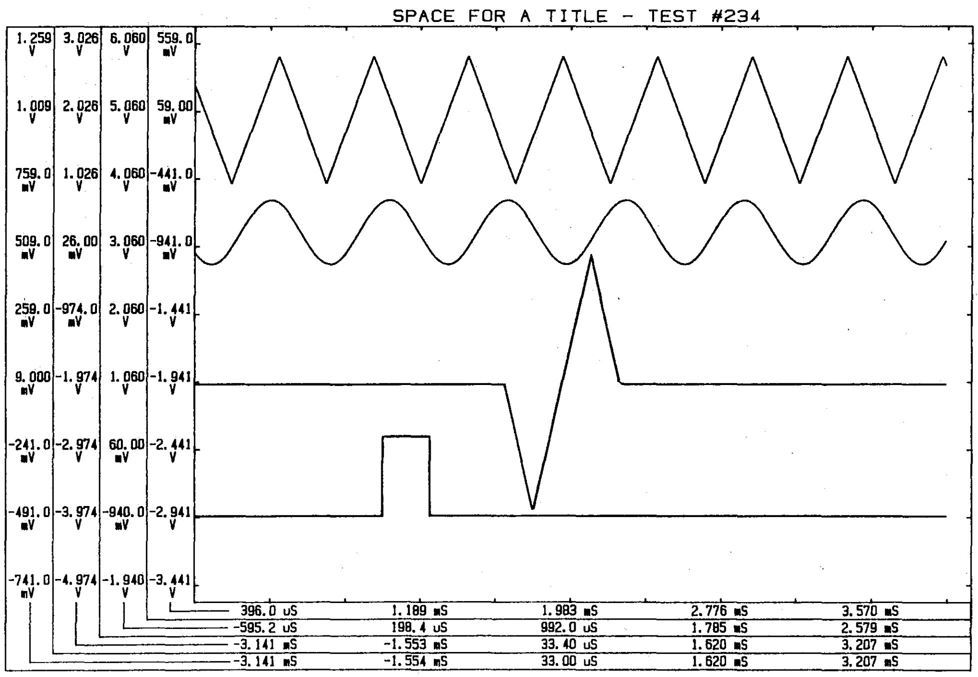


Figure 15-2 - Y/T Plot of Four Waveforms

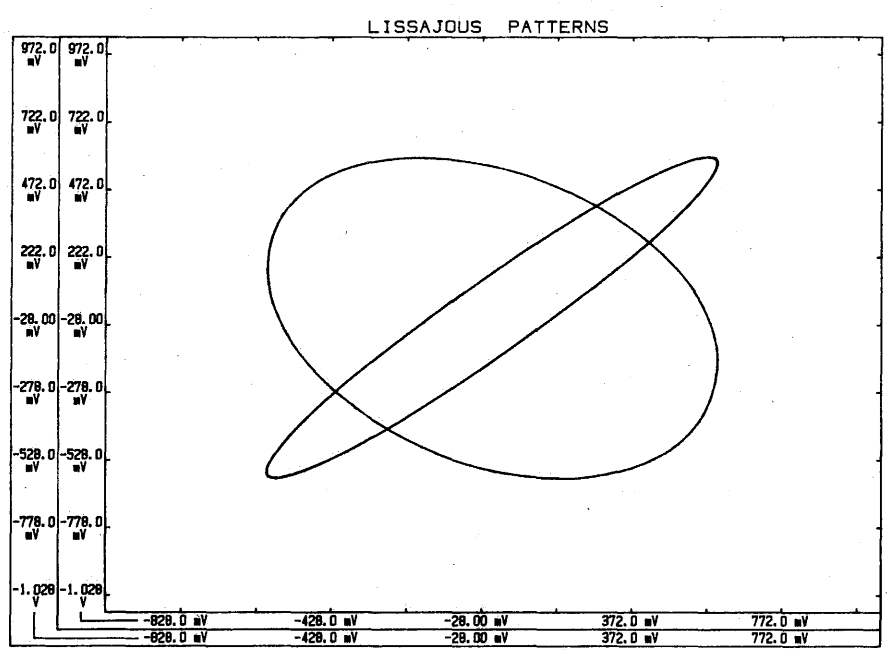


Figure 15-3 - X/Y Plot of Two Lissajous Patterns

4094A & 4094B Only

INTRODUCTION

> **NOTE:** This section describes the plotter procedure for the Model 4094A and 4094B oscilloscopes only. Refer to the preceding section for the 4094C oscilloscope.

The 4094 digital plot program is designed to plot up to four separate waveforms on a digital plotter with an RS232 Interface. If your plotter has a GPIB interface, a disk downloadable plot program is available on the Standard Package of programs.

PLOTTER Pin #	4094 Pin # (Plotter Port)
2	2
3	3
7	7
20	4

Figure 15-1

NOTE: Hardware Handshaking uses pin 20 on the plotter, and pin 4 on the 4094. Most HP plotters power-up to accept Hardware Handshaking. Some require the user to select this option.

Digital Plotter Requirements

#1. Must have RS232 Interface.

#2. Must use HPGL (Hewlett Packard Graphics Language).

#3. Must use Hardware Handshaking.

Typical Plotters: 7470A, 7440 ColorPro, 7475 with option 001, Nicolet Sprint.

Digital Plot Features

- Plots up to four plots on a single sheet of paper.
- Provides two plotting modes:

  Standard Resolution - Maximum of 1024 points (40 seconds - 2.5 minutes).

  High Resolution - All points plotted (up to 7 minutes).
- Plots different line types (e.g., dashed, dot-dashed, etc.) for each of the four plots when high resolution is not selected.
- Pauses between plots, allowing different colored pens to be used.
- Provides scale information: volts/div. and time/div., etc.
- Scales plot to accomodate various graph paper dimensions.
- Plots only the waveform indicated by the Plug-in/Channel Identifier.
- Plots YT and/or XY waveform displays.
- Plots vertical and/or horizontal expanded waveforms.
- Plots a title displayed on the display screen's Status Line.

4094A & 4094B Only

PLOT ELEMENTS IDENTIFICATIONS

Figure 15-2 illustrates a typical plotting format, the dimensions of which are determined by the lower left and upper right plotting limits.

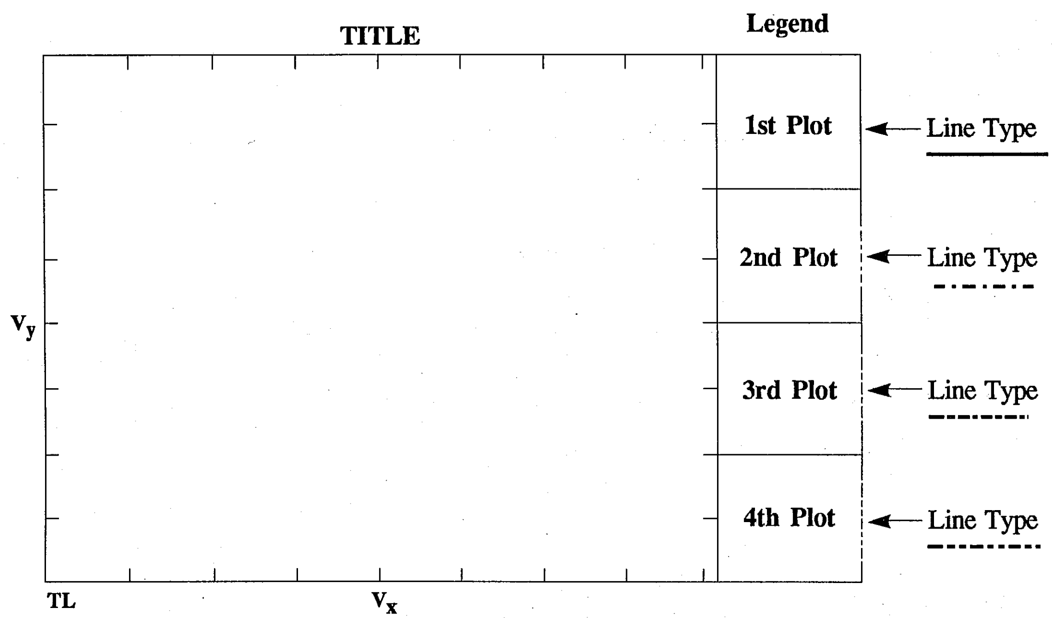


Figure 15-2

LEGEND

The legend is divided into four boxes. Each box identifies the time and voltage references for the following elements.

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.

4094A & 4094B Only

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 . For example, DIETZGEN Millimeter Graph Paper No. 341-M or equivalent.

The graph paper should be equivalent to the dimensions illustrated in Figure 15-3.

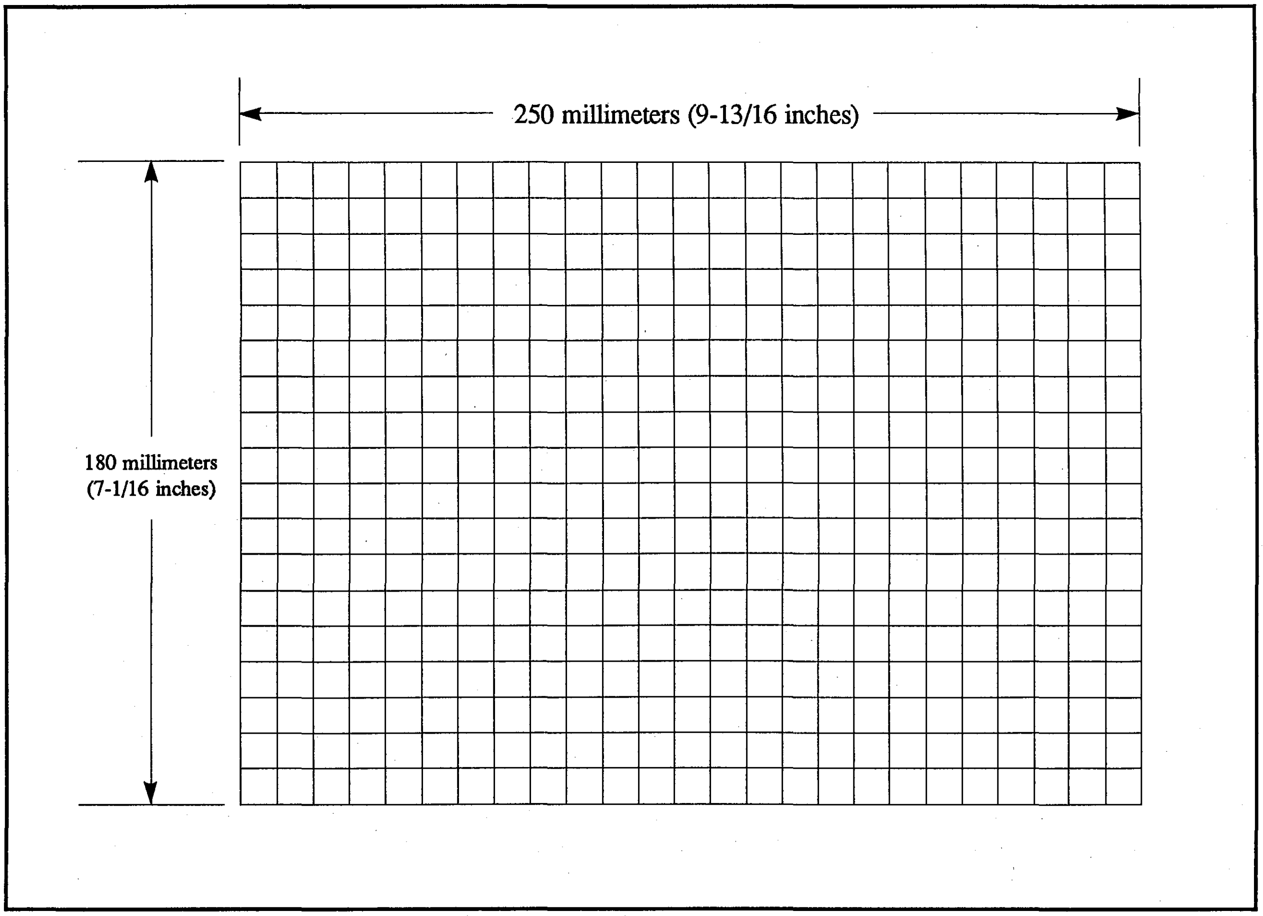


Figure 15-3

4094A & 4094B Only

LOADING THE PEN

When inserting the pen into the plotter's pen holder, hold the pen holder at point A (Figure 15-4) to ensure that the pen is securely "locked" into position.

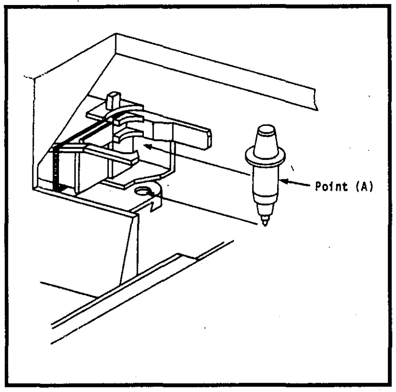


Figure 15-4

ABORTING THE PLOTTER PROGRAM

The Plotter Program can 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.

4094A & 4094B Only

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 15-1. For example, if
Memory Switch = ALL
Data Points Per Waveform = 7,936
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 POSITION	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 15-1

(*) All of the selected waveform's displayed data points are plotted.

4094A & 4094B Only

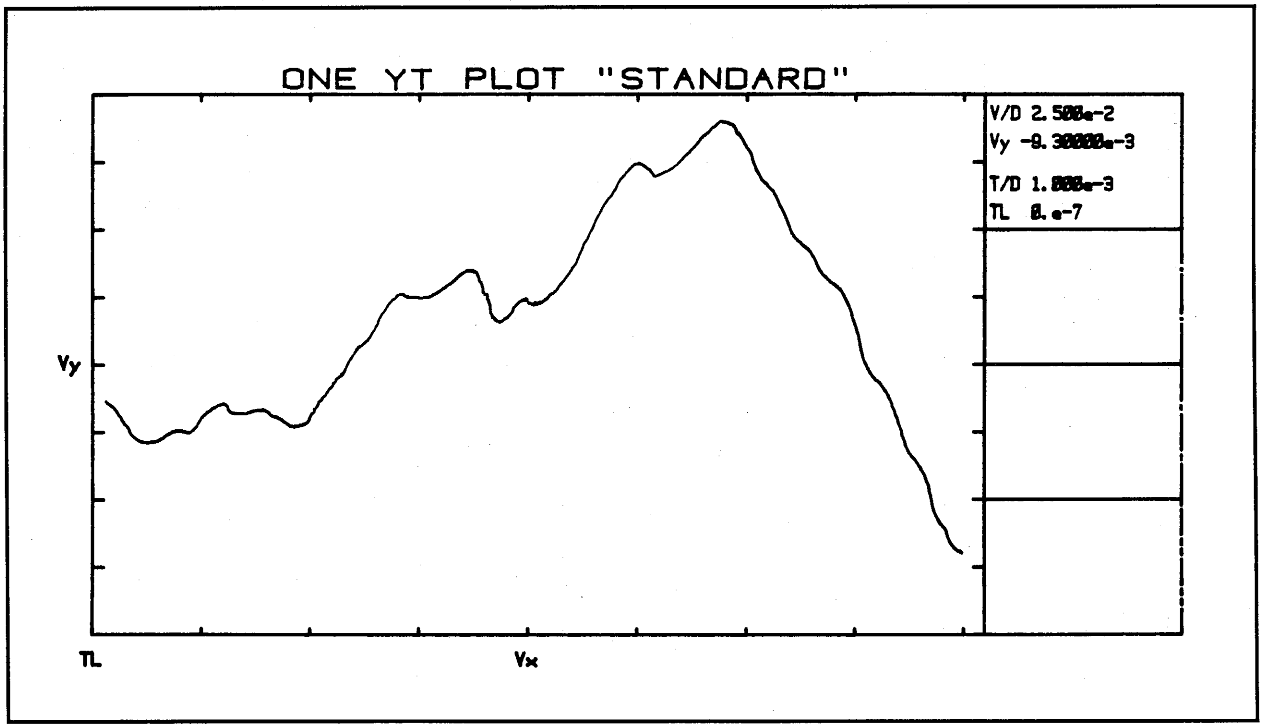


Figure 15-5

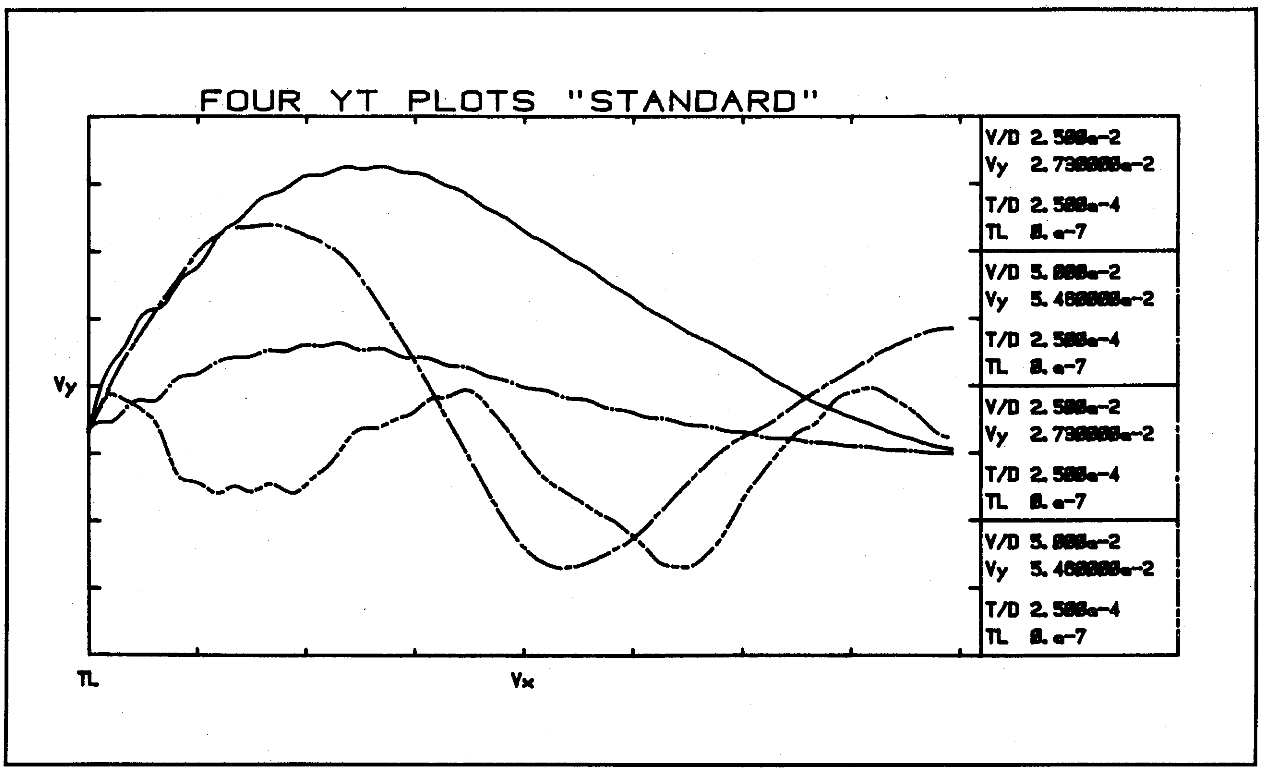


Figure 15-6

4094A & 4094B Only

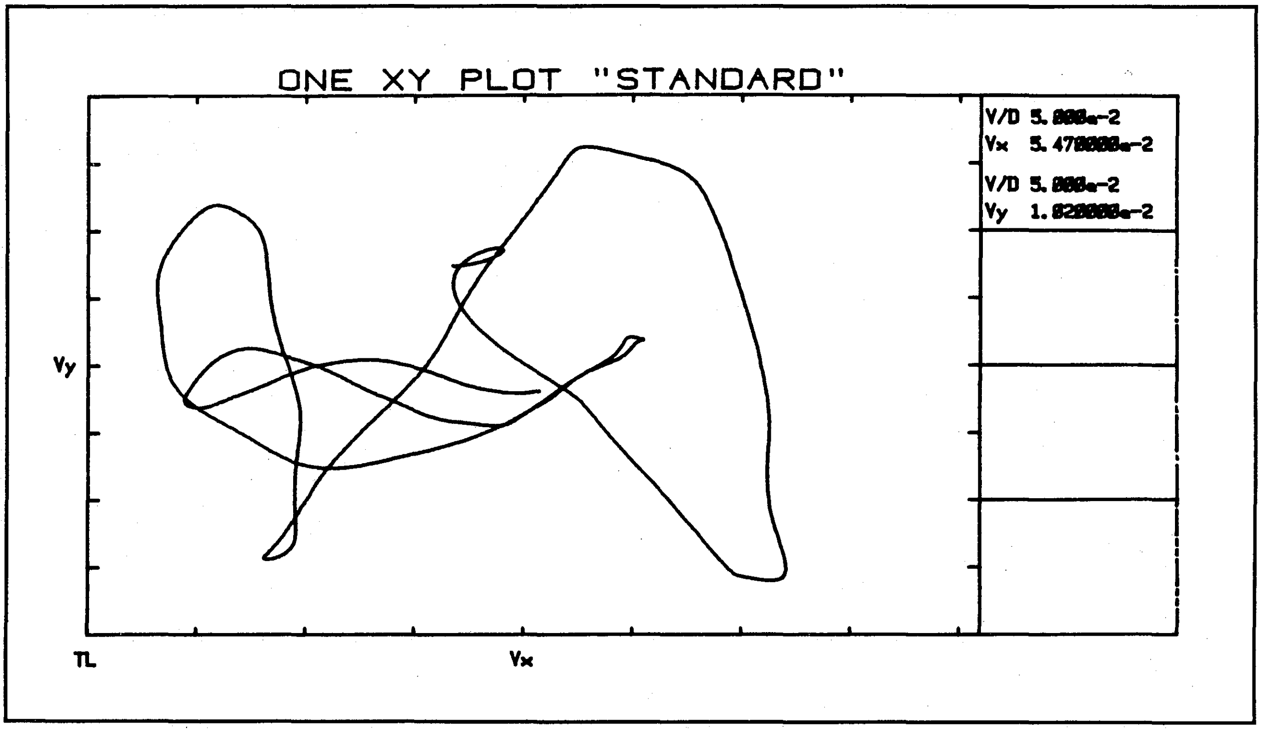


Figure 15-7

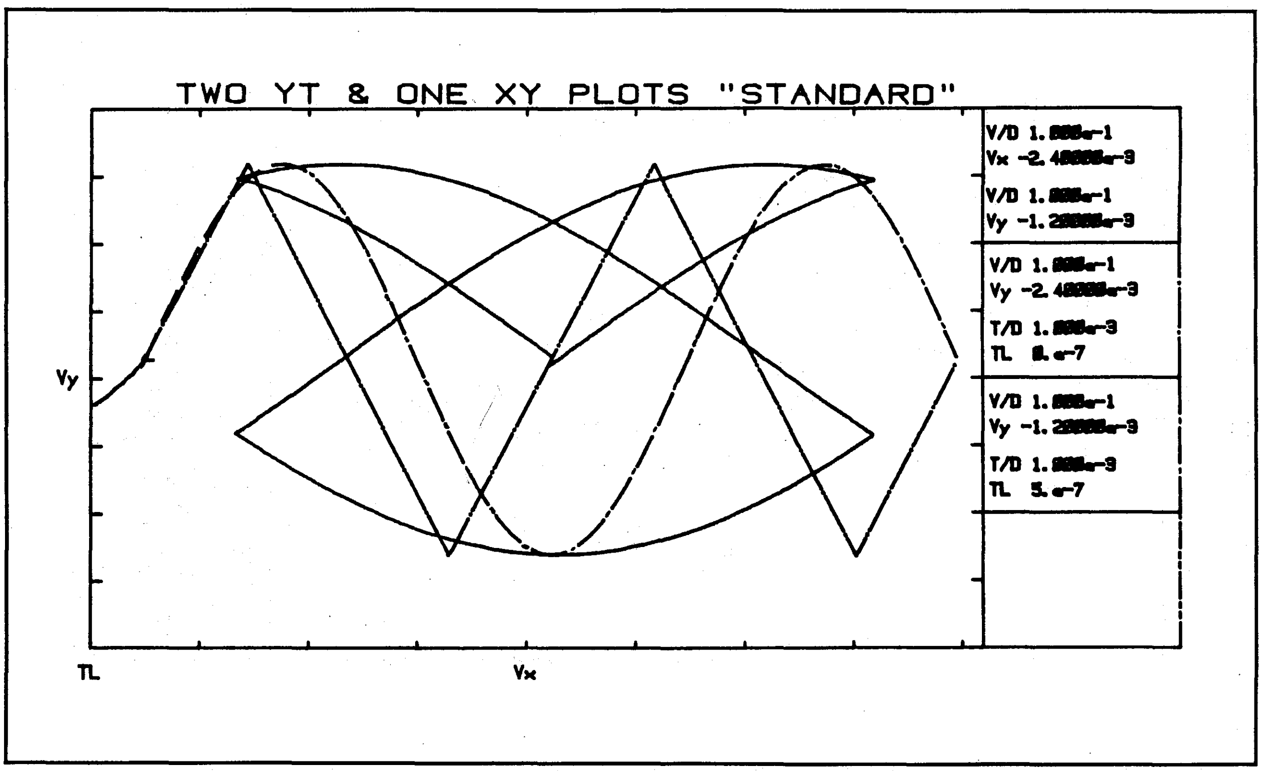


Figure 15-8

4094A & 4094B Only

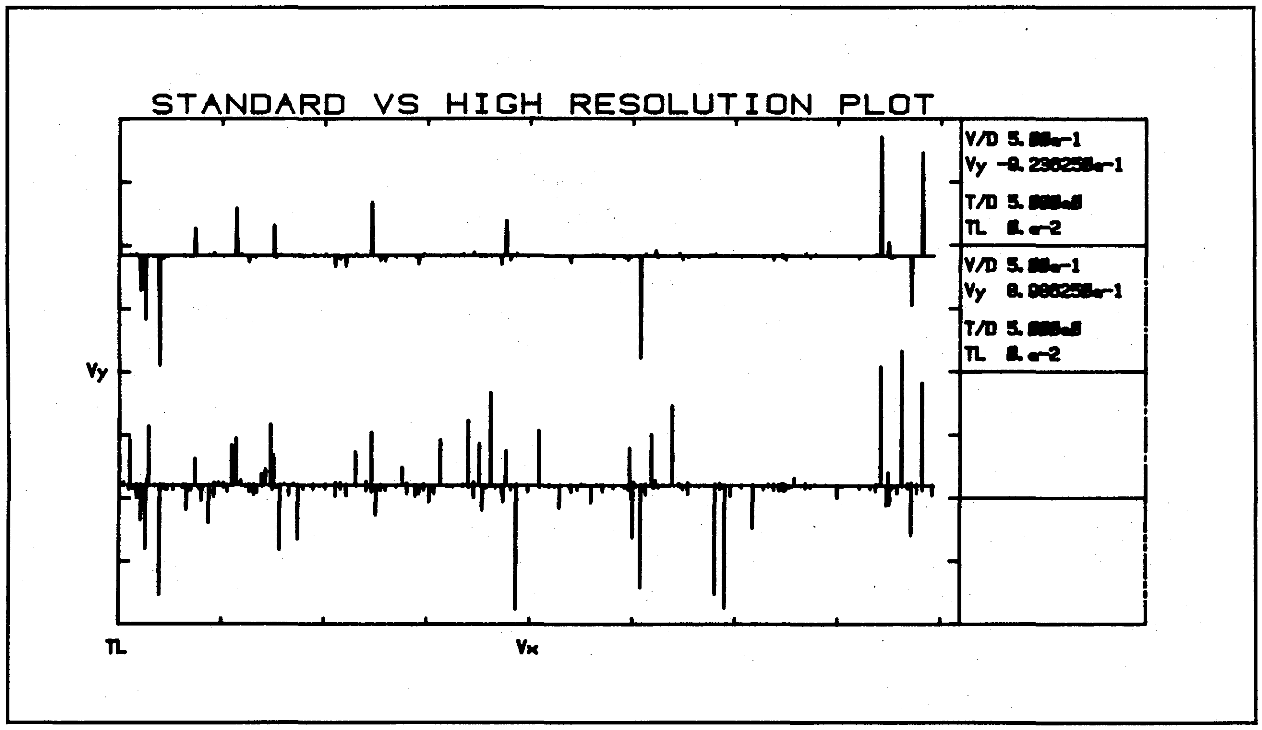


Figure 15-9

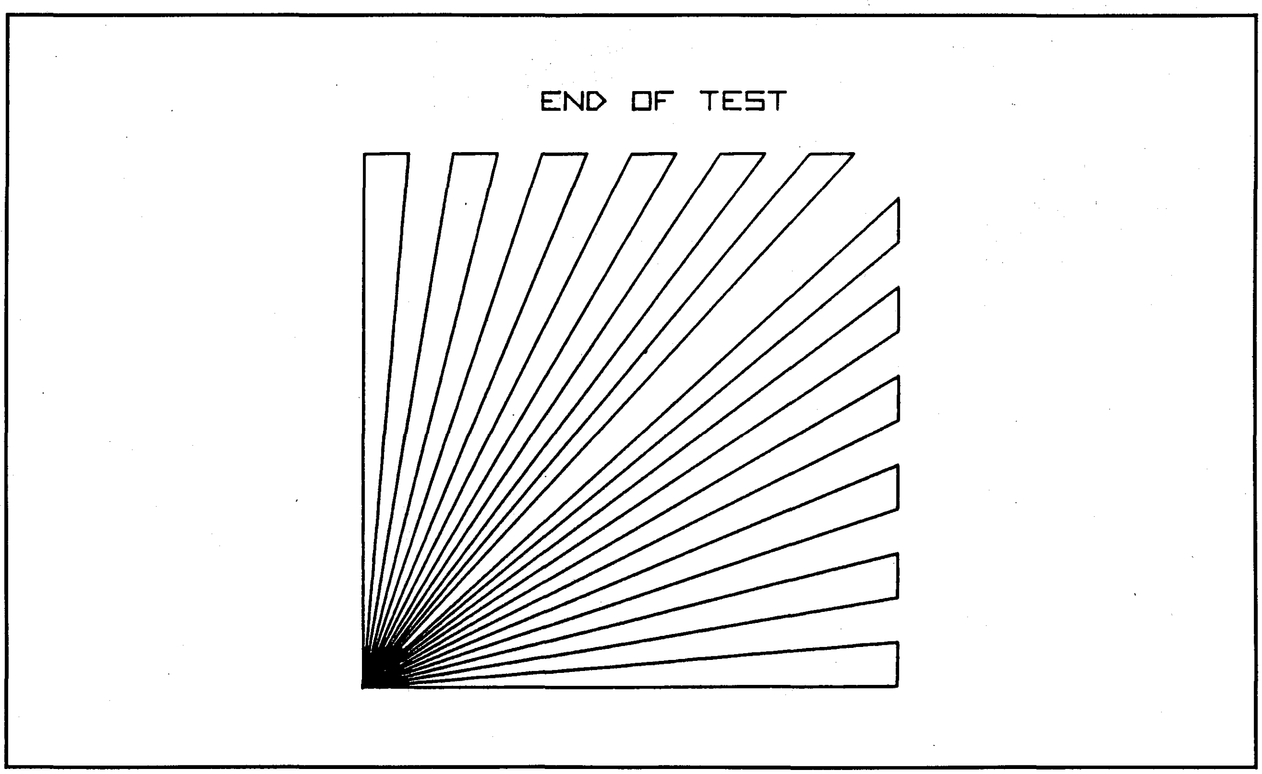


Figure 15-10

4094A & 4094B Only

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 Standard Program Package manual for instructions on the use of the Standard Pak program diskette. Then 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.

WARNING: High voltages exist within the 4094. Use care while performing Step #4.

#4. The 4094's plotter port 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 15-11).

NOTE: If a different BAUD rate is required, put switch 5 to the OPEN position and select the baud rate on switches 1-4 (see page 13-10). Match this BAUD rate setting with the setting on the plotter (see Plotter manual).

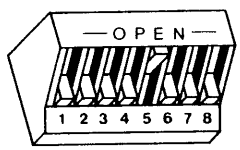


Figure 15-11

#5. Refer to the Plotter manual to set the plotter's PARITY to NONE.

#6. Refer to the Plotter manual to set the plotter BAUD RATE to 2400.

IMPORTANT - Verify the plotter's line voltage selection before applying power to the plotter. Refer to the Plotter manual.

#7. Load the paper.

#8. Place the mainframe FUNCTION switch to the PEN position.

NOTE: Lower left and upper right plotting limits may be set to match the graph paper (or desired plot size). See Plotter manual for changing plot size.

4094A & 4094B Only

#9. Press the Mainframe's EXECUTE button.

a. The border, Vy, Vx, TL, and Title are plotted when the button is released.

b. The plotter pauses to allow the user to select a waveform for plotting and to change pens, if desired.

#10. If only one waveform is being displayed on the screen, proceed with Step #11.

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.

#11. Position the selected waveform on the screen as necessary. This includes vertical/horizontal expansion, cursor position, YT or XY display, etc.

#12. If a high resolution plot is desired (every data point is plotted with a solid line), press and hold in the Mainframe EXECUTE button while placing the AUTO-CENTER 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.

#13. The plotter pauses to allow the user to select a waveform for plotting and to change pens, if desired.

#14. Repeat Steps #10 through #13 until up to four plots have been completed, if desired. A plot can be aborted at any time by turning the mainframe FUNCTION switch away from the PEN position.

4094A & 4094B Only

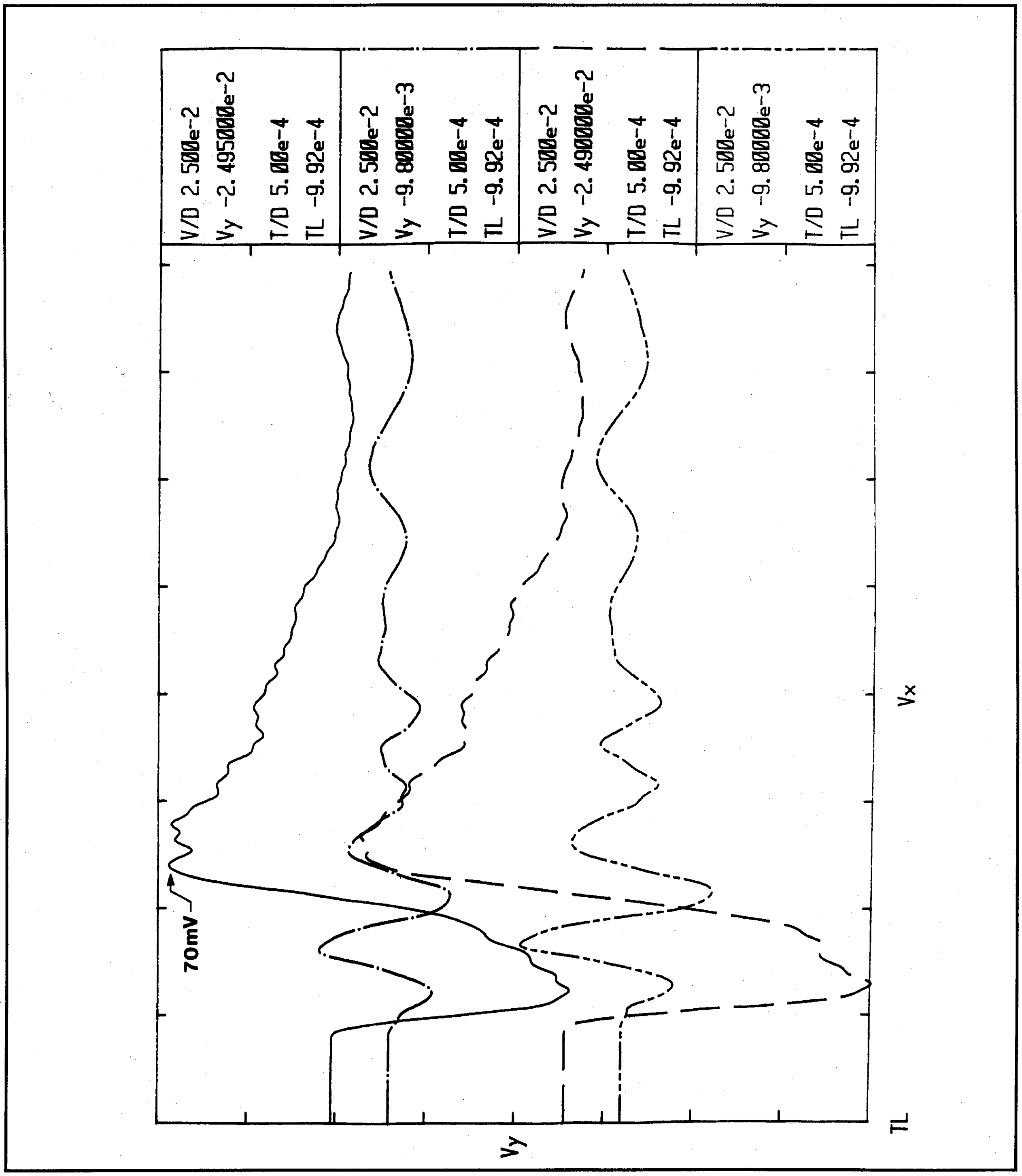


Figure 15-12

4094A & 4094B Only

READING THE DIGITAL PLOT

Two sample plots are included with this description. Figure 15-12 shows four signals (voltage vs. time), and Figure 15-13 shows an XY waveform (voltage vs. voltage). Look at Figure 15-12 first.

Which Box Refers to Which Waveform?

The line type shown at the right side of each box represents the waveform that is defined within that box. The upper most box in this example defines the waveform drawn with a continuous line.

Reading a Voltage Change

Refer to the uppermost box used to define the continuous line wave-form. The tick marks on the vertical (Y-axis) of the plot represent divisions, so V/D (volts per division) for the continuous line waveform =
2.5 e-2 = 2.5 X 10^2 = 25 mV.

To read the voltage from the trough to the peak of this waveform:

#1. Count the divisions separating the trough and peak:
4.5 divisions, approximately.

#2. Multiply by the volts/division:
4.5 X 25 mV = 112 mV, approximately

Reading Absolute Values

Vy is labeled on the plot at the center tick mark on the Y-axis and is used a reference line for voltage. If a horizontal line was drawn from Vy across the plot, the line would represent -24.95 millivolts on the uppermost waveform. Note that for the waveform represented by the second box (dot-dash-dot-dash, etc.), the horizontal line would represent -9.8 millivolts.

To find the value at a point on the waveform, (e.g., the peak of the first waveform indicated by the arrow) -

#1. Count the divisions from Vy:
+3.8 divisions, approximately.

#2. Multiply by the Volts/Division:
+3.8 X 25 mV = 95 mV

#3. Add Vy:
95 mV + (-24.95 mV) = 70mV, approximately.

Reading TIme

The tick marks on the X-axis represent divisions defined by T/D (Time Per Division) in the box. In this case, each tick mark represents 5 x 10^4, or 0.5 milliseconds along the X-axis. From the minimum to the maximum value on the upper waveform, the time difference is about 1.2 divisions, or about 1 millisecond before the trigger. The trigger point is therefore about 2 divisions from the left-hand side of the plot, or at the 2nd tick mark on the horizontal axis.

To find the time value at a point on the waveform, (e.g., the time at the peak of the first waveform) -

#1. Count the divisions from TL:
+2.4 divisions

#2. Multiply the the Time/Division:
+2.4 x 0.5 msec/division = +1.2 milliseconds

#3. Add TL:
+1.2 msec + (-.992 msec) = 0.2 milliseconds, approximately.

4094A & 4094B Only

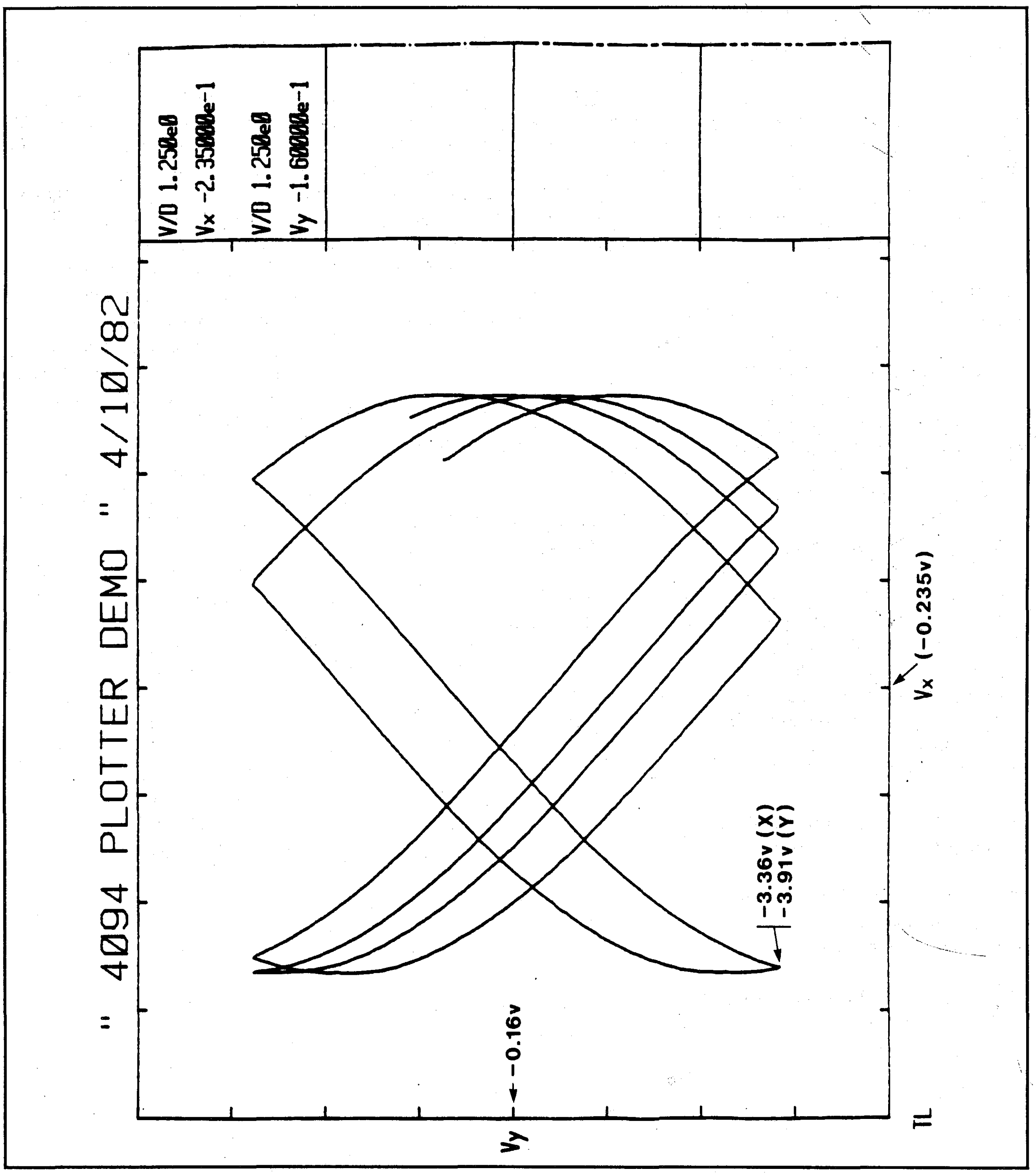


Figure 15-13

4094A & 4094B Only

Reading X/Y Plots

Refer to Figure 16-13.

If the plot is derived from the X/Y display mode, the numerics in the box refer only to volts because the 4094 displays volts on both the X-axis and Y-axis.

The upper two numbers (V/D and Vx) refer to the X-axis. The lower two refer to the Y-axis. (V/D = Volts Per Division).

Vx and Vy are labeled on the plot as reference points. For example, if a line was drawn vertically from Vx, any point crossed by the line would be at -0.235 volts. If a line was drawn horizontally from Vy, any point crossed by the line would represent -0.16 volts.

Reading the X-Axis Voltage

#1. Count the divisions from Vx:
-2.5 divisions

#2. Multiply by Volts/Division:
(-2.5) x (1.25 V) = -3.125 V

#3. Add Vx:
(-3.125 V) + (-2.35 X 10^{-1} V)
= (-3.125 V) - (0.235 V) =
-3.36 V

Reading the Y-Axis Voltage

#1. Count the divisions from Vy:
-3 divisions

#2. Multiply by Volts/Division:
(-3) x (1.25 V) = -3.75 V

#3. Add Vy:
(-3.75 V) + (-1.6 X 10^{-1} V) =
(-3.75 V) - (0.16 V) = -3.91 V

NOTE: The complexity of the digital plot comes from the fact that there are so many possible displays on the 4094 oscilloscope.

If further assistance is needed, please call a Nicolet applications engineer at (608) 273-5008.