Errata

Title & Document Type: 54100A/D Digitizing Oscilloscope Operating & Programming Manual

Manual Part Number: 54100-90901

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HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

OPERATING AND PROGRAMMING MANUAL

MODEL 54100A/D
DIGITIZING OSCILLOSCOPE

Manual Part No. 54100-90901
Microfiche Part No. 54100-90801

PRINTED: SEPTEMBER 1984

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SAFETY CONSIDERATIONS

GENERAL — This is a Safety Class I instrument (provided with terminal for protective earthing).

OPERATION — BEFORE APPLYING POWER verify that the power transformer primary is matched to the available line voltage, the correct fuse is installed, and Safety Precautions are taken (see the following warnings). In addition, note the instrument's external markings which are described under "Safety Symbols."

WARNINGS

Servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

BEFORE SWITCHING ON THE INSTRUMENT, the protective earth terminal of the instrument must be connected to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two conductor outlet is not sufficient protection.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to the earth terminal of the power source.

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Do not install substitute parts or perform any unauthorized modification to the instrument.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

SAFETY SYMBOLS

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the product.

Indicates hazardous voltages.

Earth terminal (sometimes used in manual to indicate circuit common connected to grounded chassis).

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

Section 1
When You Receive Your Instrument

1-1. INTRODUCTION

This Operating and Programming Manual contains information required to install, operate and program the Hewlett-Packard Model 54100A/D Digitizing Oscilloscope. Paragraph 1-3 lists the accessories supplied with the instrument. Section I covers instrument safety, identification, options, accessories, receiving information and other basic data. Section II provides guidelines for using this manual.

1-2. SAFETY CONSIDERATIONS

The Hewlett-Packard Model 54100A/D is a Safety Class 1 instrument (instrument with an exposed metal chassis that is directly connected to earth via the power supply cable).

WARNING

Before you apply power to the unit make sure you review this manual and become familiar with the definitions of the safety markings and pertinent instructions. These must be followed to insure safe operation and that the instrument is maintained in a safe condition.

1-3. ACCESSORIES SUPPLIED WITH THE 54100A/D

The 54100A/D Digitizing Oscilloscope is supplied complete with the following accessories:

Three 54002A input pods

One power cable

One Operating and Programming Manual.

NOTE

The 54100D is shipped with four 54002A input pods.

1-4. ACCESSORIES AVAILABLE

The following accessories are available for the 54100A/D:

54001A 10 KOhm, 1 GHz miniture active probe and a 1.5M cable. (See figure 1-1.)

54003A 1 MOhm, 300 MHz, with 10:1 probe. (See figure 1-2.)

54050A Front panel protective cover.

11536A 50-Ohm Probing Tee. Used to minimize disturbance of transmission characteristics. Compatible with the 54001A high bandwidth probe (see above). Requires one 54051A probe adapter (see below)

10211A (24 pin) and 10024A (16 pin) IC Test Clips.

54051A Probe Adapter. Adapts the 54001A (see above) mini-probe tip (or other HP mini-probes) to the probing accessories included in the 10020A resistive divider probe kit, and to the 11536A probing tee.

10240B BNC Blocking Capacitor. Used to ac-couple signals to the 54100A/D's inputs.

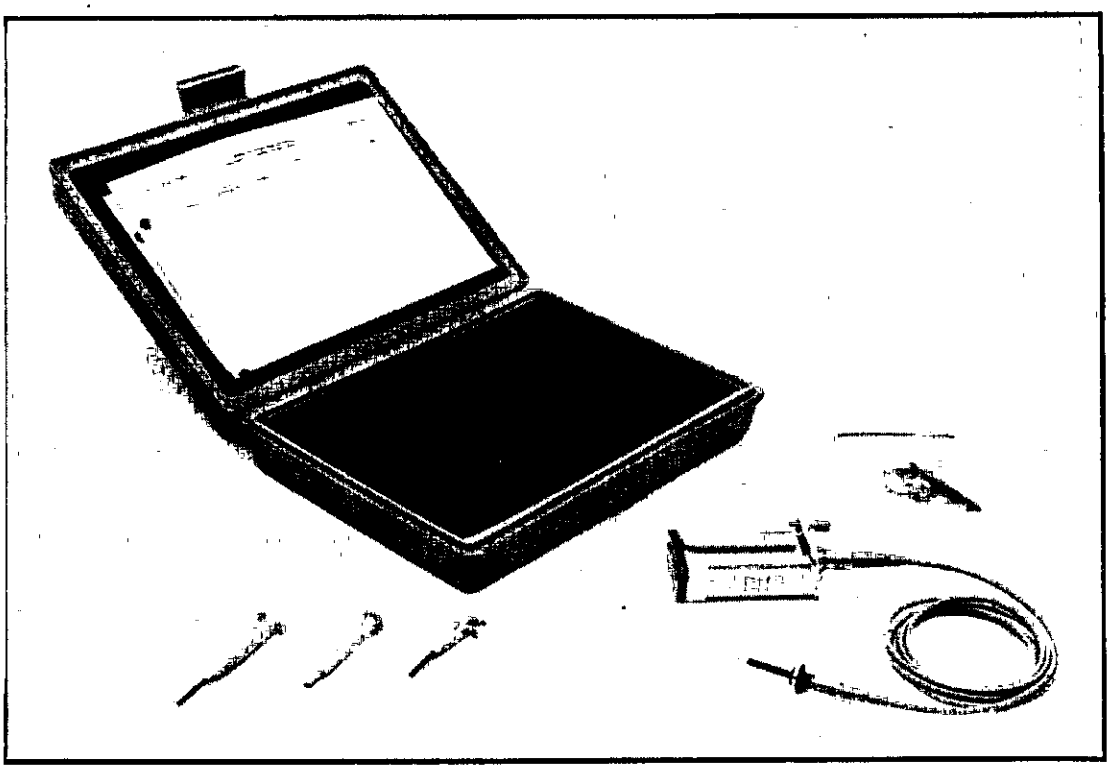


Figure 1-1. 54001A 1 GHz Miniture Active Probe

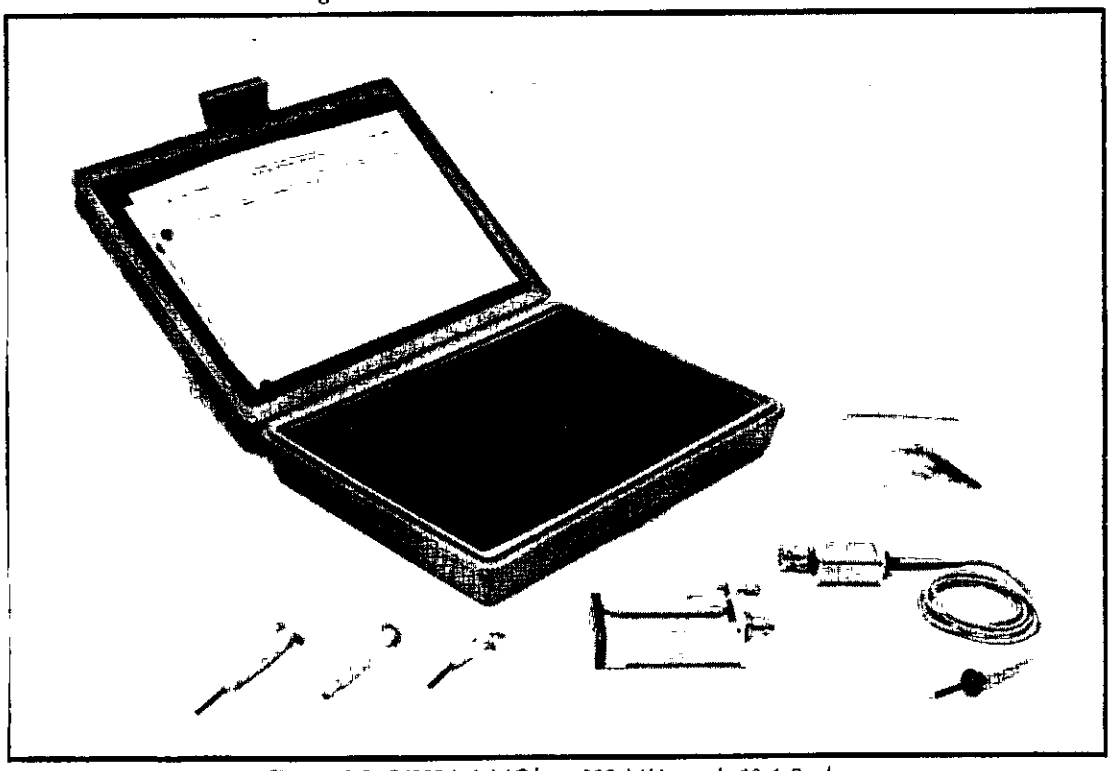


Figure 1-2. 54003A 1 MOhm, 300 MHz with 10:1 Probe

1-5. OPTIONS

The 54100A/D Digitizing Oscilloscope has two options available:

Option 908 provides rack ears and associated mounting hardware for rack mounting the 54100A/D. The HP part number is 5061-0078.

NOTE

The 54100A/D is not recommended for use with rack slides installed

Option 910 provides an additional Operating and Programming Manual for the 54100A/D. The HP part number is 54100-90901.

1-6. Power Cable

WARNING

Before energizing this unit you must insure that the chassis of the instrument is properly grounded. This precaution is to avoid the possibility of injury or death which may result if the protective ground is defeated.

The 54100A/D is provided with a 3 wire power cable. When this cable is connected to an appropriate AC power receptacle it provides a ground for the instrument cabinet. The type of power cable shipped with each instrument depends on the country of destination. See table 1-1 for power cable description and applications.

1-7. INITIAL INSPECTION

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the instrument.

Inspect the shipping container for damage. If the shipping container or packaging materials are damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as listed in Paragraph 1-3. If the contents are incomplete, or if there is mechanical damage or defect, notify the nearest Hewlett-Packard office. If either the shipping container is damaged or the packaging material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection. The HP office will arrange for repair or replacement without waiting for claim settlement.

1-8. Claims For Damage

If physical damage is evident or if the instrument does not meet specifications when received, notify the carrier and the nearest Hewlett-Packard Sales/Service Office. The sales/service office will arrange for repair or replacement of the unit without waiting for settlement of the claim against the carrier.

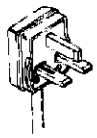
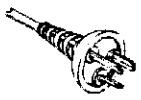
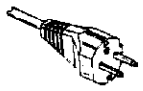
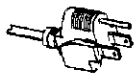
1-9. Storage and Shipment

The 54100A/D Digitizing Oscilloscope may be stored and shipped in environments that do not exceed the following limits:

Temperature	-40°C to +75°C
Humidity	<95% relative
Altitude	<15,300 metres (50,000 feet)

The instrument should also be protected from temperature extremes that would cause condensation in the instrument.

Table 1-1. AC Power Cables

PLUG TYPE	CABLE PART NO.	PLUG DESCRIPTION	LENGTH IN/CM	COLOR	COUNTRY
OPT 900 250V 	8120-1351 8120-1703	Straight *BS1363A 90°	90/228 90/228	Gray Mint Gray	United Kingdom, Cyprus, Nigeria, Zimbabwe Singapore
OPT 901 250V 	8120-1369 8120-0696	Straight *NZSS198/ASC 90°	79/200 87/221	Gray Mint Gray	Australia, New Zealand
OPT 902 250V 	8120-1689 8120-1692 8120-2857	Straight *CEE7-Y11 90° Straight (Shielded)	79/200 79/200 79/200	Mint Gray Mint Gray Coco Brown	East and West Europe, Saudi Arabia, So Africa, India (Unpolarized in many nations)
OPT 903 125V 	8120-1378 8120-1521 8120-1992	Straight *NEMA5-15P 90° Straight (Medical UL544	90/228 90/228 96/244	Jade Gray Jade Gray Black	United States, Canada, Japan (100V or 200V), Mexico, Philippines, Taiwan
OPT 904 250V 	8120-0698	Straight *NEMA6-15P	90/229	Black	United States Canada
OPT 905 250V 	8120-1396 8120-1625	CEE22-V1 (Systems Cabinet use) 250V	30/76 96/244	Black Black	
OPT 906 250V 	8120-2104 8120-2296	Straight *SEV1011 1959-24507 Type 12 90°	79/200 79/200	Mint Gray Mint Gray	Switzerland
OPT 912 220V 	8120-2956 8120-2957	Straight *DHCK107 90°	79/200 79/200	Mint Gray Mint Gray	Denmark

*Part number shown for plug is industry identifier for plug only. Number shown for cable is HP Part Number for complete cable including plug

E = Earth Ground
L = Line
N = Neutral

1-10. Packaging

Original packaging i.e , the containers and materials identical to those used in factory packaging are available from Hewlett-Packard. If the unit is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of servicing required, return address, model number, and full serial number. Mark the container FRAGILE. In any correspondence refer to the instrument by model number and full serial number.

If other packaging is to be used use the following general instructions for repackaging with commercially available materials should be followed:

a. Wrap the instrument in heavy paper or plastic. If you are shipping the unit to a Hewlett-Packard office or service center be sure to attach a tag to the instrument indicating the type of service required, return address, model number and full serial number.

b. Use a strong shipping container. A double wall carton made of 2.4 MPa (350 psi) test material is adequate.

c. Use a layer of shock absorbing material 75 to 100 mm (3 to 4 inches) thick around all sides of the instrument to provide firm cushioning and prevent movement inside the container. Protect the control panel with cardboard.

d. Seal the shipping container securely.

e Mark the shipping container FRAGILE to insure careful handling.

f. In any correspondence, refer to instrument by model number and full serial number.

Section 2
How To Use This Manual

This Operating and Programming Manual has been designed as both a tutorial operating manual and a reference manual for writing programs to operate the oscilloscope remotely.

The first four sections of the manual are concerned with instrument specifications, receiving information and operating environment information for the 54100A/D.

The next four sections (5 through 8) of the manual are concerned with front panel operation and front panel exercises. Sections 9 through 11 are dedicated to the remote programming of the 54100A/D and an overview of the HP-IB interface.

Here is an overview of what this manual contains:

WHEN YOU RECEIVE YOUR INSTRUMENT, SECTION 1

This section includes installation information, receiving information, warranty data and much more You should read Section 1 before initial installation and operation.

MEET THE 54100A/D DIGITIZING OSCILLOSCOPE, SECTION 3

This section provides a description of this oscilloscope and complete specifications and operating characteristics. This section also includes a probe selection table.

GETTING READY TO USE THE 54100A/D, SECTION 4

This section contains important data about the required operating environment and power requirements for the 54100A/D. You should review this section prior to initial operation.

GETTING STARTED WITH THE FRONT PANEL, SECTION 5

This section introduces you to the front panel layout and it's four functional areas. Section 5 provides vital information for the first time user.

FAMILIARIZE YOURSELF WITH THE MENUS, SECTION 6

Many of the front panel controls on the 54100A/D are multi-functioned. To better understand these controls this section defines all front panel functions and maps the different function groups. This section is formatted so that it can be used as a reference by operators, regardless of skill level.

FRONT PANEL EXERCISES, SECTION 7

This section provides step-by-step exercises that will help you become more familiar with making measurements from the front panel of the 54100A/D. Section 7 builds on the information presented in Section 6.

LET'S MAKE A HARDCOPY DUMP, SECTION 8

This section provides information concerning the use of graphics printers and plotters with the 54100A/D via HP-IB. This section also provides a list of Hewlett-Packard printers and plotters that are compatible with this instrument.

REMOTE CONTROL, SECTION 9

This section discusses the remote operation of the instrument over the HP-IB. Such topics as HP-IB compatibility, remote/local modes, local lockout, learn and cal strings and notation conventions and definitions are dealt with. Review this section before writing programs for this instrument.

COMMAND SET OVERVIEW, SECTION 10

This section contains the instruction set, syntax diagrams and other detailed programming reference information for the 54100A/D.

COMMAND SET QUICK REFERENCE GUIDE, SECTION 11

This section provides a brief definition and syntax information for each key word. These key words are organized in functional groups for ease of use. This quick reference guide provides an excellent source of reference information for the more experienced programmer.

APPENDIX A

Appendix A contains example programs for the 54100A/D using the HP 200 series scientific computer using the HP Basic 2.0 operating system.

APPENDIX B

Appendix B provides the advanced user with a discussion of the channel-to-channel timing skew and trigger delay calibration concerns when using the 54100A/D.

APPENDIX C

Appendix C provides the advanced user detailed information concerning the automated measurements that the 54100A/D can perform. This appendix discusses such topics as measurement throughput, accuracy, and resolution.

The following table indicates those chapters which are recommended reading for various types of 54100A/D users. You may fall into more than one category. For example, you may be an inexperienced programmer who installs the 54100A/D.

Table 2-1. User Table

	Chapters											Appendix		
Reader/User	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**A**	**B**	**C**
Installation Personnel	•	•		•										
First Time User (Front Panel)			•	•	•	•		•						
Advanced User (Front Panel)						•	•	•					•	•
Beginning Programmer			•	•	•	•	•		•		•			
Advanced Programmer										•		•		

Section 3
Specifications and Operating Characteristics

HP 54100A/D SPECIFICATIONS

VERTICAL (voltage):

	Input Pod		
	HP 54002A 50 Ω Input	**HP 54001A Miniature Active Probe**	**HP 54003A 1 MΩ Probe†**
Bandwidth (-3 dB)*	dc to 1 GHz	dc to 700 MHz	dc to 300 MHz
Transition Time (10% to 90%)*	≤350 ps	≤450 ps	≤1.2 ns
Deflection Factor (full-scale = 8 divisions)	10 mV/div to 1 V/div in 1-2-5 steps	100 mV/div to 10 V/div in 1-2-5 steps	
DC Accuracy, Single Voltage Marker	±3% of full-scale ±2% of offset‡	±6% of full-scale ±2% of offset ±50 mV	
DC Delta Voltage Accuracy Using Two Voltage Markers On The Same Channel	±1% of full-scale ±3% of reading‡	±1% of full-scale ±6% of reading	

** These specifications apply over ambient temperature range of +15°C to +35°C.*
‡ When driven from a 50 Ω source.
† With the 10:1 divider probe supplied with the HP 54003A.

Table 3-1. Vertical Voltage Specifications

DYNAMIC RANGE: Deflection factor and offset should be scaled such that the unmagnified signal remains within the full scale display range.

MAGNIFIER: Expands displayed signal vertically from 1 to 16X, adjustable in 0.5% steps.

DC OFFSET:
Range: ±1.5 × full-scale (referenced to center screen).
Adjustment Resolution: Adjustable in steps of 0.0025X full-scale.

INPUTS: Two inputs, configurable with HP 54000 series pods.

HORIZONTAL (time):
Deflection Factor (full-scale = 10 div): 100 ps/div to 1 sec/div.
Adjustment Resolution: Adjustable in 1-2-5 steps via the knob and the step keys. Adjustable to three significant figures via the key pad or HP-IB command.

DELAY (time offset):
Pre-trigger Range: Up to -200 ms or -10 div, whichever is greater.
Post-trigger Range: Up to +1 sec or +10 div, whichever is greater.
Adjustment Resolution: Adjustable in steps of 10 ps or 1×10^{-6} × delay setting, whichever is greater.

TIME BASE ACCURACY:
Single Channel: ≤(100 ps ± 2×10^{-5} × Delta t reading).
Dual Channel: ≤(200 ps ± 2×10^{-5} × Delta t reading).

TRIGGER:

Trigger Source	Vertical Channel 1 or 2			Trigger Input 3 (HP 54100D: Trigger Input 3 or 4)		
Input Pod	**HP 54002A**	**HP 54001A**	**HP 54003A***	**HP 54002A**	**HP 54001A**	**HP 54003A***
Trigger Level Range	±2 × full-scale			±2 V	±20 V	
Trigger Level Adjustment Resolution	0.0025 × full-scale			2 mV	20 mV	
Trigger Sensitivity DC to 100 MHz	0.12 × full-scale			40 mV	400 mV	
Above 100 MHz (frequency range)	0.24 × full-scale (100 MHz to 500 MHz)		0.24 × full-scale (100 MHz to 300 MHz)	80 mV (100 MHz to 500 MHz)	800 mV (100 MHz to 500 MHz)	800 mV (100 MHz to 300 MHz)
Pulse width > 1 ns	0.24 × full-scale			80 mV	800 mV	

*With the 10:1 divider probe supplied with the HP 54003A

Table 3-2. Trigger Specifications

RMS Jitter: ≤(50 ps + 5 × 10^{-7} × delay setting).
Trigger Source: Chan 1, Chan 2, Trig 3, (HP 54100D: Trig 4). Independent trigger level and polarity settings on all sources. Edge trigger on any source. Logical pattern trigger on all sources.
Trig 3 and Trig 4 Inputs: Configurable with HP 54000 series pods.

HP 54100A/D OPERATING CHARACTERISTICS

DIGITIZER:
Resolution: 7 bits (1 part in 128). Effective resolution can be extended up to approximately 10 bits by using magnification and averaging.
Digitizing Rate: Up to 40 megasamples/second.

DISPLAY:
Data Display Resolution: 500 points horizontally by 256 points vertically.
Data Display Formats:
SPLIT SCREEN: Each channel is four divisions high.
FULL SCREEN: The two channels are overlaid. Each channel is eight divisions high.
Display Modes:
VARIABLE PERSISTENCE: The time that each data point retained on the display can be varied from 200 ms to 10 sec, or it can be displayed indefinitely.
AVERAGING: The number of averages can be varied from 1 to 2048 in powers of 2. On each acquisition, 1/n times the new data is added to (n-1)/n of the previous value at each time coordinate. Averaging operates continuously; the average does not converge to a final value after n acquisitions.
Graticules: Full grid, axes with tic marks, or frame with tic marks.

VERTICAL:
Input Protection: A relay opens when applied voltage exceeds rated input for the input pod in use (see Specifications).

HORIZONTAL:
Delay Between Channels: A difference in delay between channels can be nulled in 10 ps steps up to 10 ns to compensate for differences in input cables or probe length.
Reference Location: The reference point can be located at the left edge, center, or right edge of the display. The reference point is that point where the time is offset from the trigger by the delay time.

Trigger:

INPUT PROTECTION: A prompt will appear on the display when the applied voltage exceeds rated input voltage for pod in use (see Specifications).

HOLDOFF:

Holdoff-By-Events: Range of events counter is from 2 to 67 million events. Maximum counting rate is 80 MHz. An event is defined as anything that satisfies the triggering conditions selected.

Holdoff-By-Time: Adjustable in 10 ns steps from 70 ns to 670 ms.

TRIGGER MODES:

Edge Trigger: On any source (see Specifications, Trigger Source).

Pattern Trigger: A pattern can be specified for all sources. Each source can be specified as high, low, or don't care. Trigger can occur on the last edge to enter the specified pattern or the first edge to exit the specified pattern.

Time Qualified Pattern Trigger (HP 54100D only): Trigger occurs on the first edge to exit the specified pattern, only if the pattern was present for less than (greater than) the specified time. Filter time is adjustable from 10 ns to 5 sec. Filter recovery time is ≤8 ns. In the "When Present < (time)" mode, the pattern must be present > 1 ns for the trigger to respond.

State Trigger (HP 54100D only): A pattern can be specified for any three sources. Trigger can be set to occur on an edge of either polarity on the source specified as the clock, (not one of the pattern sources), when the pattern is present or not present. Setup time for the pattern to be present prior to the clock edge is < 4 ns; hold time is zero.

Delayed Trigger (HP 54100D only):

EVENTS-DELAYED MODE: The trigger can be armed by an edge on any source, then triggered by the nth edge on any other source. The number of events, n, can be set from 1 to $1 \times 10^{-8}-1$. Maximum event counting rate is 150 MHz.

TIME-DELAYED MODE: The trigger can be armed by an edge on any source, then triggered by the first edge on any other source after a specified time has elapsed. The delay time can be set from 20 ns to 5 seconds.

MEASUREMENT AIDS:

Markers: Dual voltage markers and dual time markers are available. Voltage markers can be assigned to either channel or to both channels.

Auto Top-Base: Automatically sets voltage markers on the top and base of a pulse using a histogram technique. Markers can, also, be automatically set to 10-90%, 20-80%, or 50% points on a transition.

Automatic Edge Finders: The time markers can be assigned automatically to any displayed edge of either polarity on either channel or both channels. The voltage markers establish the threshold reference for the time markers in this mode.

Automatic Pulse Parameter Measurements: The following pulse parameter measurements can be performed automatically (as defined in IEEE Standard 194-1977, "IEEE Standard Pulse Terms and Definitions").

Frequency
Period
Pulse duration
Risetime
Falltime
Pulse amplitude
Top magnitude
Base magnitude
Preshoot
Overshoot
rms volts (HP-IB programmable only)
Duty Cycle (HP-IB programmable only)

SETUP AIDS:

Presets: Vertical deflection factor, offset, and trigger level can be preset independently on each channel for ECL or TTL levels.

Auto-Scale: Pressing the Auto-Scale button causes the vertical and horizontal deflection factors and the trigger source to be set for a display appropriate to the signals applied to the inputs. Requires a duty cycle > 0.1%, and amplitude > 20 mv peak, and a frequency > 50 Hz. Operative only for relatively stable input signals.

Save/Recall: Ten front panel setups may be saved in non-volatile memory. If Auto-Scale is inadvertently pressed, pressing Recall followed by Auto-Scale, restores the instrument to the state prior to the first Auto-Scale.

Waveform Memories: Two memories are provided for waveform storage. Each memory is a pixel map of the display. Any number of waveform pictures may be written into each memory. Once stored, individual waveforms cannot be accessed individually. The display of each memory can be turned on or off without affecting its contents. Waveforms in memory are displayed at half brightness to distinguish them from live waveforms.

POWER REQUIREMENTS:

Voltage: 115/230 Vac, +15% to -25%, 48-66 Hz.

Power: 290 watts maximum, 500 VA maximum.

GENERAL CHARACTERISTICS:

Dimensions: Refer to outline drawing (figure 3-1).

Weight:

NET: Approximately 19 kg (42 lb).

SHIPPING: Approximately 23.5 kg (52 lb).

ENVIRONMENTAL CHARACTERISTICS:

Temperature:

OPERATING: 0° C to +55° C (+32° F to +131° F). Note: See specifications.

NON-OPERATING: -20° C to +75° C (-4° F to 167° F).

Humidity:

OPERATING: Up to 90% relative humidity at +40° C (+104° F).

NON-OPERATING: Up to 95% relative humidity at +65° C (+149° F).

Altitude:

OPERATING: Up to 4600 metres (15,000 ft).

NON-OPERATING: Up to 15,300 metres (50,000 ft).

Vibration: Vibrated in three orthogonal axes for 15 minutes per axis; 0.38 mm (0.15 in.) peak-to-peak excursion; 5 to 55 Hz. 1 minute/octave sweep.

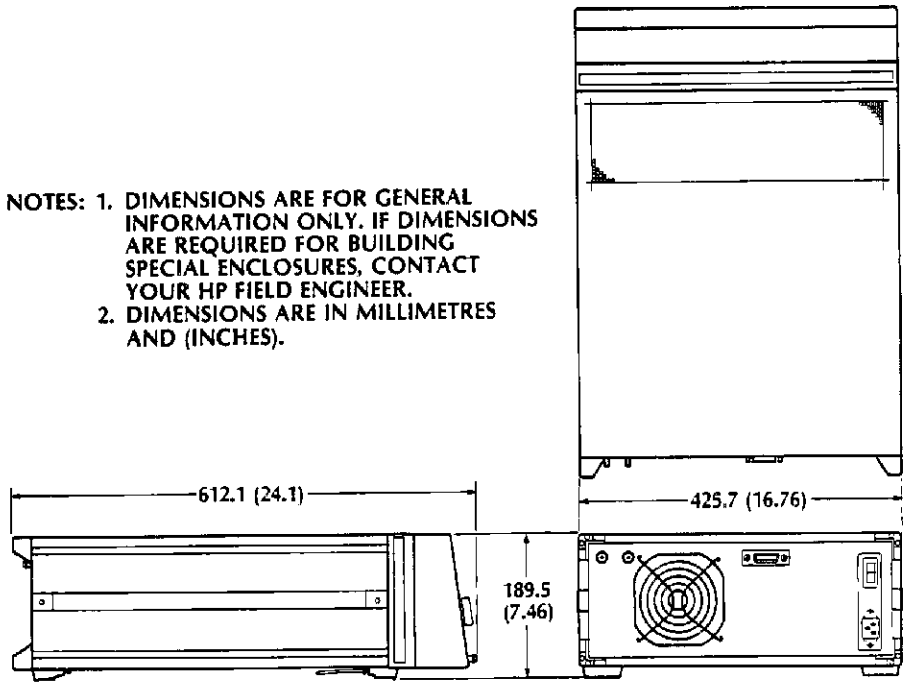


Figure 3-1. HP 54100A/D Dimensions

	HP 54002A 50 Ω Input	HP 54001A 1 GHz Miniature Active Probe	HP 54003A 1 MΩ Input, With 10:1 Probe Attached	HP 54003A 1 MΩ Input, With 10:1 Probe Removed
Maximum Input Voltage	5 V rms	20 V peak	20 V peak	2 V peak
Coupling	dc	dc	dc	dc
Input Capacitance (Nominal)	N/A	2 pF	8 pF	10 pF
Input Resistance (Nominal)	50 Ω	10 kΩ	1 MΩ	1 MΩ
Bandwidth* (-3dB)	dc to 1 GHz	dc to 1 GHz	dc to 300 MHz	dc to 300 MHz
Transition Time* (10% to 90%)	≤350 ps	≤350 ps	≤1.2 ns	≤1.2 ns
Division Ratio*	1:1	10:1 ±3%	10:1 ±3%	1:1 ±1%

** Refer to VERTICAL and TRIGGER specifications for system performance specifications*

Table 3-3. HP 54100A/D Inputs

Probe	Length	Division Ratio	Typical Circuit Loading		System Response With the HP 54100A/D		Usable Signal Range	Notes
			Capacitive	Resistive	Rise Time	Bandwidth		
HP 54001A 1 GHz miniature active probe	1.5 m	10:1 ±3%	2 pF	10 kΩ	450 ps	700 MHz	±20 V	Unitary probe/pod.
HP 54003A 1 MΩ probe	1 m	10:1 ±3%	8 pF	1 MΩ	1.2 ns	300 MHz	±20 V	Includes separable probe and 1 MΩ BNC input pod
HP 10018A 1 MΩ probe	2 m	10:1 ±3%	10 pF	1 MΩ	1.8 ns	200 MHz	±20 V	Requires 1 MΩ BNC input pod, supplied with HP 54003A.
HP 10014A 10 MΩ probe	1.1 m	10:1 typical	10 pF	10 MΩ	1.4 ns	250 MHz	±20 V	Requires 1 MΩ BNC input pod, supplied with HP 54003A.
HP 10030A miniature passive divider probe	2 m	10:1 ±3%	1 pF	500 Ω	700 ps	500 MHz	±4 V	Use with 50 Ω BNC input pod HP 54002A (supplied with HP 54100A D).
HP 10026A 50 Ω, 1:1 miniature probe	1 m	1:1	N/A	50 Ω	450 ps	700 MHz	±5 V	Use with 50 Ω BNC input pod HP 54002A (supplied with HP 54100A D).
HP 10027A 50 Ω, 1:1 miniature probe	2 m	1:1	N/A	50 Ω	700 ps	500 MHz	±5 V	Use with 50 Ω BNC input pod HP 54002A (supplied with HP 54100A D).
HP 10020A passive divider probe kit, includes six probe tips	1.2 m	1:1 5:1 ±3% 10:1 ±3% 20:1 ±3% 50:1 ±3% 100:1 ±3%	N/A 0.7 pF 0.7 pF 0.7 pF 0.7 pF 0.7 pF	50 Ω 250 Ω 500 Ω 1000 Ω 2500 Ω 5000 Ω	500 ps 500 ps 500 ps 500 ps 500 ps 500 ps	700 MHz 700 MHz 700 MHz 700 MHz 700 MHz 700 MHz	5 Vrms 12 V p-p 17 V p-p 21 V p-p 35 V p-p 50 V p-p	Use with 50 Ω BNC input pod HP 54002A (supplied with HP 54100A D.)

Table 3-4. Probe Selection Guide

Section 4
Getting Ready To Use The HP 54100A/D

4-1. HP 54100A/D SPECIFICATIONS

This section provides information concerning the operating environment and the power requirements for the HP 54100A/D Digitizing Oscilloscope. It is important that the user provide the correct power source and operating environment for this instrument. Failure to do so can cause serious damage to the instrument and/or provide a health hazard to the user.

4-2. OPERATING ENVIRONMENT

CAUTION

Insure the instrument has adequate clearance on all surfaces to provide for sufficient air flow for cooling. Do not block any of the vent holes or the fan's air inlet.

The operating environment must be maintained within the following parameters:

Temperature	0° C to 55° C
Humidity	<90% up to 40° C
Altitude	<4572 metres (15,000 feet)

The instrument should also be protected from temperature extremes that would cause condensation in the instrument.

4-3. POWER REQUIREMENTS

The 54100A/D requires a power source of 115 or 230 Vac +15/-25 percent; 48-66 Hertz single phase. Power consumption is 290 watts maximum or 500 VA maximum.

CAUTION

Before connecting this instrument to the AC power source, insure that the line select switch on the rear panel of the instrument is set to the appropriate position (see figure 4-1)

A blade-type screwdriver may be used to change the position of this switch. Figure 4-2 shows the line select switch set for 115 Vac operation. If this switch is not set correctly, serious damage to the instrument will likely result.

Once the correct setting on the line select switch has been made and the appropriate power cord has been installed and connected to the mains, the unit can be turned on (see paragraph 4-4). By selecting the appropriate line voltage with the line select switch, you also are determining the correct circuit breaker trip current. If 115 Vac line voltage is selected, the circuit breaker trip current will be 6 amps. If 230 Vac line voltage is selected, the circuit breaker trip current will be 3 amps.

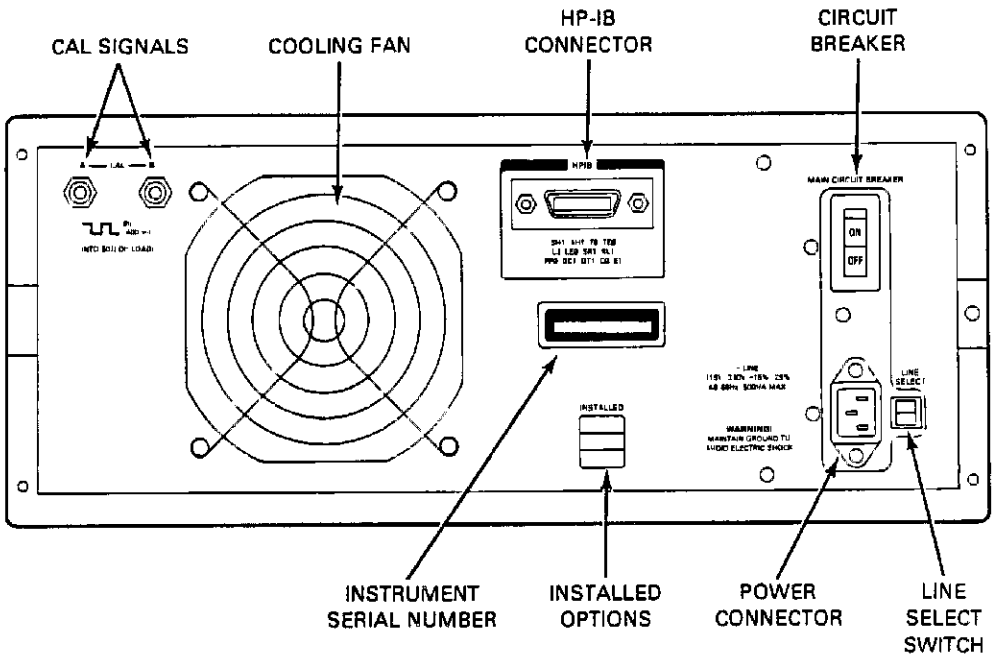


Figure 4-1. HP 54100A/D Rear Panel

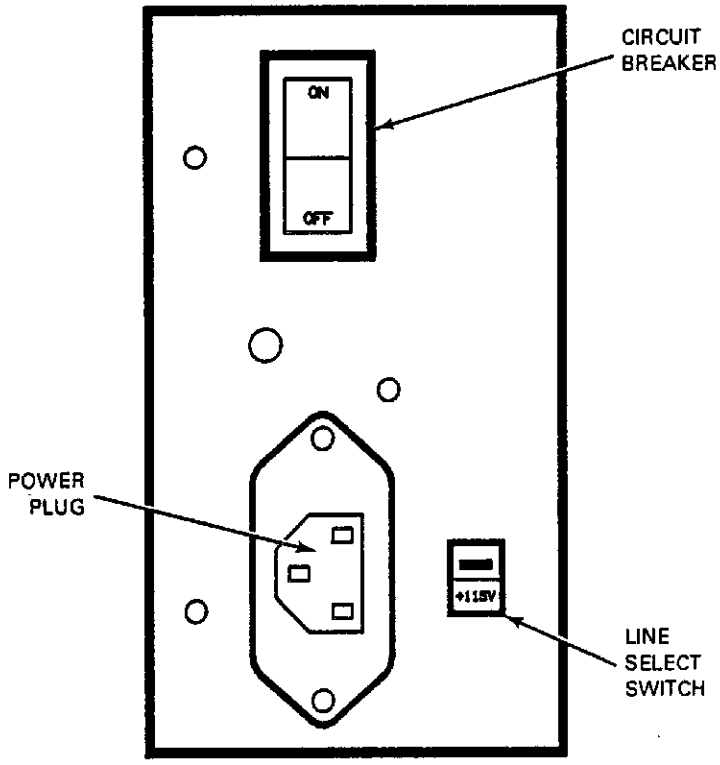


Figure 4-2. Power Module

The 54100A/D has two switches that can interrupt the power for the instrument. The first is the line switch and the second is the mains breaker:

1. The line switch is located on the left side of the instrument just rear of the front bezel at the lower edge (see figure 4-3).

2. The mains breaker is located on the upper right hand corner of the rear panel (see figure 4-1).

If either the line switch or mains breaker are in the OFF or "0" position, the unit will not function.

4-4. POWER CABLE

WARNING

Before energizing this unit you must insure that the chassis of the instrument is properly grounded. This precaution is to avoid the possibility of injury or death which may result if the protective ground is defeated.

The 54100A/D is provided with a 3-wire power cable. When this cable is connected to an appropriate AC power receptacle, it provides a ground for the instrument cabinet. The type of power cable shipped with each instrument depends on the country of destination. See table 1-1 for power cable description and applications

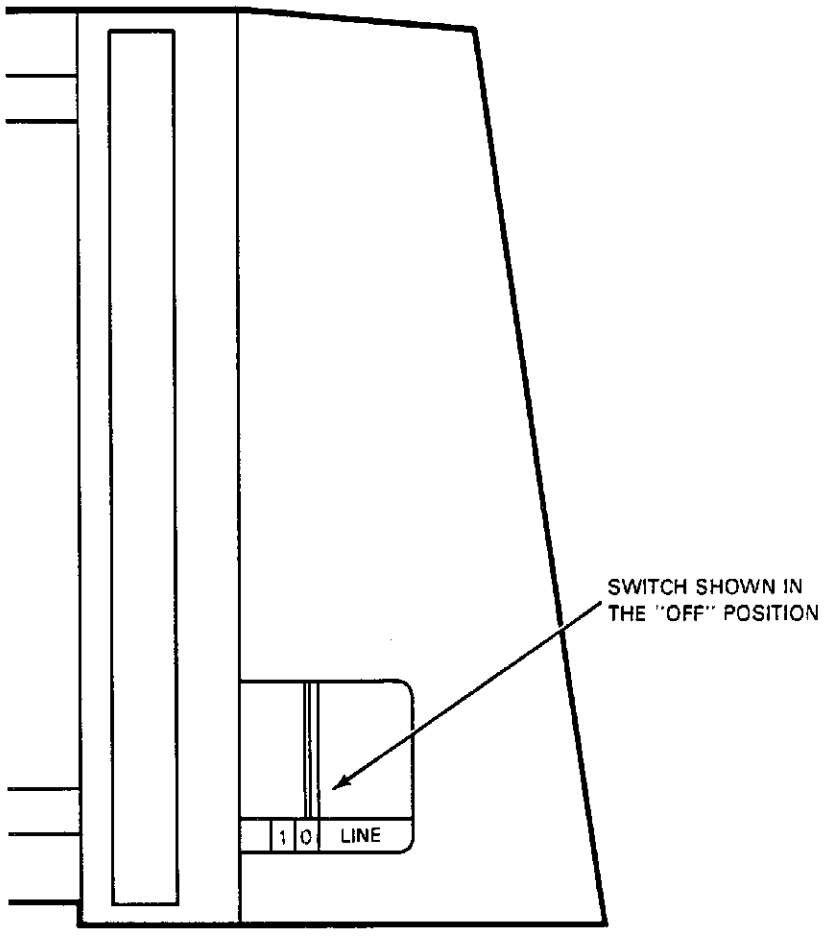


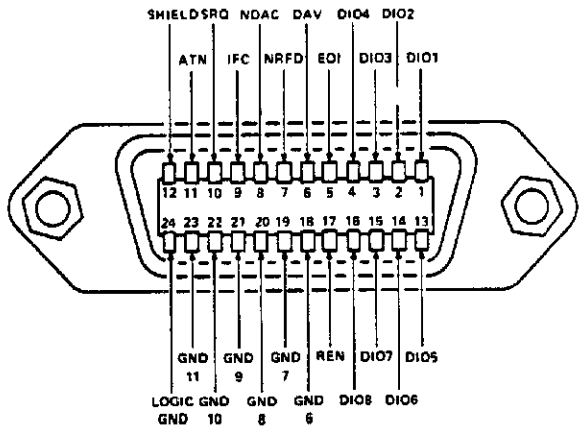
Figure 4-3. Front Panel Power Switch

4-5. HP-IB ADDRESS SELECTION

The HP-IB address can be read and selected from the front panel of the 54100A/D with the use of soft keys that are located at the bottom of the CRT and at the right of the CRT. In order to set or change the HP-IB address, put the 54100A/D into the TALK/LISTEN mode (soft key selectable), then input the desired address from the front panel. The 54100A/D supports the following HP-IB interface functions: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1. For further information concerning the 54100A/D HP-IB operation, see Section 9.

4-6. HP-IB INTERCONNECTIONS

Interconnection data concerning the rear panel HP-IB connector is provided in figure 4-4. The HP-IB system allows the interconnection of up to 15 (including the controller) HP-IB compatible instruments. The HP-IB cables have identical connectors on both ends so that several cables can be connected to a single source without special connectors or switch boxes. System components and devices may be connected in virtually any configuration (see figure 4-5).



Where: ATN = Attention
DAV = Data Valid
DIO 1-8 = Data Input-Output
EOI = End or Identify
IFC = Interface Clear
NDAC = Not Data Accepted
NRFD = Not Ready For Data
REN = Remote Enable
SRQ = Service Request

Logic Levels
The Hewlett-Packard Interface Bus Logic Levels are TTL compatible, i.e., the true (1) state is 0.0 Vdc to +0.4 Vdc and the false (0) state is +2.5 Vdc to +5.0 Vdc

Programming and Output Data Format
Refer to Section 9.

Mating Connector
HP 1251-0293, Amphenol 57-30240

Mating Cables Available
HP 10833A, 1 metre (3.3 ft)
HP 10833B, 2 metres (6.6 ft)
HP 10833C, 4 metres (13.2 ft)
HP 10833D, 0.5 metres (1.6 ft)

Cabling Restrictions

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6 ft) of connecting cable per instrument.
2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20.0 metres (65.6 ft).

Figure 4-4. HP-IB Interface Connector

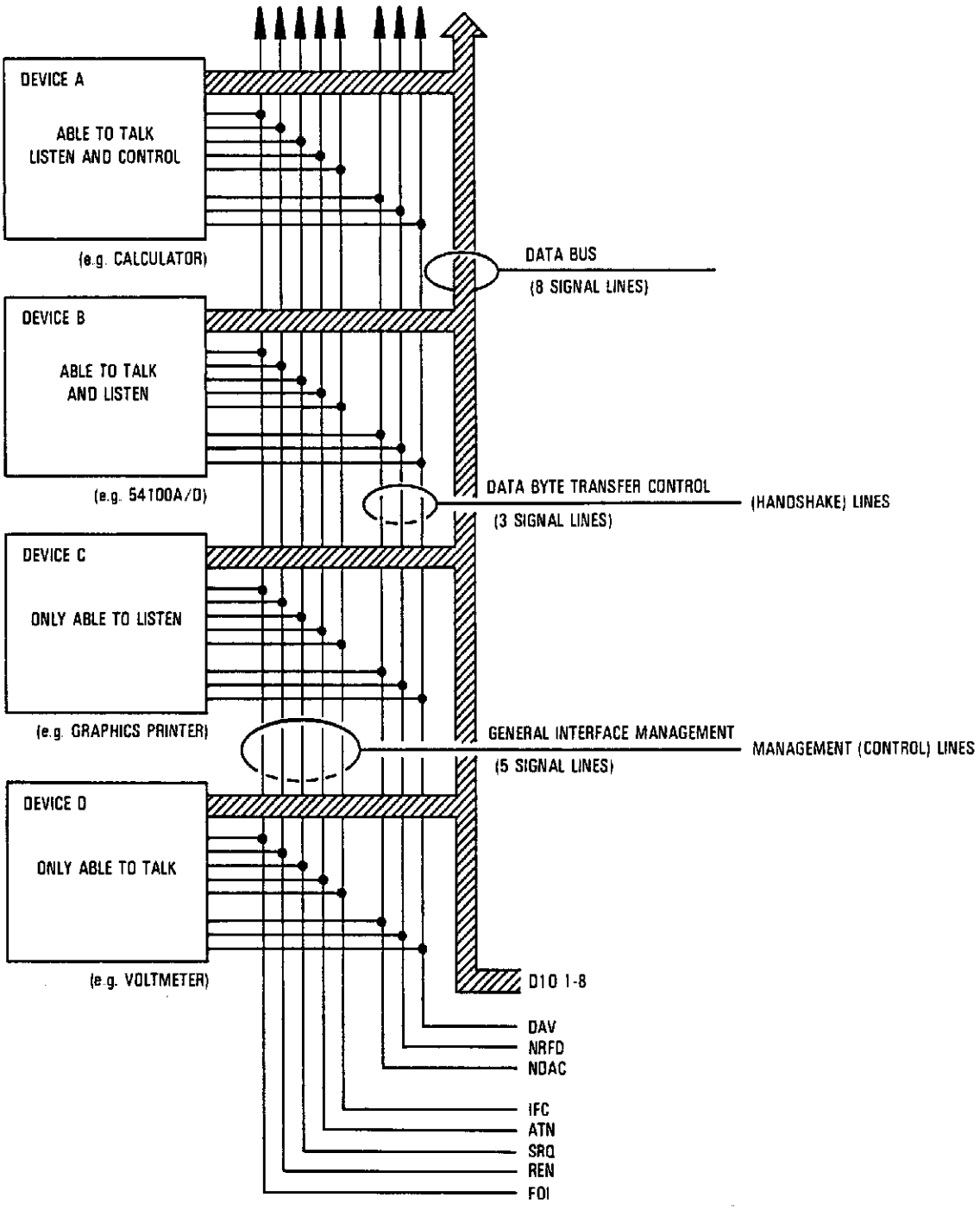


Figure 4-5. HP-IB Interface

Section 5
Front Panel

5-1. GETTING STARTED WITH THE FRONT PANEL

This section describes the front panel of the 54100A/D and discusses its four functional areas. The four functional areas on the front panel of the 54100A/D Ditigizing Oscilloscope include:

A. System Control
B. Entry
C. Menu Selection
D. Function.

These four groups of keys give the operator complete local control of the instrument. (See figure 5-1.)

5-2. SYSTEM CONTROL

The SYSTEM CONTROL keys are located on the top right hand side of the front panel directly under the label, "SYSTEM CONTROL".

The SYSTEM CONTROL keys provide control of acquisition, the dynamic display, SAVE/RECALL registers and automatic display scaling.

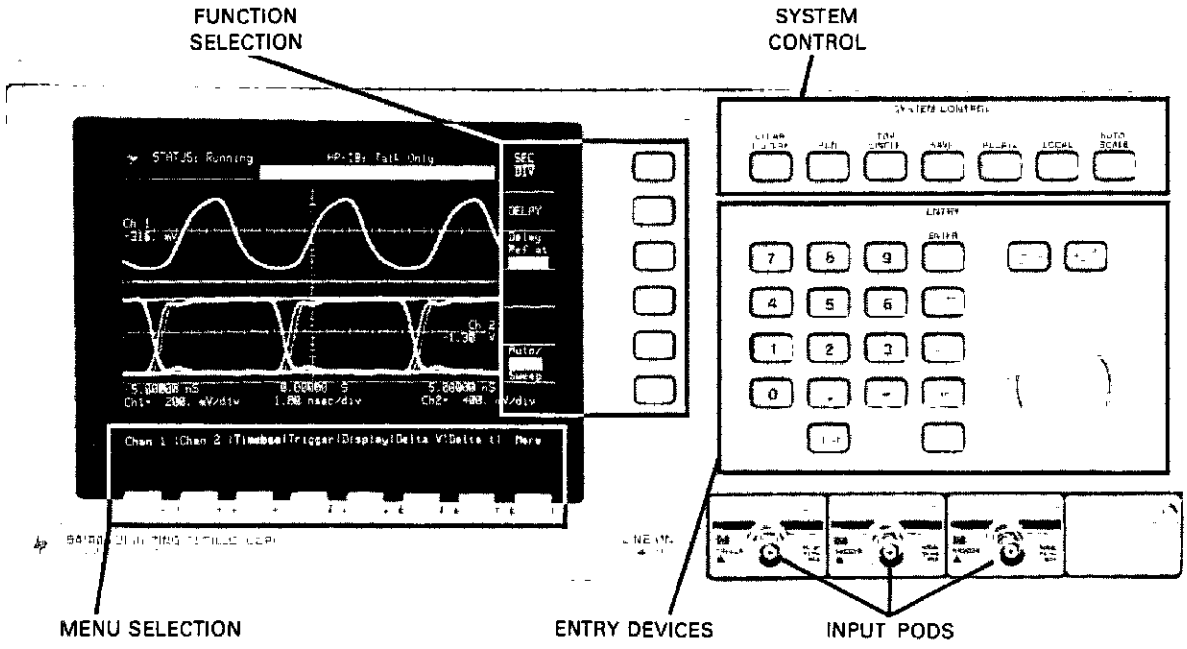


Figure 5-1. 54100A, D Front Panel

The CLEAR DISPLAY key erases the dynamic (active) display. This key will not erase a waveform in memory that is being displayed. When the CLEAR DISPLAY key is pressed the instrument will momentarily stop acquiring data, erase the screen and then resume acquiring data. If the STOP/SINGLE key has previously been pressed, the CLEAR DISPLAY key will erase the displayed waveform and acquisition will not resume unless the RUN key is pressed, or if a single acquisition is desired the STOP/SINGLE key can be pressed for the second time. If you are acquiring a large number of averages and you change the input signal you can quickly reset the average registers by pressing the CLEAR DISPLAY key. This will save the time that the display would normally take to integrate to the new signal levels.

The RUN key causes the 54100A/D to resume acquiring data after acquisition has been stopped by the STOP/SINGLE key. When the STOP/SINGLE key is pressed the instrument will stop acquiring data and display, indefinitely, the last data that was acquired. Each subsequent STOP/SINGLE key press arms the instrument to make a single acquisition that would be started by the next trigger event. To return to the previous operating mode press the RUN key. When the STOP/SINGLE key has been pressed the SEC/DIV, VOLTS/DIV and other front panel controls that would normally cause the displayed waveform to change will erase the active display as if the CLEAR DISPLAY key had been pressed.

5-3. SAVE/RECALL

This instrument allows the user to SAVE and RECALL up to ten different front panel setups in nonvolatile memory.

To SAVE the current front panel setup in one of the ten SAVE/RECALL registers, press SAVE, then press the number (0-9) of the register desired. All front panel functions, modes and Cal factors (reference paragraph 6-19) menu selection and input device assignments are saved. SAVE/RECALL will not cause execution of measurements, edge finders "Start Print" or other action keys.

To RECALL a previously saved front panel setup press RECALL, then press the number (0-9) corresponding to the desired register.

To return to the condition that existed prior to the last AUTO-SCALE, press RECALL then press AUTO-SCALE. This feature allows you to recover if the AUTO-SCALE is accidently pressed.

5-4. LOCAL

When the LOCAL key is pressed an RTL (return to local) message is sent to the HP-IB interface and the unit will return to local (front panel) control if it had previously been in remote operation and if the HP-IB controller had not invoked a Local Lockout.

The LOCAL key is the only active front panel key when the unit is in REMS (remote state).

5-5. AUTO-SCALE

When the AUTO-SCALE key is pressed the instrument will select the vertical sensitivity, vertical offset, trigger level and sweep speed for a display of the input signal. If input signals are present at both vertical inputs the sweep will be triggered on Chan 1 and the display will go to the split screen mode and scale the vertical sensitivity for each channel and will be scaled appropriately. If only one of the vertical inputs has a signal on it the split screen function will be turned off. See Operating Characteristics for input signal requirements for proper AUTO-SCALE operation.

When the AUTO-SCALE cycle is complete the Timebse menu will be selected and the input devices will be assigned to the SEC/DIV function.

5-6. ENTRY DEVICES

Under the SYSTEM CONTROL keys is an area labeled ENTRY. Located in this portion of the front panel is a number pad, a vertical column of 5 ENTER keys, the "knob" and two step keys, (refer to figure 5-1). These three items are referred to, throughout this manual, as the "entry devices".

The entry devices are used to change the value of any of the items in the function menus that are displayed in UPPER CASE letters, e.g., VOLTS/DIV and SEC/DIV. The function menus are on the right side of the CRT.

The value of the selected variable function is displayed in inverse video at the top of the CRT.

5-7. MENU SELECTION

Softkeys provide front panel control of the 54100A/D digitizing oscilloscope.

This instrument has two sets of softkeys, the first set is located at the bottom of the CRT, and the second set is right of the CRT. The keys at the bottom of the CRT are referred to as the "menu selection keys" as they are used to choose a desired function menu. As you press the ditferent function menu selection keys the function menus along the right side of the CRT will change. Pressing the More key at the bottom right hand corner of the CRT provides an additional seven function menus. If the More key is pressed again the original menu will return.

After you have selected a function menu, notice some of the function menu softkey labels have text shown in inverse video. If the adjacent soft key is pressed the text that is in inverse video will change, e.g., to turn a function On or Off, or to activate an associated function, e.g., pattern trigger, edge trigger, state trigger.

When a softkey with an upper case label is pressed the label will intensify and the input devices will be slaved to that function.

The third type label for a function softkey will have the first letter of each word in upper case and there will be no inverse video text field associated with the label. When a function key with this type of label is pressed the function will execute. This type of label is used primarily in the Param and Cal & Tst menus, e.g., Peak-to-Peak Voltage and Frequency.

Section 6
Familiarize Yourself With The Menus

6-1. INTRODUCTION

This section contains a description of the front panel operation of the 54100A/D. Operating details and front panel layout are discussed in detail. You should read this section completely before continuing to Sections 7 and 8.

6-2. VERTICAL

After you have energized the unit, connect one of the cal signals from the rear panel to the channel 1 input. The most convenient method of scaling the vertical and horizontal is to press the AUTO-SCALE key. This key causes the 54100A/D to evaluate the vertical inputs and scale the vertical and timebase for a triggered and appropriately scaled display. See Operating Characteristics in Section 1 for limitations of AUTO-SCALE.

6-3. AUTO-SCALE

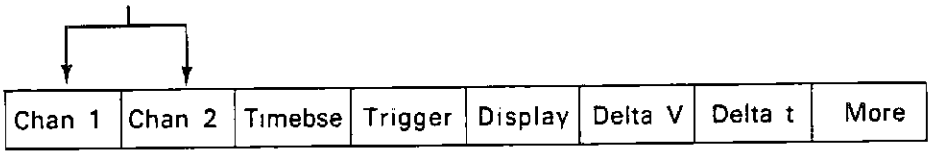
When the AUTO-SCALE key is pressed the DELAY will be set to 0 seconds and referenced to center screen. The instrument will be left in the Timebse menu with SEC/DIV the assigned function for the Entry Devices.

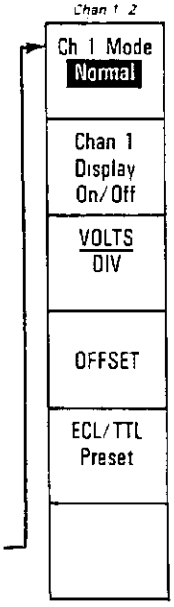
Rotate the "Knob" and notice the sweep speed change, enter "1" from the key pad and press the μsec entry key, the sweep speed will go to 1 μsec/div. Next alternately press the step keys, the sweep speed will either sweep faster or slower depending on which step key is pressed. These three devices are referred to as the Entry Devices and are used to change variable functions on this instrument.

If no signal is detected on the inputs an inverse video error message on the display will state "No signal found".

If there is a signal present at the inputs of both channels, the 54100A/D will go to the split screen function i.e., channel 1 will be displayed in the top half of the display and channel 2 will be displayed in the bottom half of the display. The unit will be set to trigger on channel 1.

6-4. CHANNEL 1 and CHANNEL 2 MENUS





When Chan 1 or 2 menu is selected, one of two function menus will appear on the right side of the display,(see figure 6-1), one for the Normal mode and one for the Magnify mode. If you wish to change from one mode to the other, press the Ch Mode key. The Magnify mode cannot be used if a channel's display is not "On".

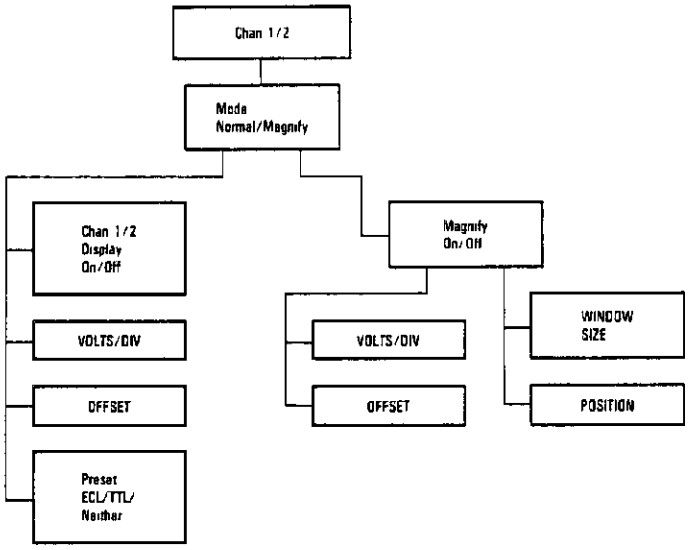
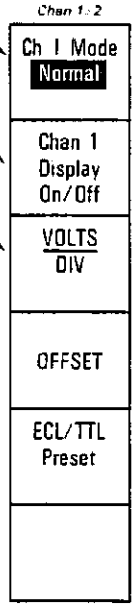


Figure 6-1. Chan 1/2 Menu

6-5. NORMAL MODE

The Normal mode should be selected when the entire vertical magnitude of the input signal needs to be observed. When operating in this mode, you should not adjust VOLTS/DIV or OFFSET in such a fashion that the signal will be off scale vertically as erroneous results may be acquired.



The display On/Off key is the second from the top. Push it and notice that the Chan 1 signal disappears and reappears depending on whether On or Off is selected. This function key turns off the display for a particular channel. It does not stop that channel from acquiring data. Next is the VOLTS/DIV key which when selected will allow the vertical sensitivity to be changed in a 1-2-5 sequence in three ways: (NOTE: a 1-2-4 sequence is used when you are in the split screen mode).

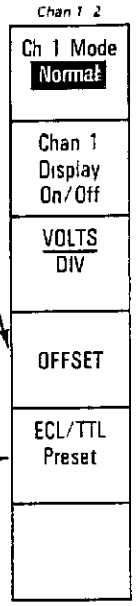
1. Vertical sensitivity can be changed by using the number pad on the Entry portion of the front panel. After a number on the key pad has been pressed, the appropriate "units" key must be pressed to complete the operation. The units keys are located just to the right of the key pad. Note: In the Normal mode all entries other than 1-2-5 will default to the nearest 1-2-5 range. In the Magnify mode, sensitivity can be entered to 3 digit resolution.

2. The knob may be used to change the vertical sensitivity.

3. The step keys, located just above the knob, may be used to increment or decrement the vertical sensitivity.

These three entry devices may be used on any function menu item that is written in UPPER CASE letters e.g., VOLTS/DIV, SEC/DIV, OFFSET etc.

The next function key is OFFSET which when selected allows the trace to be moved up or down by using the number pad, the knob, or the step keys. This function works much the same way as a conventional oscilloscope position control. The OFFSET voltage as referenced to center screen is shown in inverse video at the top of the display.

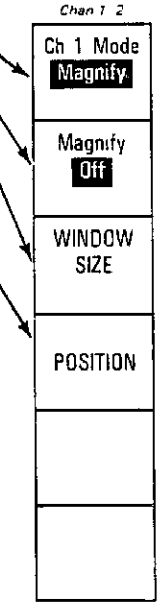


The next function key is the Preset key. This key provides three choices:

1. ECL
2. TTL
3. Neither

When ECL or TTL is selected the instrument automatically selects the correct OFFSET, VOLTS/DIV, and TRIG LEVEL for the logic family that was selected. If the ECL or TTL function is selected the selection will be highlighted. When neither preset is desired press the preset key until neither ECL or TTL is highlighted. The OFFSET, VOLTS/DIV, and TRIG LEVEL will then return to their previous settings.

6-6. MAGNIFY MODE



When the magnify function menu is selected, Magnify can be turned On/Off by pressing the Magnify On/Off key. When Off is selected there will be two variable functions on the vertical function menu; WINDOW SIZE and POSITION. They can be changed by using any of the entry devices i.e., step keys, the knob, or number pad. The horizontal lines that define the window can be moved closer together or farther apart by manipulating the entry devices. The window defines the range that will be displayed full scale when Magnify is keyed on.

When the POSITION function is selected, the user can move the window on the vertical axis by using the input devices. Note: This is different from vertical position; the window moves, not the signal. The Magnify function is easy to demonstrate:

Connect the cal signal to Chan 1 and push AUTO-SCALE.

Select:

Mode=Magnify,
Magnify=Off
Display=Averaged
# of Averages=64

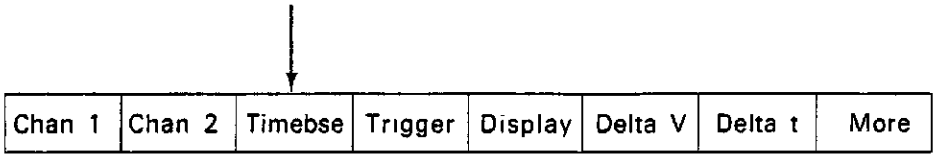
Alternately select and adjust WINDOW SIZE and POSITION so the window is about the pulse top. When Magnify is turned On the portion of the signal that was defined by the window will fill the display. The vertical sensitivity or offset for the magnified display is shown in inverse video at the top of the display.

The vertical sensitivity i.e., VOLTS/DIV, and OFFSET can be adjusted in the Magnify mode by selecting the appropriate function key and using one of the entry devices.

You would use the magnify function if you wanted to evaluate a small signal such as a reflection or overshoot that was present on large signal. Magnify can also be used to provide increased vertical sensitivity.

The Magnify mode allows higher vertical resolution, up to 16X magnification when in the average mode and is most useful when the display is in the averaged mode. (See paragraph 6-10, Display Menu.)

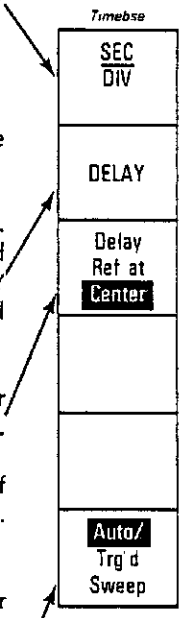
6-7. TIMEBASE (Timebse) MENU



After the AUTO-SCALE system control key is pressed you will notice that the instrument has established itself in the timebase(Timebse) menu and the SEC/DIV function.

The Timebse menu contains two variable functions. Note: Variable functions are identified by UPPER CASE LABELS. (See figure 6-2.)

The SEC/DIV function allows the time scale on the X-axis to be varied from 1 sec/div to 100 ps/div in a 1-2-5 sequence by using the entry devices i.e., the knob, step keys, or the number pad. Sweep speeds can be entered from the number pad with up to 3 digits of resolution.



The effect is very similar to turning the time/division switch on a conventional oscilloscope.

For sweep speeds slower than 1μs/div the sampling rate is changed to provide an appropriate display on the CRT.

The DELAY function controls the pre and post trigger delay and can be varied by the entry devices. The adjustment resolution for DELAY time is equivalent to 0.2% of the time interval represented by 10 horizontal divisions (but not less than 2 ps or 1 ppm whichever is greater). The DELAY function has an effect similar to that of a horizontal position control on a conventional oscilloscope, but with the added advantage of having a range of millions of screen widths.

The Delay Ref. key allows you to reference the delay to the right or left graticule edge or center screen. The time at the Delay ref. is equivalent to the trigger time. DELAY=0 is the trigger point.

When the DELAY function is selected delay time is displayed in the inverse video field at the top of the display. Maximum pre and post trigger time intervals vary with sweep speed and Delay Ref. location.

Negative DELAY values infer time before the trigger and positive DELAY values infer time after trigger. The trigger point is at Delay=0.

The last key on the Timebse menu is the Auto/Triggered (Trg'd) key. When the Auto sweep function is chosen the unit will provide a baseline on the display in the absence of a signal. If a signal is present but is not triggered the display will be unsynchronized but will not be a baseline.

If the unit is in Trg'd sweep and no trigger is present the unit will not sweep, and the data acquired on the previous trigger will remain on-screen.

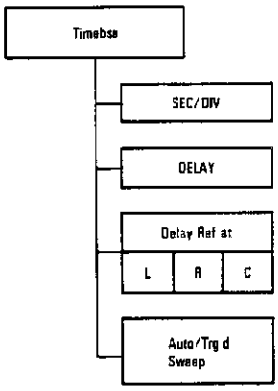


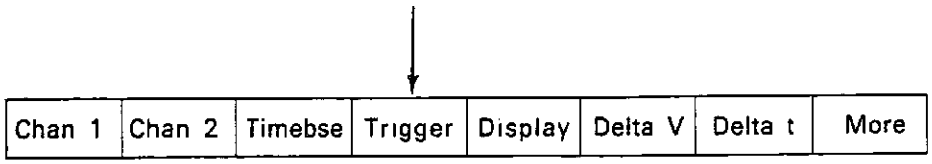
Figure 6-2. Timebse Menu

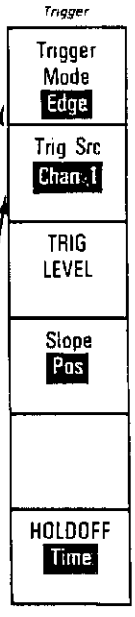
Always use the Trg'd Sweep function when the trigger rep. rate goes below 20Hz to prevent the Auto Sweep circuitry from generating a sweep prior to the trigger event. The signal on the display that was initiated by the Auto trigger generator would be asynchronous with the signal on the sweep that was initiated by the trigger event. The oscilloscope will trigger normally if the trigger repetition rate is greater than 20 Hz.

NOTE

The 20Hz auto trigger repetition rate applies even for long DELAY or large SEC/DIV settings.

6-8. TRIGGER MENU





The Trigger menu allows you to select Trigger mode, Trigger Source, Slope and Holdoff. This menu also is used to invoke the unit's combinatorial triggering capability i.e., logic pattern triggering. (See figure 6-3.)

When previewing the Trigger menu notice the two trigger modes, the Edge mode and the Pattern Mode. Let's first discuss the Edge Mode. Edge Mode allows you to select one of three different trigger sources (Trig Src) for the 54100A and four sources for the 54100D, adjust the trigger level (TRIG LEVEL), select the slope of the input signal that is to be used to define the trigger event (Pos/Neg), and define the HOLDOFF in Time or Events.

The Trig Src key permits the selection of one of three possible trigger sources; Chan 1, Chan 2, or the external trigger input (Trig 3). Note: the 54100D has a second external trigger input (Trig 4) for a total of four trigger sources.

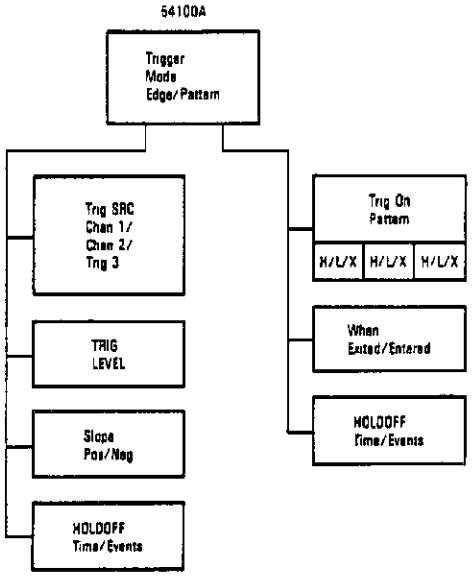


Figure 6-3. Trigger Menu

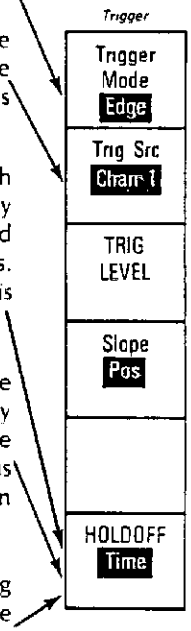
If Chan 1 or 2 is selected as the Trig Src a horizontal trace will appear on the display showing the TRIG LEVEL with respect to the displayed signal when TRIG LEVEL is assigned to the entry devices.

Slope selects the Neg or Pos slope of the input signal to be used as the trigger. The trigger slope and level can be set independently for each channel and the settings for that channel will be retained even though another channel is selected as the trigger source, or another trigger mode is selected.

The HOLDOFF circuitry allows you to define the period following a trigger event during which the trigger circuit is disabled. The 54100A/D allows HOLDOFF to be defined by Events or Time. By pressing the HOLDOFF function key you can determine whether the HOLDOFF is to be defined by time or events. An event is defined as a change in the input that satisfies the trigger conditions. If Time is used to define HOLDOFF the range is from 70 ns to 670 ms. HOLDOFF by Events range is from 2 events to 6.7 X 10^7 events. Maximum counting rate for events is 80MHz.

HOLDOFF by time can be used to trigger on a complex waveform by controlling the time from the last trigger event to when another trigger event can be accepted for referencing the display. By setting the HOLDOFF time to slightly less than the fundamental period of a reasonably stable signal a synchronized display will result. With HOLDOFF set correctly all but one of the numerous events occuring over the signal fundamental period are skipped which causes the same event in each cycle to be used for triggering the display.

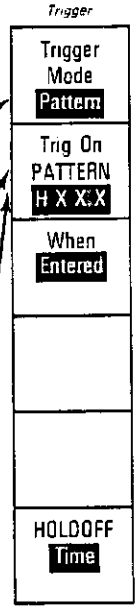
HOLDOFF by Events can be used to trigger stability on a complex waveform by actually counting the events themselves that are to be skipped before accepting another for a trigger. By setting the HOLDOFF by events to one less than the number of events occurring over the fundamental period of the signal a stable display will result. HOLDOFF by events is equivalent to placing a divide-by-N counter in the trigger path where N is one plus the holdoff value.



Unlike conventional oscilloscopes the trigger system in the 54100A/D is completely independent of the timebase. This means that adjusting the DELAY or SEC/DIV functions will not disturb the display synchronization established with HOLDOFF. Also the Auto Sweep circuitry acts upon the repetition rate of accepted triggers so HOLDOFF by Time values greater than 50 ms or large HOLDOFF by Events values can result in a low effective trigger repetition rate. In this case the Trg'd Sweep function should be used.

HOLDOFF can be varied by using any of the entry devices and is displayed in inverse video at the top of the display when the HOLDOFF function has been selected.

6-9. PATTERN MODE



Press the Trigger Mode function key to access the Pattern Mode. In the Pattern Mode you have 3 bit pattern recognition capability, (the 54100D has 4 bit capability), and the instrument can be triggered either when entering or exiting this pattern. HOLDOFF can be defined either by Events or Time.

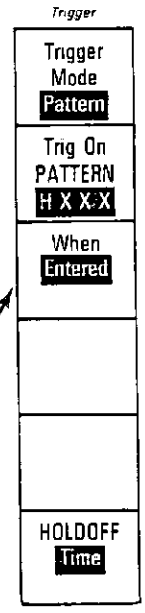
The label for the Trig On PATTERN function key includes three characters in an inverse video text field. When the Trig On PATTERN key is pressed one of these characters will be highlighted. By using the entry devices you can change this character to one of three letters; X, L or H. Pressing Trig On Pattern again will sequence through the character field so each can be edited.

NOTE

The inverse video text field on the 54100A includes three characters

X indicates a "don't care condition", L indicates a requirement for an input <the trigger level for that input. H indicates a requirement for an input >the trigger level for that input.

The three characters in this text field determine whether the voltage levels at each of the three inputs, i.e., Chan 1, Chan 2 and Trig 3, are required to be above or below TRIG LEVEL or are not used as a trigger qualifier. If these characters read "L H X", Chan 1 would have to be below TRIG LEVEL, Chan 2 would have to be above TRIG LEVEL to satisify the pattern condition. In this example for the 54100A Trig 3 is not used as a trigger qualifier because it's in the don't care condition. The 54100D has an additional external trigger input, Trig 4.



NOTE

Set the TRIG LEVEL for each trigger source while you are in the Edge mode. These trigger levels must be set before going to the Pattern mode or proper Pattern triggering may not occur.

The next key on the function menu is the When Entered/Exited key. When this key is pressed the inverse video text field next to the key will change from Entered to Exited or vice versa. If When Entered is selected, the unit will generate a trigger on the last transition that makes the PATTERN true. If When Exited is selected the unit will generate a trigger on the first transition on any of the inputs that cause the PATTERN to be false, after it was initially true.

When you are in the Pattern Mode and you have pressed the Trig On PATTERN key the inverse video text field at the top of the CRT will list what condition a particular input must be in to satisfy the pattern requirements e.g., "CH 1 Trigger = Low", "Trig 4 = High", etc.

The triggering capabilities that have been discussed to this point are shared by the 54100A and 54100D except where it is specifically stated otherwise. The remainder of this chapter deals exclusively with the additional triggering capabilities of the the 54100D. (See figure 6-4 for a map of the 54100D trigger menu.)

The 54100D had two additional functions on the Pattern Trigger Mode menu; When Present > and When Present <. These functions can be accessed by pressing the When Key. These two functions allow time to be used as an additional trigger qualifier.

If When Present > is selected, a trigger event will occur if the trigger pattern is true for a minimum time period. This period is listed in the label for the TIME key and can be varied from 10 ns to 5 sec. by the entry devices.

When the trigger pattern remains true for the required period of time, a trigger will occur when any of the inputs transition to a false state.

If the pattern becomes true and then goes false before the specified time, no trigger will occur.

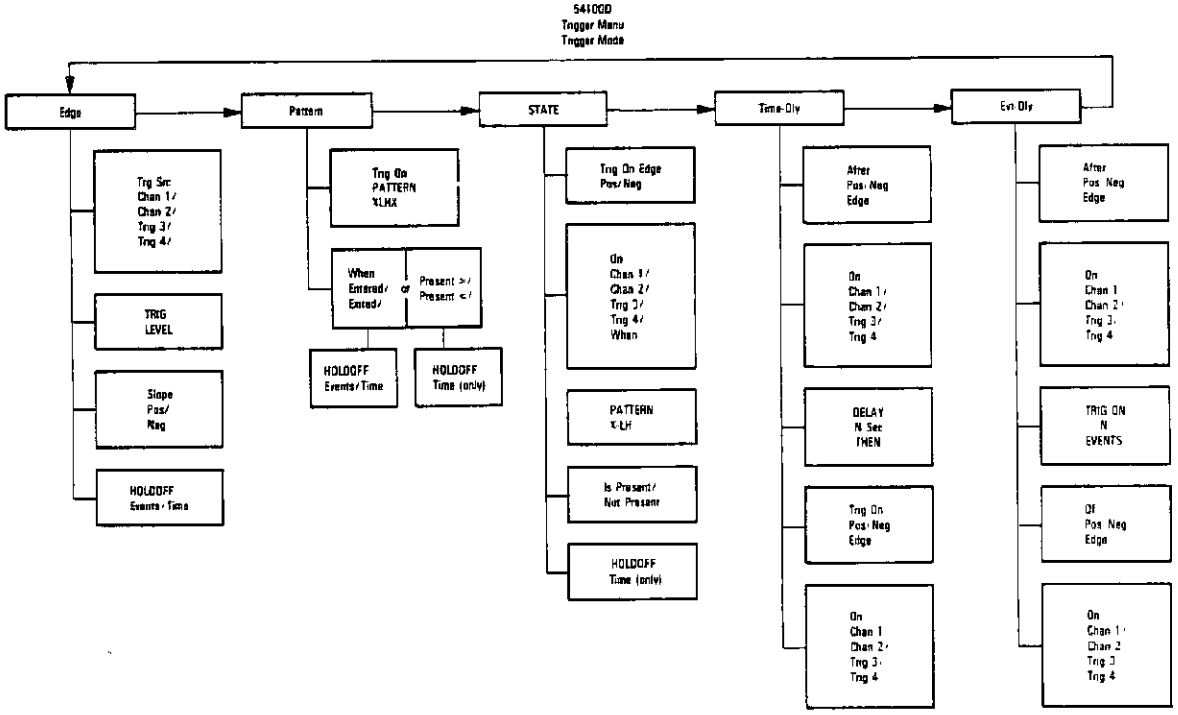
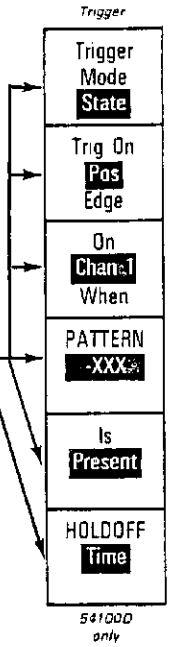


Figure 6-4 54100D Trigger Menu

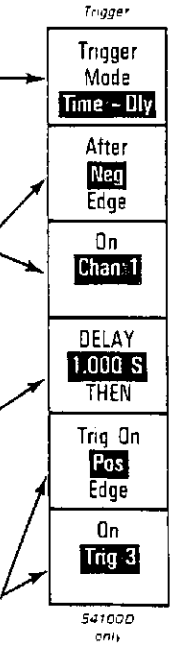
If When Present < is selected, a trigger will occur only if the trigger pattern is satisfied and one of the inputs transitions to a false state before a given time period. In this mode, the pattern must be true for at least 1 ns to be recognized.

This period is listed in the TIME key label and can be varied from 10 ns to 5 sec. by the entry devices. Only HOLDOFF by Time is available with the When Present modes.



Press the Trigger Mode key, the label will change to State. In the State mode one of the inputs is selected as a simple edge source, the other three inputs define a logical pattern.

A trigger will occur on the edge (pos/neg) when the pattern is true and Is Present is selected. A trigger will also occur on the edge (pos/neg) when the pattern is false and Is Not Present is selected. The polarity of the edge that is used for trigger edge source is selectable and and the threshold is set by TRIG LEVEL when you were in the edge mode. Only HOLDOFF by Time is available with the State mode.



Press the Trigger Mode key and the label will read "Time Dly", (Time Delay) This menu allows you to arm on a signal edge on any source, wait for a period of time and then trigger on an edge from a different source. The edge polarities, the sources that are used to define the edges, and the delay time are all user definable.

The second and third function keys allow you to select the polarity and source of the arming edge. The DELAY Time range is from 20 ns to 5 sec.

The fourth key allows you to define a waiting period between the arming edge that is used as a trigger qualifier and the edge on which the the 54100D triggers.

The fifth and sixth function keys allow you to select the polarity and source of the edge that is used as the trigger event.

The last Trigger Mode is the Evnt-Dly, (Event Delayed), mode. This menu allows you to define an edge as a trigger qualifier. Once this edge is detected the unit will trigger after a definable number of edges on any other source.

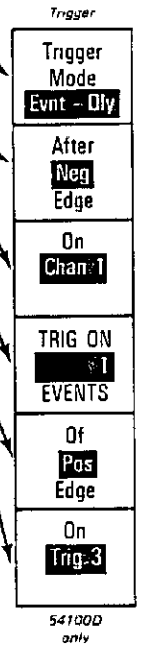
The second and third keys on the menu allow you to select the polarity and source of the arming edge.

The fourth key allows you to determine the number of edges on the trigger source that are to take place before the trigger event.

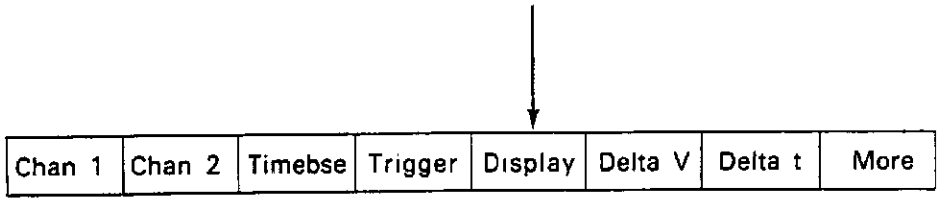
The fifth and sixth keys allow you to determine the polarity and source of the triggering and counting edge.

In the Edge mode TRIG LEVEL is used to specify a threshold for each source independently. It is these thresholds that are in effect in all other modes wherever a source is active in a triggering function. Other than thresholds there is no interaction between the trigger menus. Changing slopes or patterns in one menu will not affect corresponding entries in other mode menus.

In most of the triggering modes it is possible to specify parameters which will reduce the effective trigger repetition rate (display triggers) to below 20 Hz. Since the Auto Sweep function measures the rate of display triggers the timebase should be put in Trg'd mode to avoid premature automatic triggers with large event delay counts, filter times etc.



6-10. DISPLAY MENU



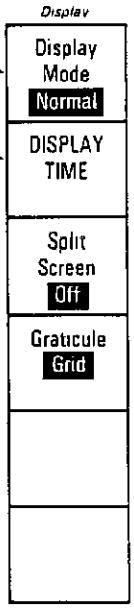
When the Display function menu is chosen two modes are available, Normal and Averaged. (See figure 6-5.)

In the Normal mode each displayed data point is displayed for a period of time defined by the user. You can vary the DISPLAY TIME (persistance) from 200 ms to infinity.

In infinite persistence the data points will remain on the display until the CLEAR DISPLAY key is pressed or until the sweep speed, vertical sensitivity or trigger level are changed. The Persistence is shown in inverse video at the top of the display.

If variable persistence (persistence other than Infinite) is selected you have a flexible display that changes with variations in the input signal but stores the signal indefinitely on the display if the trigger is lost and the unit is in Trg'd Sweep.

A minimum persistence setting is useful when the input signal is changing and the user needs immediate feedback, such as in rapid probing from point-to-point, or setting the amplitude or frequency of a signal source. More persistence is useful when observing long-term changes in the signal or low signal repitition rates. At fast sweep speeds and low trigger rep. rate conditions more persistence is needed to gain an adequate number of data points on the display. Infinite persistence is useful for worst-case characterization of signal noise, jitter, drift, timing, etc.



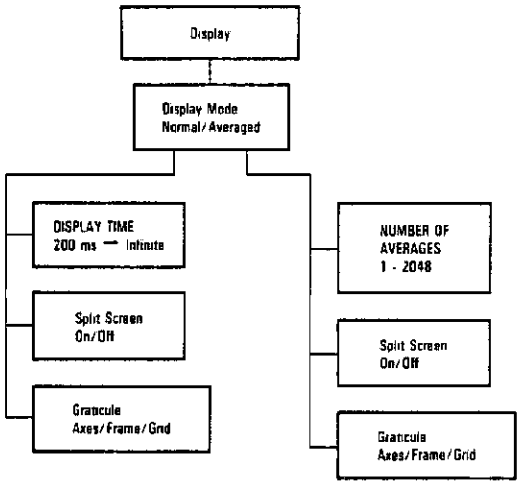
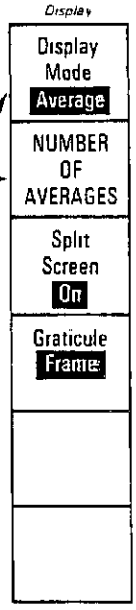


Figure 6-5. Display Menu

There is a limit to the number of data points that can be displayed on the screen at any one time in the variable persistence mode. The display time is temporarily reduced whenever the number of points exceeds 5,500. This has the effect of reducing the number of data points on the display. When this happens you might see the display appearing to pulsate, i.e., a number of points will accumulate and then the display will fade and build up again, etc.



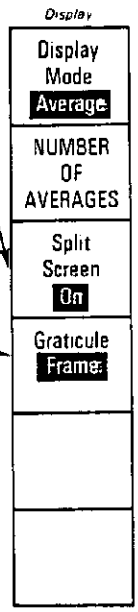
If Averaged Mode is selected the last acquired data points are averaged with previously acquired data before they are displayed. The number of data points that are averaged is variable from 1 to 2048 in powers of 2.

Vertical resolution can be extended and displayed, noise can be significantly reduced by using the Averaged mode. As the number of averages is increased, the display becomes less responsive to changes to the input signal(s); however, noise is reduced, and resolution is improved as more averages are used. By selecting the appropriate number averages the throughput for the automatic pulse parameters or the precise edge locators can be controlled. Since these automatic measurements use averaging the user can trade off the speed of the measurements against the repeatability of the measured results.

The input signal is digitized and each data point is assigned a time slot relative to the trigger. In the averaging mode the unit calculates the average of the most recent data point with the previous values in the same time slot. You can define the number of data points that are to be averaged from 2 to 2048 in powers of 2. Each average is calculated from data acquired for each time slot, data for adjacent time slots is not averaged together.

The current number of averages which have been accumulated is listed on the second line of text in the upper left of the screen. When a precise measurement is made in the average mode, this readout displays the running number of averages for the measurement. Because only data points from the same acquisition time with respect to the trigger are averaged together, averaging does not reduce the bandwidth or risetime of the acquired waveform.

The next function key on the Display menu is the Split Screen key. When Split Screen is keyed On, Chan 1 will be presented in the upper half of the display and Chan 2 in the lower half. Scaling accuracy is maintained as this function is turned Off/On. When the split screen function is keyed off Chan 1 & 2 are overlaid on the display area.

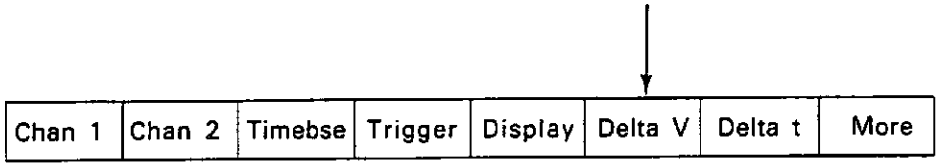


NOTE

In the Split Screen mode each channel occupies 4 vertical divisions rather than 8 as is the case when Split Screen is Off. This requires the vertical sensitivity in VOLTS/DIV be doubled.

Three different graticules are available in the display function menu. Press the graticule key and cycle through them to see how they appear. You will find that using the frame graticule makes it easier to see the Delta V and Delta t markers.

6-11. DELTA V(VOLTS) MENU



When the Delta V (Delta Volts) menu is enabled, two markers are displayed. These markers can be used to make absolute voltage measurements on the signal under evaluation or as reference markers when adjusting a signal to a given amplitude (See figure 6-6.)

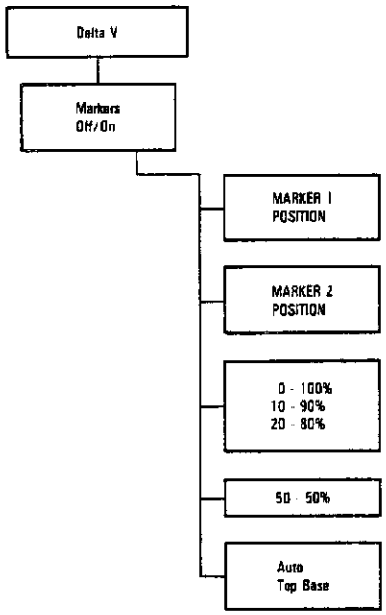
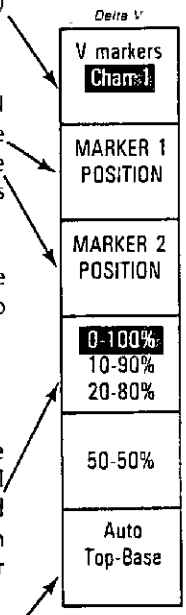


Figure 6-6. Delta V Menu

Once the Delta V menu is selected the markers cannot be activated unless the display for Chan 1 or 2 is turned on.

Choose the channel you would like to evaluate and enable the V Markers. Observe the next two functions on the Delta V menu, MARKER 1 POSITION and MARKER 2 POSITION. (See figure 6-7.)



After assigning the markers to the desired channel or channels, selecting MARKER 1 POSITION and MARKER 2 POSITION function keys will allow you to position the markers vertically with the entry devices. The voltage shown in inverse video at the top of the display indicates the voltage level of the V Marker that has been selected. Delta V, the difference between the two markers, is shown in the factors area at the bottom of the display.

In the lower portion of the display are "display factors", these factors include the delta V value and the absolute value for each marker. Delta V is the voltage difference between the two Vmarkers. This measurement capability simplifies waveform measurements.

The next three keys on the Delta V menu automatically position the V markers on the display

The 0-100/10-90/20-80% key causes the instrument to perform some calculations and position the V markers for the user. When the V markers are positioned manually the inverse video field will change to 0-100%. If the key that is showing 0-100% is pressed the label will change to 10-90% and the markers will move to the 10% and 90% points of their previous levels. If the key is pressed again the label will change to 20-80% and the markers will move to the 20% and 80% points of their original levels.

The Auto Top-Base key automatically locates the top and base of the displayed waveform. This is done by evaluating a histogram of the displayed signal.

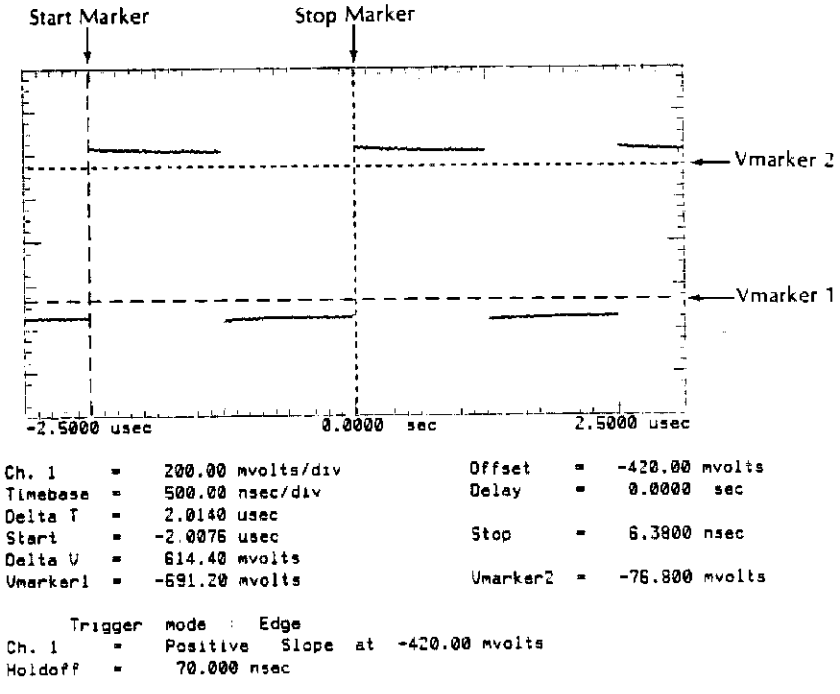
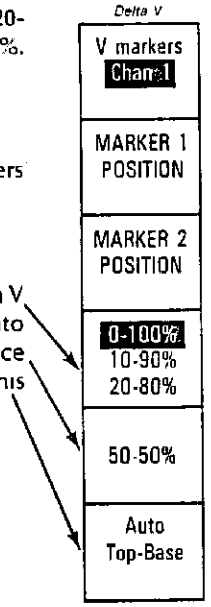


Figure 6-7. Vmarkers

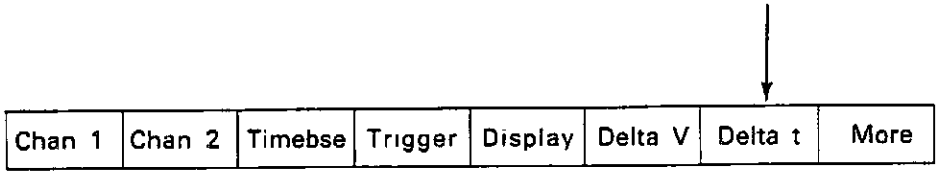
If either of the V Markers are manually repositioned while the function switch is in 10-90% , 20-80% or 50-50% the original reference will be lost and the label for the key will change to 0-100%. The 50-50% key moves both markers to the 50% point of the 0-100% levels.

Auto Top-Base, 0-100%/10-90%/20-80%, 50-50% function keys are disabled when the Vmarkers are selected for Ch 1 & 2.

Input the cal signal from the rear panel to Chan 1 and press AUTO-SCALE. Next select the Delta V function menu and key on the V markers. Now, establish the top-base reference by pressing Auto Top-Base. To demonstrate the action of the 0-100/10-90/20-80% key press it several times, notice how it cycles through the three selections and how the V markers move. Press the 50-50% key, this establishes the V markers at the 50% point of the signal.

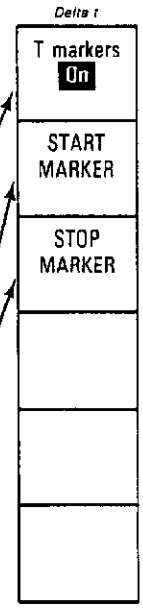


6-12. DELTA T (TIME) MENU

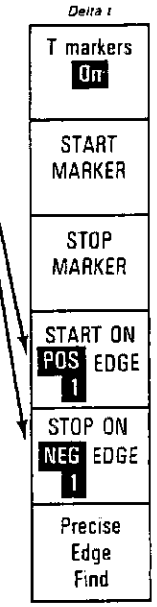


The Delta t function menu provides control for two T (time) markers that can be used to make measurements in the time domain. The display factors include Δt which is the time interval between the two T markers. In figure 6-7 the Start Marker=2μs and the Stop Marker=0 Sec. These times tell you the time interval between the T markers and the Delay Ref.(See figure 6-8.)

After the T markers have been enabled, each T marker can be moved manually by selecting START MARKER or STOP MARKER and using the entry devices. The inverse video text field at the top of the CRT lists the time between the selected marker and the delay ref.



The Delta t menu is extended when the Delta V markers are turned On. START ON EDGE, STOP ON EDGE, and Precise Edge Find Functions are available on the Delta t menu when the Delta V markers are on. Try this exercise to demonstrate these capabilities.



Connect the cal signal to Chan 1 and press the AUTO-SCALE Control key. Select the Delta t menu and turn the T markers On. Manually move the START MARKER so that it coincides with the first positive leading edge of the Cal signal (figure 6-7). This is one way of making a time interval measurement.

In the display factors the START MARKER is approximately 2 μs ahead (-2.0 μs) of the trigger event (Delay=0) which was established at center screen when you used AUTO-SCALE. The STOP MARKER is located at approximately center screen and the time interval between the T markers (delta t) is approximately 2μs.

Select the Delta V menu and turn the V markers On. Press Auto Top-base then press 50-50%. For this measurement the significant thing is to make sure that the V markers intersect the rising and falling edges of the signal.

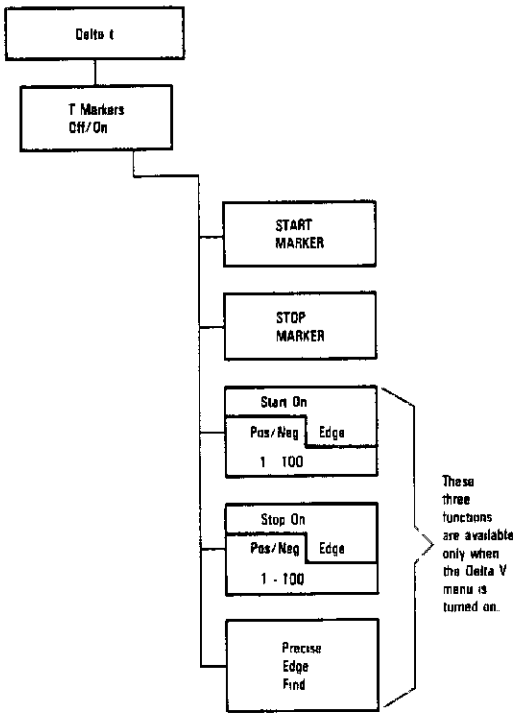
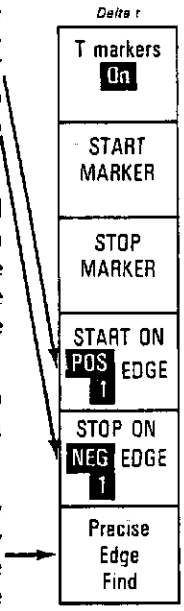


Figure 6-8. Delta t Menu

Return to the Delta t menu. Press START ON EDGE function key several times, notice that the Pos/Neg indicator alternates and START MARKER moves from the positive edge of the first pulse to the negative edge of the same pulse. Try using each of the entry devices to move the START EDGE to another pulse. STOP EDGE can be changed in this fashion also. Start On Edge and Stop On Edge are "coarse" edge locators in as much as data already collected on screen is used to locate the edges.

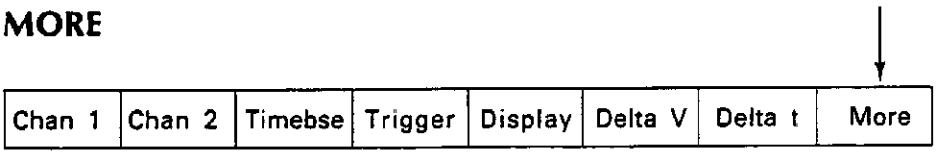


To demonstrate the last Delta t menu function, precise Edge Find, return to the Delta V menu and press Auto Top-Base to locate the top and base of the Cal signal, then select 10-90%. Now again return to the Delta t menu. Set Start Edge to Pos 1 and Stop Edge to Pos 1 and press Precise Edge Find. Δt (in the factors text field) will represent the rise time of the pulse, in this case approximately 2 ns. Note that the 54100A/D automatically selects a faster sweep range, to increase the resolution of the edge finder.

The Precise Edge Find function initiates an automatic time interval measurement. The 54100A/D will acquire the data, make the measurement and have the Delta t and Delta V markers visible on the display so that you can see where the automated measurements were made.

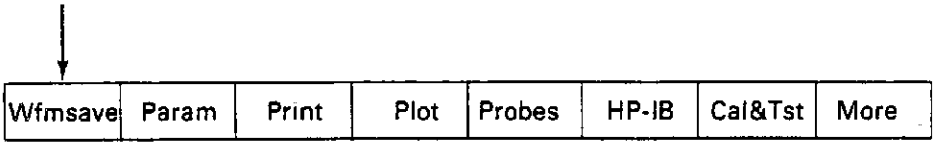
When you use the Precise Edge Find function the unit will expand the selected edges defined by the Start On Edge and Stop on Edge functions. This expansion is accomplished with newly acquired data. By expanding the edge in this fashion the horizontal resolution is increased. The speed and repeatability of this measurement is influenced by the number of averages. The more averages the more repeatable and slower the measurement will be. Other items that will influence measurement speed and repeatability are; input signal edge speed, repetition rate and signal jitter. Even though the displayed data does not shift to averaged mode, the automatic edge locating routine calculates averaged data when locating the edge(s).

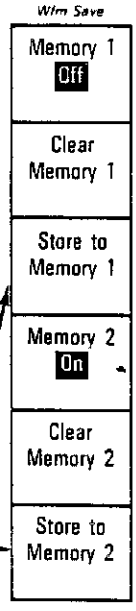
6-13. MORE



To view the remaining menus press the "More" key. It is located in the lower right hand corner of the display. This key allows you access to seven additional function menus. Pressing the More key again allows you to return to the original set of menu keys.

6-14. WFMSAVE (WAVEFORM SAVE)





The 54100A/D has two volatile pixel memories. These are in addition to the dynamic memory that is used for the active display. These memories have a resolution of 501 pixels horizontally and 256 pixels vertically. Which is the same as the active display.

When you select Wfmsave you have full control of these two pixel memories. The contents of each memory can be viewed or removed from the display by selecting either memory and keying it On or Off. To store a signal in one of the static memories press Store to Memory 1/2. (See figure 6-9.)

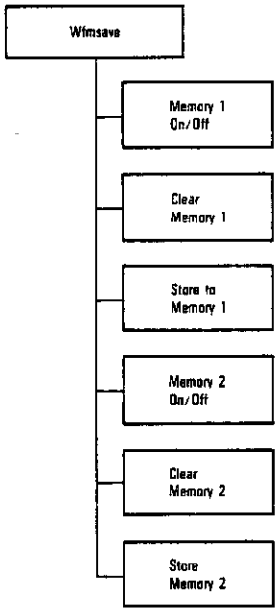
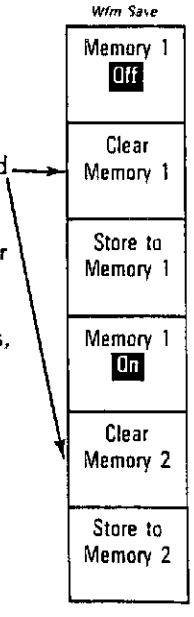


Figure 6-9. Wfmsave Menu

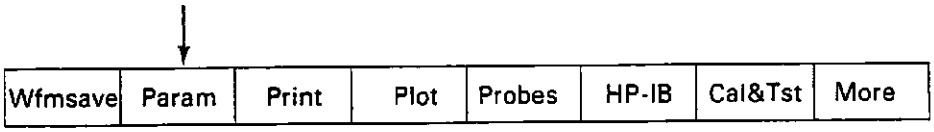
Multiple waveforms may be superimposed in these memories and kept for future viewing and comparisons. To purge a memory press Clear Memory 1/2.

Any stored waveforms will remain available for viewing until the instrument power is removed or the appropriate Clear Memory key is pressed.

When a waveform is stored in memory, only the pixel display is maintained. The scaling factors, volts/div., sec/div., or factors are not stored.



6-15. PARAM (PARAMETERS)



When you press the Param menu select key, you will have access to three function menus which can be accessed by pressing the More key on the function menu. (See figure 6-10.) If neither channel is activated Measure will default to Chan 1 and measurements will automatically activate the Chan 1 display.

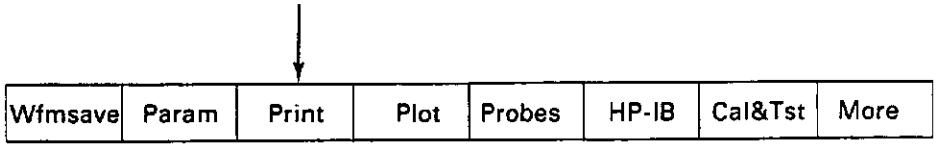
The Param menus use the measurement capabilities of the Delta t and Delta V menus to make automatic pulse measurements. These measurements can be made whether a channel's display is On or Off.

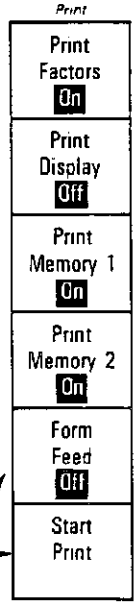
The first function menu that is presented when Param key is pressed is the Measure function. This key selects the channel to be measured.

The next function key is the All key, when pressed the 54100A/D automatically makes the measurements below and lists the results in the factors area. The More key on each of these menus allows you to select the next Param menu when pressed.

Freq (Frequency)	+ Width	Peak-to-Peak Voltage
Period	-Width	Preshoot
More	Rise Time (10-90%)	Overshoot
	Fall Time (10-90%)	More
	More	

6-16. PRINT





The Print menu allows display and memory data to be output over HP-IB to a graphic printer that is compatible with Hewlett-Packard Raster Scan Standard. The waveforms in this manual were generated using an HP 2225A THINKJET Graphics Printer driven by a 54100D. (See figure 6-11.)

The 54100A/D must be in the "Talk Only" mode and the printer must be in the "Listen Always" mode. The 54100A/D can be set to Talk Only when in the HP-IB menu. (Refer to paragraph 6-18.)

The Print function menu offers you four print options, an automatic form feed option and a Start Print key. The four print options allow the selection of the data that is to be output to the graphics printer. Any or all data sources can be output at the same time, i.e., any combination of the Factors, Memory 1, Memory 2, and the display data can be sent to the printer for a hardcopy.

If you desire automatic Form Feed after a hardcopy, key this function On. After the data has been selected for copying, press the Start Print key to initiate the hardcopy. Signal acquisition stops during printing. To stop printing press the Abort Print key.

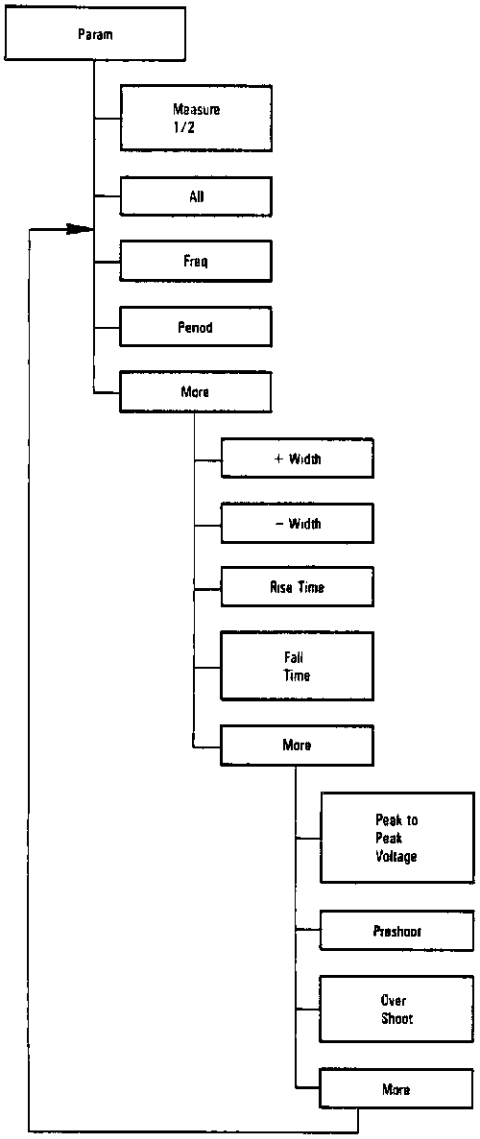


Figure 6-10. Param Menu

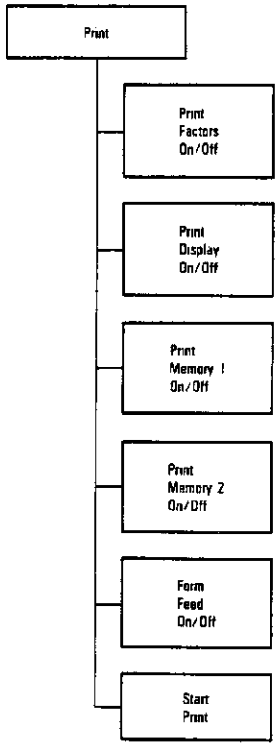
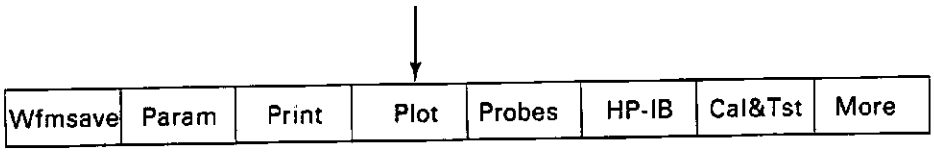
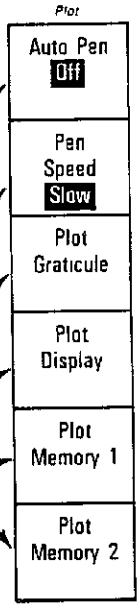


Figure 6-11. Print Menu

6-17. PLOT



When the Plot Menu is selected the HP-IB output from the 54100A/D is formatted in HP-GL. (See figure 6-12.) The 54100A/D must be in "Talk Only" and the HP-GL plotter must be in the "Listen Only" mode. Refer to paragraph 6-19 for information concerning the HP-IB menu.



The first option on the plot menu is the Auto Pen selection. When this function is On a new pen will be selected when a different function is chosen to be plotted, that is, if the plotter has multi pen capability. If Auto Pen is Off the plotter will not load or change pens when a plot function is selected.

The next Plot option is Pen Speed. You may choose Fast or Slow if your plotter has this feature. Use slow when you are making overhead transparencies, for best results use Slow for Leroy pens, also.

When Plot Graticule is selected the displayed graticule, including display factors, will be output to the plotter.

When Plot Display is selected all active displayed waveforms will be output to the plotter.

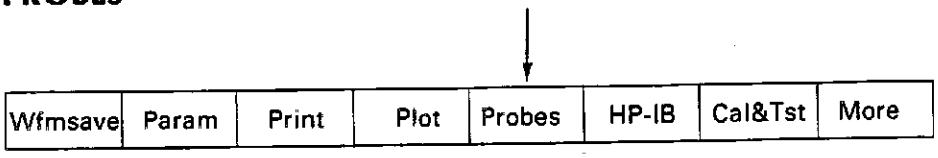
When Plot Memory 1 or Memory 2 is selected stored waveforms in that memory will be output to the plotter.

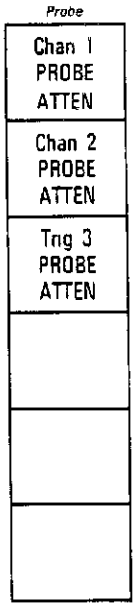
If the Display menu is in the Averaged mode, the output from the 54100A/D will cause the plotter to draw a continuous line plot of the displayed waveform.

If the Display menu is in the Normal mode or if you are plotting from one of the memories the output from the 54100A/D is formatted such that the plotter will plot the waveform in a pixel format i.e., dot by dot.

When plotting from the waveform memories, it is important to note that the 54100A/D will plot the memories based on the Split Screen On/Off state of the active waveform display. Waveform memories that were stored with Split Screen On should be plotted with Split Screen On. Likewise, waveform memories that were stored with Split Screen Off should be plotted with Split Screen Off. If this precaution is not taken, there may be misalignments of data and graticule such as vertical shift of the data with respect to the graticule in the lower half of the screen.

6-18. PROBES





When the Probes menu is selected you can enter any arbitrary attenuation ratio from 1 to 1000 for any of the inputs. Any of the entry devices can be used, however, the key pad allows three digit resolution and can be used as a cal factor for Vmarker measurements. (See figure 6-13.)

When you define a Probe Attenuator Ratio the actual sensitivity at the input of the 54100A/D does not change, all that is changed are the reference constants that are used for scaling the display factors and for automatic measurements, trigger levels, etc.

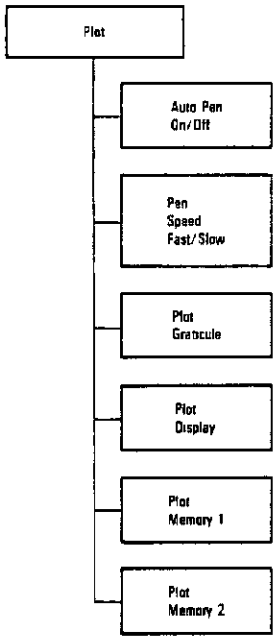


Figure 6-12. Plot Menu

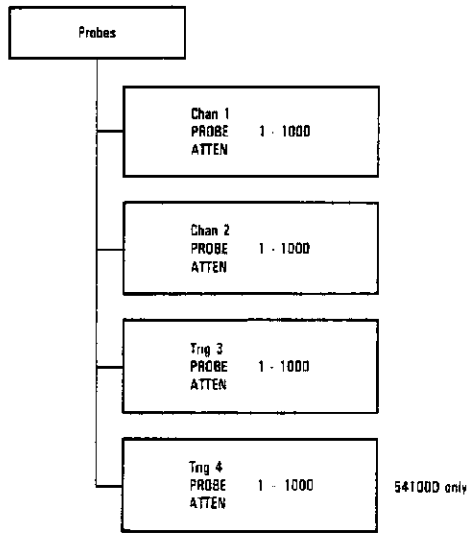
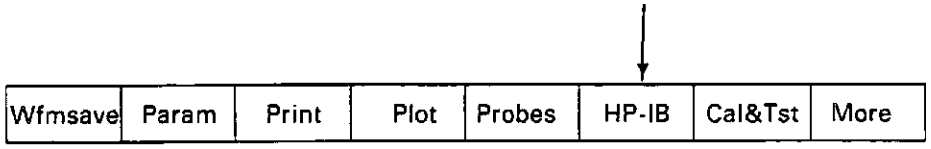
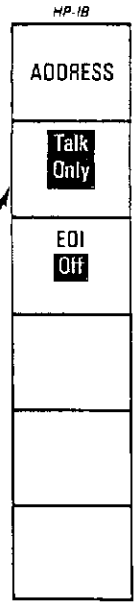


Figure 6-13. Probes Menu

Attenuation ratios can be saved with the rest of the front panel set up in the Save/Recall registers, however, when power is cycled the attenuator ratios will automatically be reset to the nominal 1:1 for the 54002A and 54003A, and 10:1 for the 54001A Active Probe, since the 54100A/D queries the input pod receptacles to determine what pods are installed at power-up.

6-19. HP-IB





When you desire to connect the 54100A/D Digitizing Oscilloscope to other HP-IB devices you would select the HP-IB function menu. This menu allows you to establish the 54100A/D as an HP-IB talker, listener, or to do both. (See figure 6-14.)

The EOI instruction can be sent at the user's discretion for such applications as binary dumps or when required by a controller when under program control.

When the 54100A/D is in the Talk/Listen mode the HP-IB address can be changed by using the Entry devices. Refer to the Programming section of this manual for for a complete discussion of the *HP-IB capabilities* of 54100A/D.

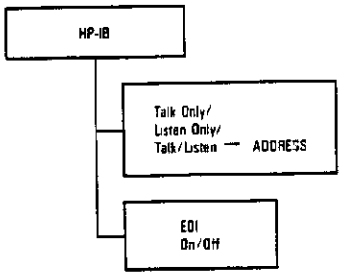


Figure 6-14 HP-IB Menu

6-20. CAL & TST (TEST)

Wfmsave	Param	Print	Plot	Probes	HP-IB	Cal&Tst	More

Cal & Tst

Cal Menu
Test Menu
CRT Setup

When the Cal & Tst (calibration & test) function menu is selected you are offered three selections; Cal menu, Test menu, and CRT Setup. The Cal menu is the only menu that will be discussed in this manual in as much as the Test menu and CRT Setup require removal of of covers and the manipulation of internal adjustments. These two menus are discussed in the optional 54100A/D Service Manual. (See figure 6-15.)

In order to obtain the proper cal for a particular system configuration it is necessary to adjust each channel's sensitivity, offset and trigger level as well as the external trigger level(s) to the values you intend to use. This will establish each input to the configuration that will be used in the actual measurement.

The objective of the cal procedure is to apply a fast edge simultaneously to inputs of the instrument and null out the systematic delay between these inputs. The fastest available edge source should be used (<1 ns transition time time is desirable), however, a signal of the same general characteristics as the signal that you intend to measure is a reasonable alternative. For each cal step the inputs should be connected to the calibration source as closely to one another as possible. BNC Tee's and probe adapters are useful to accomplish this.

Be sure to set up all sensitivities, offsets, and trigger levels before beginning the Cal menu.

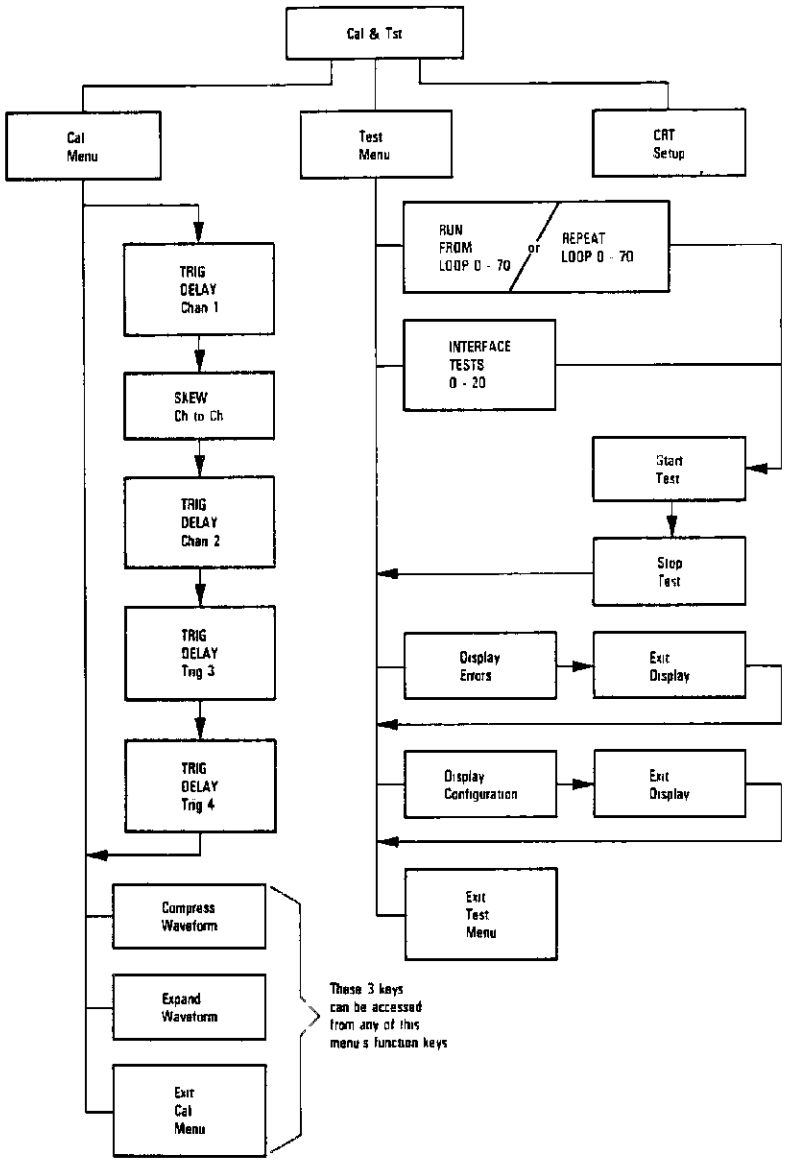


Figure 6-15. Cal & Tst Menu

The Cal menu function allows you to null any differences in propagation delay between signal paths in software in the 54100A/D. This is important so that time-difference measurement results accurately reflect time referenced to the probe tips or the points where the input coaxial cables are connected to the circuit under test.

There are two Cal. signal outputs on the rear panel. Only one cal source should be used for the Cal Menu adjustment exercise because the two cal signals are separately buffered and the time differential between the two outputs is not characterized.

Connect a BNC Tee to one of the cal signal outputs on the rear of the instrument and connect two equal length 50 ohm cables to the BNC Tee. Connect these two cables to the Chan 1 and Chan 2 inputs. Next, select the axes graticule.

For this exercise press AUTO-SCALE and set OFFSET and TRIG LEVEL to equal values for Chan 1&2. Move the signal input from Chan 2 to Trig 3 and then to Trig 4 (54100D only) and set the TRIG LEVEL Trig Src 3 and Trig Src 4 (54100D only) as close as possible to the TRIG LEVEL used for Chan 1 & 2. Now move the input cable back to Chan 2.

Press the Cal. menu function key and follow the instructions on the CRT, press the TRIG DELAY-Chan 1 function key, i.e., the top key on the function menu. As the key is pressed TRIG DELAY will intensify and a single signal will be presented on the display.

Press the Expand Waveform function key several times until the waveform is expanded and approximates figure 6-15. By using the Entry Devices adjust the position of the signal on the X-axis so that it intersects the crossing of the graticule at center screen. The value of Chan 1 Trigger Delay is highlighted in inverse video at the top of the display.

Press the top function menu key and the label will change to SKEW Ch to Ch, also the Chan 1 & 2 signals are in the split screen format and should resemble figure 6-16. The Chan 1 signal is in the upper half of the display and Chan 2 is in the lower half. The Chan 1 signal should be positioned so that it intersects the graticule crossing, this is as the result of the previous Chan 1 TRIG DELAY adjustment. Using the Entry Devices adjust the signal with the Expand Waveform Key for an appropriate display. Using the Entry Devices adjust the Chan 2 waveform on the X-axis so that it intersects the graticule crossing at center screen. When you make this adjustment you are nulling the difference in signal acquisition times from Chan 1 to Chan 2. Chan to Chan skew time is highlighted in inverse video at the top of the display.

The next adjustment to be made is the Chan 2 TRIG DELAY. Press the top function menu key, the label for this key will change to TRIG DELAY-Chan 2 and there will be a single signal on the display similar to figure 6-15. Use the Entry Devices and position the displayed signal on the X-axis so that it intersects the graticule crossing at the center of the display. The Ch 2 Trigger Delay will be highlighted in inverse video at the top of the display.

Press the top function menu key and the label will change to TRIG DELAY- Trig 3. Connect the cable that has been attached to Chan 2 to Trig 3. Adjust the Entry Devices and move the signal on the X-axis so that it intersects the graticule at the center crossing. The value of Trig 3 Delay will be listed in inverse video at the top of the display.

If you are adjusting a 54100A you have completed the Cal sequence. The 54100D, however, has an additional external trigger input and to null the difference in signal acquisition time from TRIG 4 input to the other inputs requires one further step. Move the input from TRIG 3 to TRIG 4 and press the top function key. The label will change to TRIG DELAY 4 and there will be a single signal on screen. Press the Expand Waveform key for an appropriate display and adjust the Entry Devices and move the signal on the X-axis so it intersects the graticule at the center crossing. (See figure 6-16.)

Cal factors are kept as part of the SAVE/RECALL setup and different sets of factors maybe kept with each front panel setup. When the instrument is powered down these factors will be maintained in non-volatile memory.

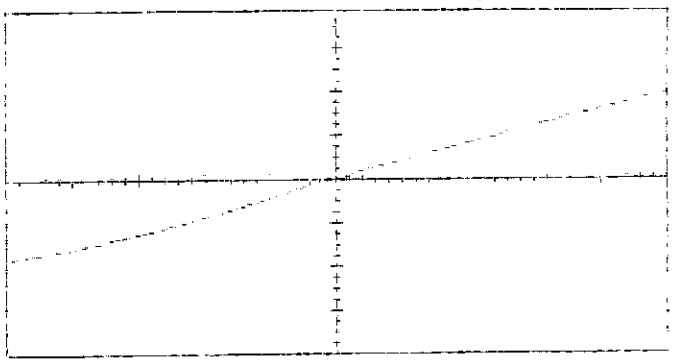


Figure 6-16. Trigger Delay

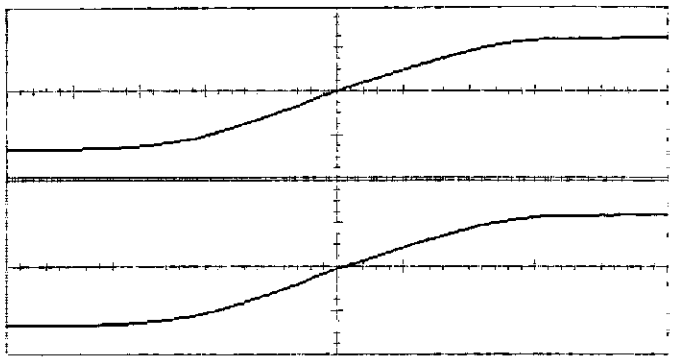


Figure 6-17. Chan to Chan Skew

Section 7
Front Panel Exercises

7-1. INTRODUCTION

This section provides exercises that will aid in becoming more familiar with local (front panel) operation. Section 6 includes a preliminary discussion on front panel operation and should be read before continuing with Section 7.

7-2. INPUTTING A SIGNAL

The 54100A has three inputs, two are vertical signal inputs and the third is an external trigger input. The 54100D has an additional input used as a second external trigger input. The fourth input on the 54100D will be discussed separately later in this section.

For the 54100A/D to accept signals, input pods must be installed. Refer to Section 3 for pod specifications. The characteristics of all inputs are dependent on the pod chosen. The appropriate input pod should be chosen after characterizing the source impedance, speed/bandwidth and magnitude of the signal to be measured.

7-3. FRONT PANEL REVIEW

Refer to figure 7-1 for a review of the front panel layout. The keys at the bottom of the CRT are referred to as the menu select keys. When one of these keys is pressed, the appropriate function menu will appear on the right side of the CRT. Additional control of the unit is available through the use of the SYSTEM CONTROL keys which are located at the top of the right side of the front panel. These SYSTEM CONTROL keys give you immediate access to those functions which are appropriate in any menu.

The ENTRY devices are used to input values for variables. The input devices on this instrument include the key pad, step keys and the Knob. If you need further information concerning the front panel refer to Section 6.

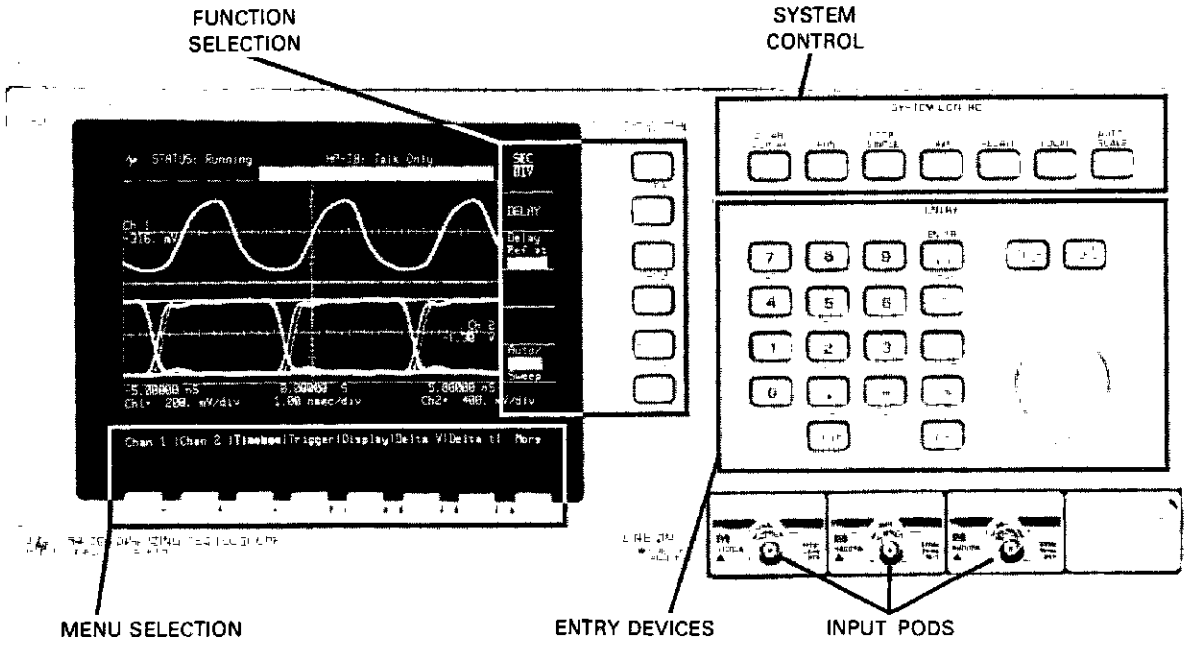


Figure 7-1. HP 54100A/D Front Panel

7-4. MAKE A VOLTAGE MEASUREMENT

This oscilloscope gives you the capability of making either a manual or automatic voltage measurement. In this discussion the instrument's Cal signal is used as the signal source. To make a voltage measurement manually you may use this procedure:

1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Select the Display menu.
4. Insure the Display Mode is Averaged.
5. Press the Delta V menu key.
6. Key the Vmarkers On.
7. Position MARKER 1 at the top of the Cal signal.
8. Position MARKER 2 at the base of the Cal signal.

The difference between the voltage levels of the two Vmarkers will be shown in the Factors area at the bottom of the CRT labeled ΔV. In this example the Cal signal measured 442 mV p-p. The positive delta voltage indicates that MARKER 2 was more positive than MARKER 1. If the markers were reversed ΔV would indicate a negative voltage (see figure 7-2).

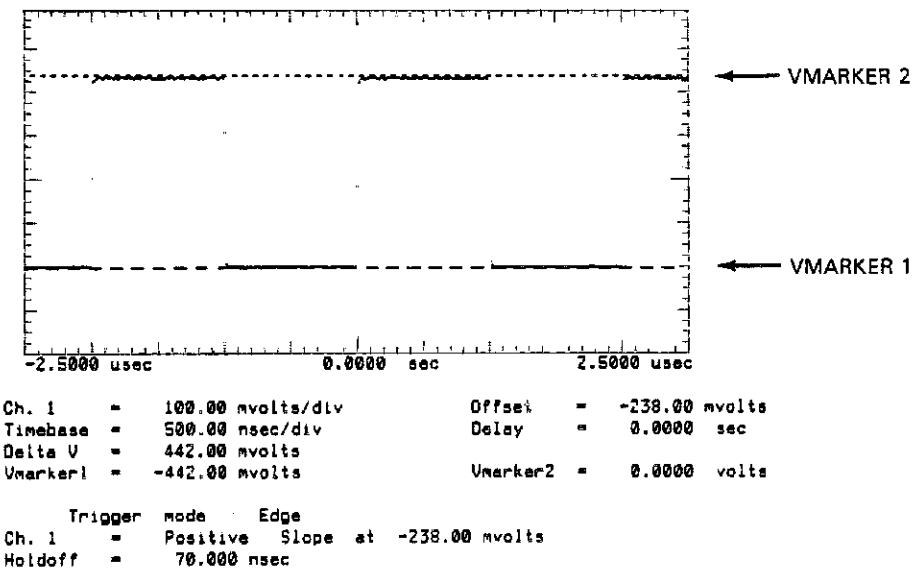


Figure 7-2. Manual Vmarker Measurement

Another method of making this measurement would be to use the Auto Top-Base function on the Delta V menu. The instrument will make an automatic voltage measurement by evaluating a histogram of the data points that are displayed on the CRT (see figure 7-3). When the Auto Top-Base key is pressed, MARKER 2 moves to the top of the Cal signal and MARKER 1 moves to the base. ΔV will indicate approximately 432 mV; this indicates that MARKER 2 is 432 mV more positive than MARKER 1 (see figure 7-4). The difference between the results of the manual and the automated measurements is that the manual measurement is accomplished by using visual resolution and the automated results are acquired mathematically. Cal signals vary slightly from unit to unit; therefore, results may vary accordingly.

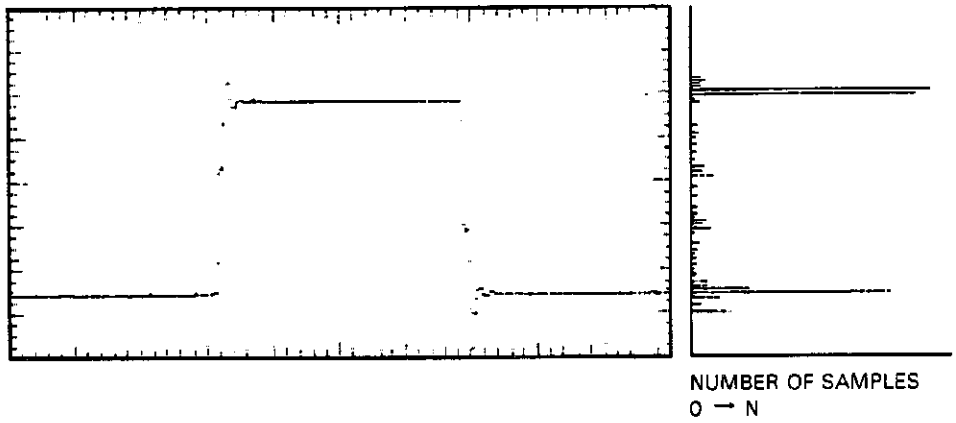


Figure 7-3. The Histogram of a Waveform

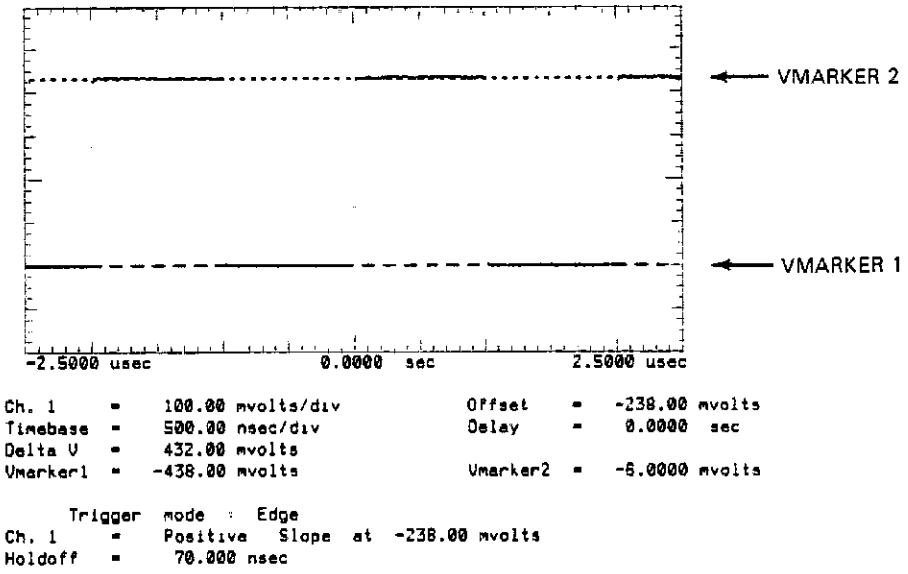
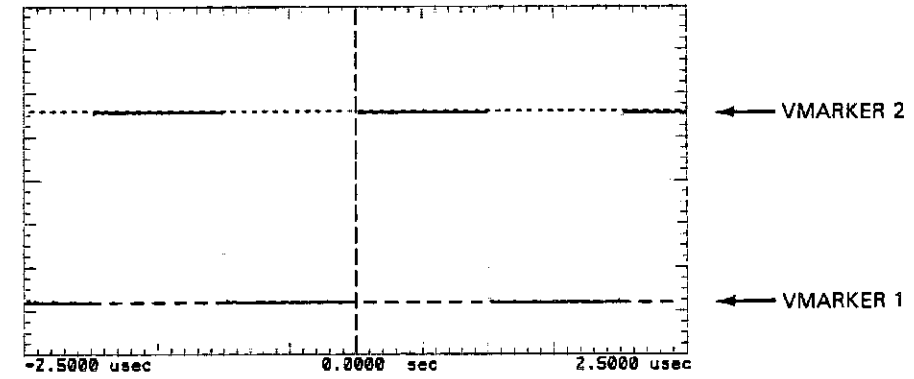


Figure 7-4. Auto Top-Base Voltage Measurement

Another way to make voltage measurements would be to use the automated capability of the unit and use the Peak-To-Peak Voltage function. When the Peak-to-Peak Voltage key is pressed, the unit determines the minimum and maximum voltage on the CRT and calculates the difference and provides the answer in the factors area.

1. Press the More menu key (bottom of the CRT).
2. Select the Param menu.
3. Press the More key (side of CRT) on the function menu twice.
4. Press the Peak-to-Peak Voltage key.

Note the results in the factors area (P-P Volts). With the example unit the value was 442 mV. This is a slightly greater absolute value than we acquired when we used Auto Top-Base. This would be expected as the peak-to-peak voltage is the difference between the minimum and maximum voltages on the display and the Auto Top-Base measurement is derived from a histogram of the same data (see figure 7-5).




```
Ch. 1      =    100.00 mvolts/div          Offset     =   -160.00 mvolts
Timebase   =    500.00 nsec/div            Delay      =    0.0000  sec
Ch. 1 Parameters                          P-P Volts  =    442.00 mvolts

      Trigger  mode  =  Edge
Ch. 1      =    Positive   Slope  at  -160.00 mvolts
Holdoff    =     70.000 nsec
```

Figure 7-5. Peak-to-Peak Voltage

An important capability of the Vmarkers is that the Vmarkers can be assigned to Chan 1 and Chan 2 independently, i.e., Marker 1 to Chan 1 and Marker 2 to Chan 2. This next exercise will help clarify how this feature works:

1. Connect the cal signal to channel 1&2.
2. Press AUTO-SCALE.
3. Select the Delta V menu.
4. Turn the Vmarkers On.
5. Press the top key on the function menu twice (the label will read Vmarkers Ch 1&2).
6. Position MARKER 1 and MARKER 2 randomly.

As the markers are moved you will notice that MARKER 1 is associated with Chan 1 and MARKER 2 is associated with Chan 2. The DC voltage level of each marker as well as the difference between them (ΔV) is listed in the factors area. This feature allows comparisons to be made between signals on Chan 1 and Chan 2. To demonstrate this:

1. Position MARKER 1 level with the top of the cal signal on Chan 1 (top signal).
2. Position MARKER 2 level with the base of the cal signal on Chan 2 (bottom signal).

NOTE

ΔV in the factors area lists the voltage difference between the two Vmarkers (see figure 7-6).

3. Select Chan 1.
4. Press the OFFSET function.
5. Move Chan 1 display using the entry devices.

As the Chan 1 Signal is positioned on the display, note that the Vmarker maintains its relative location with respect to the signal on the channel.

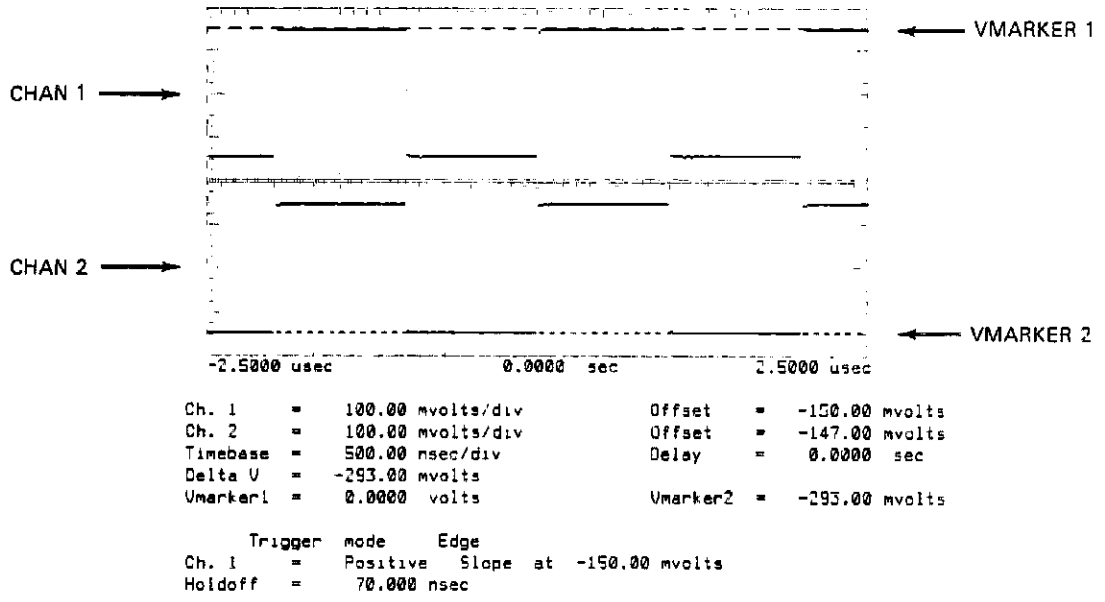


Figure 7-6. Delta Vmarkers on Split Screen

7-5. TIME DOMAIN MEASUREMENTS

This section provides a discussion and exercises that demonstrate some of the time domain measurement capabilities of the 54100A/D.

The time domain is referenced to the 10 division CRT display with a resolution of 100 ps to 1 sec/div on the horizontal axis. The two time markers can be used as horizontal references to show where an automatic measurement is being made, or to relocate signals displayed time using the DELAY function; or they can be manually located on the display for timing measurements. To demonstrate the manual time interval measurement capability, complete the following exercise:

1. Connect the cal signal to Channel 1.
2. PRESS AUTO-SCALE.
3. Select the Delta t menu.
4. Key the Tmarkers On.

NOTE

Both Tmarkers will be located at the "0.00000 S" Delay Ref. (trigger event). Auto-Scale sets the Delay Ref. at center screen.

5. Move the START MARKER to the leading edge of the first pulse.
6. Move the STOP MARKER to the trailing edge of the first pulse.

The time intervals between each marker and the trigger point as well as the time interval between START MARKER and STOP MARKER (Δt) are listed in the factors area (see figure 7-7).

In this example the START MARKER is -2.00 μs (before trigger) and the STOP MARKER is -1.00 μs (before trigger) and Δt is 1 μs.

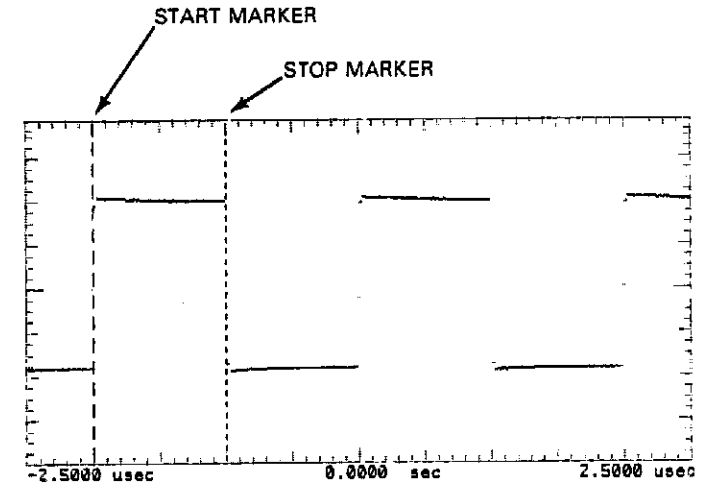


Figure 7-7. Manual Time Interval Measurement

Another method that can be used to make a time interval measurement is to take advantage of the automatic edge finding capability, which requires setting a reference with the Vmarkers for defining edges:

1. Select the Delta V menu.
2. Key Vmarkers On.
3. Press Auto Top-Base.
4. Press 50-50%.

NOTE

Step 4 places the Vmarkers at the 50% level of the Cal signal and provides references for the Δt measurements we are about to make, i.e., the unit senses the transition of the Cal signal through the Vmarkers.

5. Select the Delta t menu.

NOTE

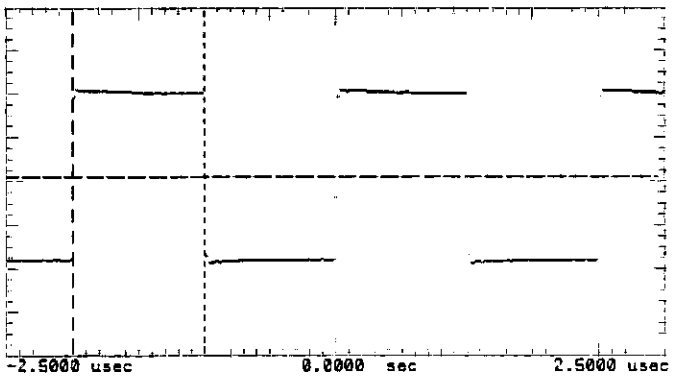
The Delta t menu has 3 additional functions; START ON EDGE, STOP ON EDGE and Precise Edge Find. These functions require the use of the Vmarkers and are only displayed when Vmarkers are On.

6. Set START ON EDGE to Pos 1.
7. Set STOP ON EDGE to Neg 1.

NOTE

When you select START ON EDGE or STOP ON EDGE as in steps 6 and 7, the first key stroke selects the function and the second changes the polarity of the edge

The unit will automatically locate the transition level (50-50%) on the first positive and negative edges and measure the time interval between the two and define the + pulse width. Check the factors area of the CRT for the results (see figure 7-8).




```
Ch. 1      =    200.00 mvolts/div          Offset     =   -408.00 mvolts
Timebase   =    500.00 nsec/div            Delay      =    0.0000  sec
Delta T    =    1.0006 usec
Start      =   -1.5984 usec                Stop       =   -997.83 nsec
Delta V    =    0.0000  volts
Vmarker1   =   -390.00 mvolts              Vmarker2   =   -390.00 mvolts

      Trigger  mode  :  Edge
Ch. 1      =    Positive   Slope  at  -408.00 mvolts
Holdoff    =     70.000 nsec
```

Figure 7-8. Edge Find

When the START and STOP ON EDGE functions are used, the displayed waveform is used as the data base for developing the time interval measurements. This limits the resolution to 1/50th of a division.

Now press Precise Edge Find. This causes the unit to rescale the horizontal axis to a faster sweep speed while it locates the Vmarkers on the edge(s) of interest.

Because of the additional scaling, Precision Edge Find requires a longer period of time to acquire a result than does the START and STOP ON EDGE functions; this should be considered if throughput is a concern.

Precise Edge Find uses averaging, which also makes it take longer. The number of averages selected in the Display menu will be acquired each time the time base is rescaled to locate the edges. For greater precision, the NUMBER OF AVERAGES can be increased; for a faster result, the NUMBER OF AVERAGES can be reduced. Extremely low repetition rate signals will also slow down the precise edge finders.

To terminate the measurement routine at any time, just press any other front panel key.

Another method of measuring the +pulse width would be to use the automated capabilities available on the Param menus:

1. Connect the cal signal to Channel 1.
2. Press AUTO-SCALE.
3. Press More menu key (bottom of CRT).
4. Select Param menu.
5. Press More (on the side of the CRT).
6. Press +Width.

The +Width value will be listed in the factors (see figure 7-9).

When any of the automated measurements in the Param menus require a time interval measurement, the unit uses the Precise Edge Find function. This would include the functions ±Width, Freq, Period, Rise Time and Fall Time. These automatic measurements were designed to provide results from on-screen signals only.

NOTE

Precise Edge Find, and all of the automatic measurements, require an active signal input.

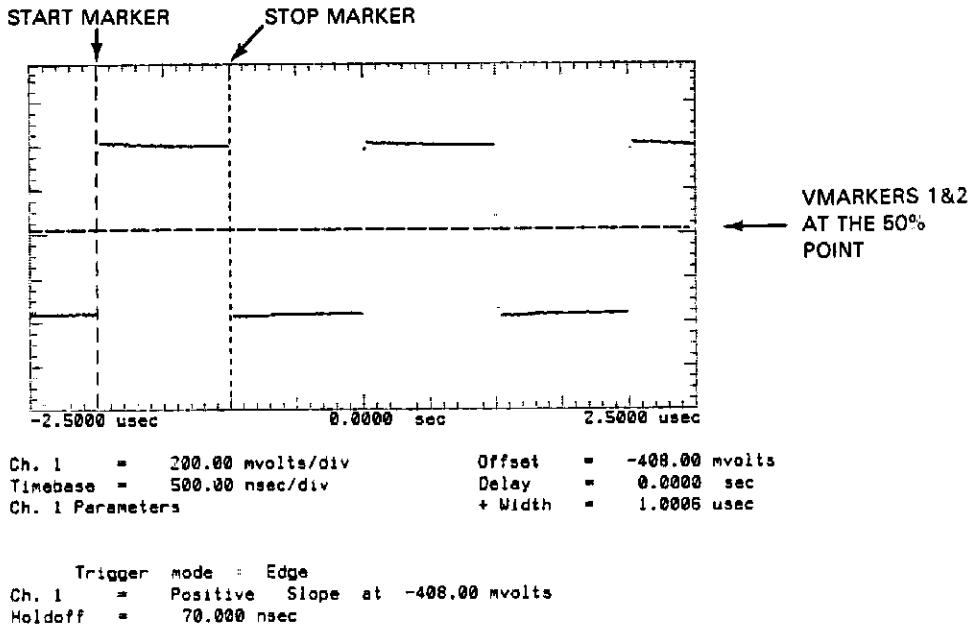


Figure 7-9. + Pulse Width

7-6. DELAY

The DELAY function provides horizontal windowing capability as well as calibrated pre and post triggering delays. Negative delay represents time before the trigger event and positive delay represents time after the trigger event. Try the following procedure to familiarize yourself with the DELAY function.

1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Select the DELAY function.

NOTE

In this exercise the Delay is referenced to center screen; the left or right side of the graticule could just as easily have been used as the reference.

4. Key in 2 sec delay using the key pad and the sec ENTER key. An error message will display "Value out of range....Set to limit". The maximum + delay on this sweep speed (500 ns/div) is 1.6 sec.
5. Key in −1 second delay. Again the unit displays the error message and sets the delay to the limit. Maximum − delay on this sweep speed is 200 ms.

NOTE

Maximum ± delays vary depending on sweep speeds, e.g., on 1 sec/div. sweep speed, maximum positive delay is 6×10^5 seconds, maximum negative delay is −10 seconds

6. Press AUTO-SCALE.
7. Select DELAY.
8. Vary Delay by rotating the knob. CW rotation provides negative delay and CCW rotation provides positive delay.

The DELAY function allows viewing of the signal before and after the trigger event.

In this last example, 1.6 seconds delay and 500 ns/div sweep speed were used. A small amount of time jitter would be obvious when viewing the delayed signal under these conditions, e.g., 1 cm of jitter represents approximately 3.2 ppm. To demonstrate the effect of time jitter, complete the following exercise:

1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Select the DELAY function.
4. Enter 1.6 sec. Delay using the key pad.
5. Select the Display menu.
6. First view the signal in the Normal mode with infinite persistence then switch the unit to the Averaged mode (top key on the function menu).
7. Set Averages=8 by using the entry devices.

NOTE

After the unit has been allowed to acquire data for a short period, the rising and falling edges of the pulse appear to slope (see figure 7-10); this is a function of the time jitter on the signal and the fact that the unit is in the Averaged mode. In this example where time jitter is present and a relatively long delay is used, the Averaged mode does not faithfully reproduce the input signal.

8. Change the Display mode to Normal.
9. Set the DISPLAY TIME to Infinite using the entry devices. Notice that after several acquisitions, the leading and lagging edges are undefined (see figure 7-11). This is caused by time jitter on the input signal. Unless a signal source is extremely stable it is common to see time jitter of this magnitude when long delays are used. The sample unit that was used demonstrated approximately 500 ns time jitter with 1.6 sec delay. This technique is a perfectly valid measurement of the jitter in the source signal, which you might typically want to measure. This type of jitter measurement is made possible by the extremely stable crystal referenced timebase. See Section 3 for timebase jitter specifications.

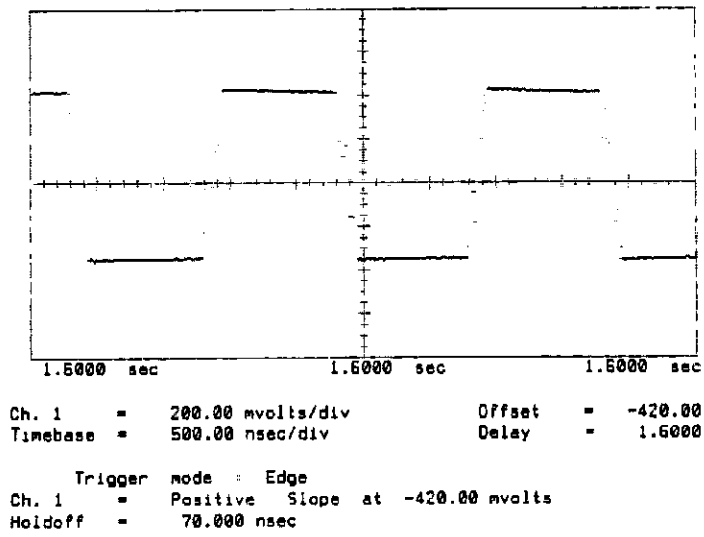


Figure 7-10. Time Jitter in the Averaged Mode

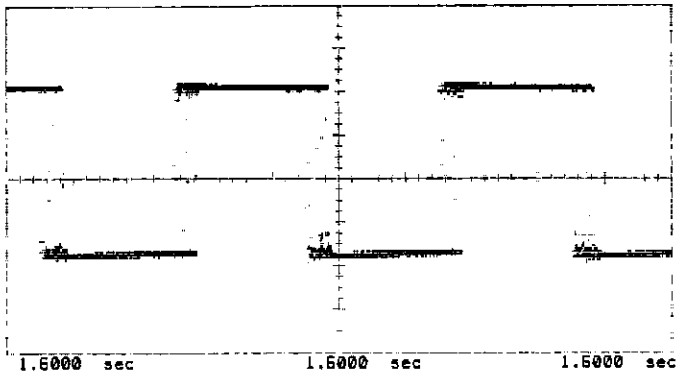


Figure 7-11. Time Jitter in the Normal Mode

Figure 7-12 compares the results obtained with the Normal mode and the Averaged mode when using a long delay with time jitter present.

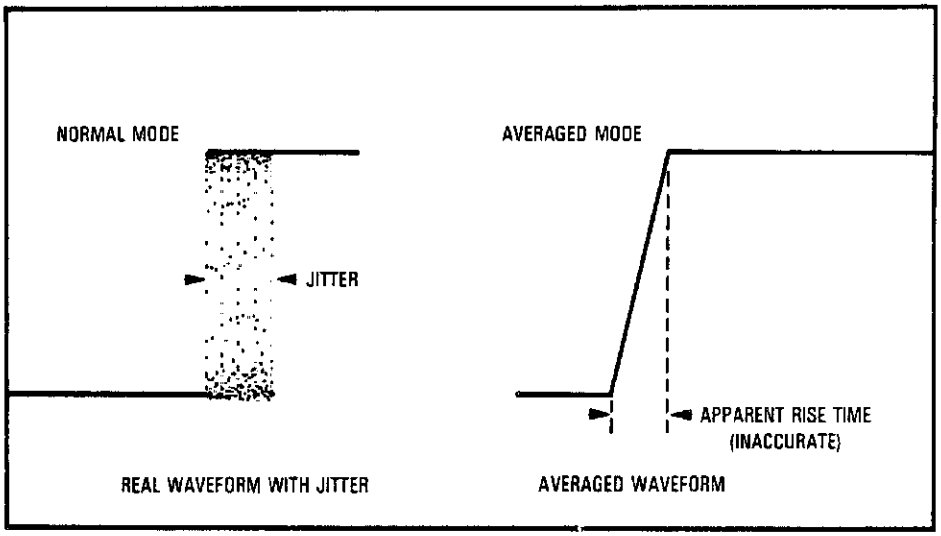


Figure 7-12 Time Jitter With Normal/Averaged Mode

The 54100D provides two additional techniques of delaying the display window by delaying the actual trigger: Event Delay and Time Delay. These two functions are part of the trigger menu and can be selected by pressing the Trigger menu key. They are different from the Timebse Delay in that they provide a trigger for the display after the Event/Time delay. This eliminates the time jitter that is seen when the Timebse delay is used. Let's first look at Event delay (this exercise is for the 54100D only):

1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Change from Auto to Trg'd Sweep.

NOTE

When Auto-Scale is pressed, the unit establishes itself in the Auto Sweep mode. If the trigger is delayed longer than approximately 50 ms, the Auto Sweep mode will cause the unit to sweep before the delay period has elapsed. The signal will appear untriggered (see figure 7-13). To eliminate this problem put the unit in the Trg'd mode.

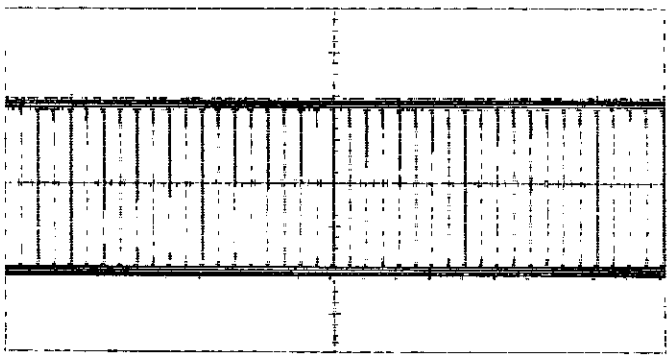


Figure 7-13. Auto Sweep Mode With Delay > 50 ms

4. Select the Trigger menu.
5. Set the trigger mode to Event-Dly.
6. Using the function keys and entry devices, set the Event-Dly menu to read: "After Neg Edge On Chan 1, TRIG ON 1,000,000 events Of Pos Edge on Chan 1".
7. Press CLEAR DISPLAY.

NOTE

After a qualifying negative edge on chan 1, the unit will delay the defined number of pulses and then trigger on the last pulse. In this example the 1,000,000th pulse will be presented at center screen (if the delay is referenced to center screen). This mode would be used if it is necessary to look at a specific pulse in a train but the signal is not stable enough to use timebase delay.

The next method of delaying the display window would be Time Dly. To demonstrate time delay, perform the next exercise:

1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Select Trg'd sweep.
4. Select the Trigger menu.
5. Select the Time Dly trigger mode.
6. Using the function keys and entry devices, set the Time-Dly menu to read: "After Neg Edge on Chan 1 DELAY 1.000 S THEN Trig On Pos Edge On Chan 1".
7. Press the CLEAR DISPLAY key. In this mode the unit waits a defined period of time after a qualifying event, in this example 1 second, and then triggers on on the edge selected.
8. Change the WAIT time to 0.5 sec. Notice that the acquisition rate is influenced by WAIT time because the effective trigger repetition rate is limited by WAIT time.

The Time-Delay mode would be used to view a signal that occurs a relatively long time after a sync signal. This would eliminate the time jitter (induced by the input signal) that would be present if the timebase delay were used. Event-Delay accomplishes essentially the same thing as Time-Delay except that events are used to delay the display window. The effect is similar when using either mode, i.e., the affect of time jitter in the source signal is eliminated.

The timebase delay on the 54100A/D is always referenced to the trigger edge that is generated in a particular trigger mode. Trigger delay, both event and time, should not be confused with the timebase delay as they are independent functions. Event-Delay and Time-Delay modes are a means of selecting which edge on the signal is used as a reference for timebase delay.

7-7. TRIGGER

In this section some of the triggering capabilities of the 54100A/D will be discussed.

The only differences between the 54100A and the 54100D are in their triggering capabilities. They do share two trigger modes; the Edge mode and the Pattern mode.

The Edge mode is similar to the trigger on a conventional oscilloscope. The trigger level can be defined, the polarity of the trigger can be selected and the source of the trigger can be determined. The 54100D has two external trigger inputs and provides four trigger sources as compared to the 54100A which has one external trigger input and three trigger sources.

In the Pattern mode the 54100D takes advantage of the additional external trigger input and provides 4-channel pattern recognition while the 54100A provides 3 channels. Try this exercise to demonstrate some of the triggering capabilities of the Edge mode:

1. Connect the cal signal to channel 1&2.
2. Press AUTO-SCALE. The unit will establish itself in the split screen mode with Chan 1 at the top and Chan 2 at the bottom of the display. Chan 1 will be defined as the active trigger source.
3. Select the Trigger menu.
4. Select TRIG LEVEL. The trigger level will be indicated by a horizontal line through the Chan 1 signal(see figure 7-14).

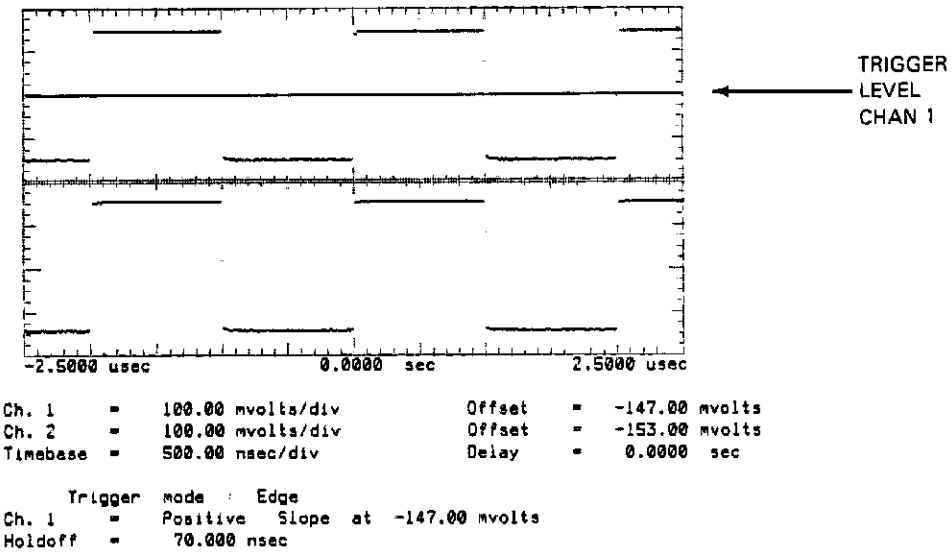


Figure 7-14. Split Screen With Trigger On Chan 1

5. Change the trigger level by rotating the knob.

NOTE

If the trigger level trace is moved above or below the chan 1 signal, the signals on chan 1&2 will loose sync The step keys and the key pad may also be used to change the trigger level.

6. Select Chan 2 as the Trig Src. The unit is now triggering on Chan 2. The line showing the trigger level will be on the Chan 2 display. The trigger level on Chan 2 can be varied by using the input devices (see figure 7-15)
7. Select Trig 3 as the Trig Src. Notice that the signals are untriggered.
8. Move the Chan 1 input to Trig 3 (Trigger 3 input). The initial trigger level for Trig 3 will be 0V and the signal on the display will not be triggered. The cal signal is negative and does not cross through the 0V threshold and therefore does not cause a trigger.
9. Vary Trig Level 3 until the signal on Chan 2 triggers. Trig 3 is now being used as a trigger for the signal on Chan 2. If a 54100D is being used, Trig 4 could be used as a trigger source in the Edge mode also.

NOTE

If any of the previously used inputs is selected as the trigger source, the trigger level remains where previously set for that source.

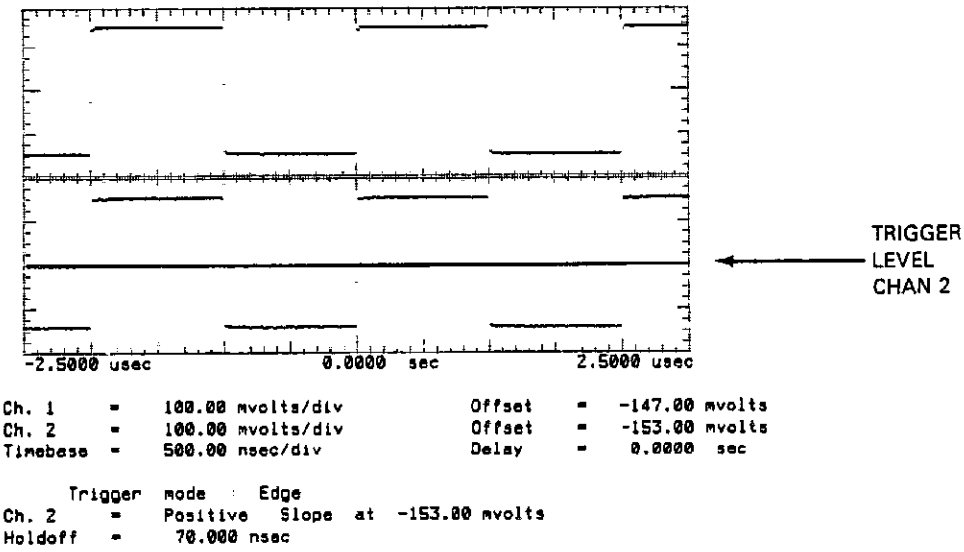


Figure 7-15. Split Screen With Trigger On Chan 2

7-8. PATTERN MODE

The other trigger mode common to the 54100A&D is the Pattern mode. In this mode each input is converted to a digital signal which is high, or true, when the input signal is above its trigger threshold and is low, or false, when below its trigger threshold. The trigger can then be set to occur when a pattern of signal levels, relative to each inputs' trigger threshold, becomes true or false. The 54100A has 3 inputs and thus a 3-channel-wide pattern and the 54100D has 4.

When the Pattern mode is used, insure that the trigger level for each input is adjusted so that the input signals cross each respective trigger level during transition. This is done in the Edge mode. It should be noted that each input has a separately adjustable trigger level and is independent of the others. This feature allows mixing different types of logic signals. Use this example to become more familiar with the Pattern Trigger mode:

1. Connect one cal signal to channel 1 using a 1 metre BNC cable.
2. Connect the other cal signal to channel 2 using 3 metres of BNC cable 2 metres will work as well but will not give as much signal delay on channel 2.
3. Press AUTO-SCALE.
4. Select Timebse menu and set the Sweep Speed to 5 ns/div.
5. Select the Display menu and set Split Screen Off.
6. Select the Trigger menu.
7. Select the Edge Trigger mode.
8. Select Chan 2 as the trigger source.
9. Adjust TRIG LEVEL triggered signal on the display.

NOTE

In figures 7-16 and 7-17, the signal path for Chan 2 is approximately 2 metres longer that the signal path for Chan 1. This provides the time differential between the two signals.

10. Set Trigger mode to Pattern.
11. Set Trig On PATTERN to read: "HHXX" for the 54100D or "HHX" for the 54100A.

    H = High State (above trigger threshold)

    L = Low State (below trigger threshold)

    X = Don't Care

12. On the Trigger menu insure "When Entered" is set. With the instrument in this configuration it will generate a trigger on the last edge that makes the pattern HHXX or HHX true. In this example the positive edge on Chan 2 is the trigger.

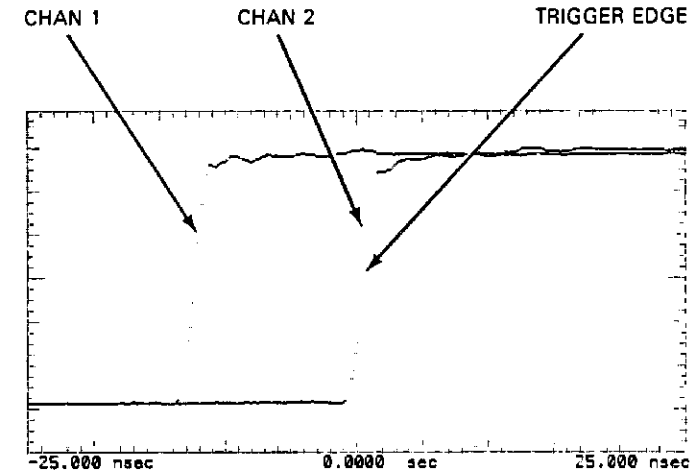


Figure 7-16. Pattern When Entered "HHX"

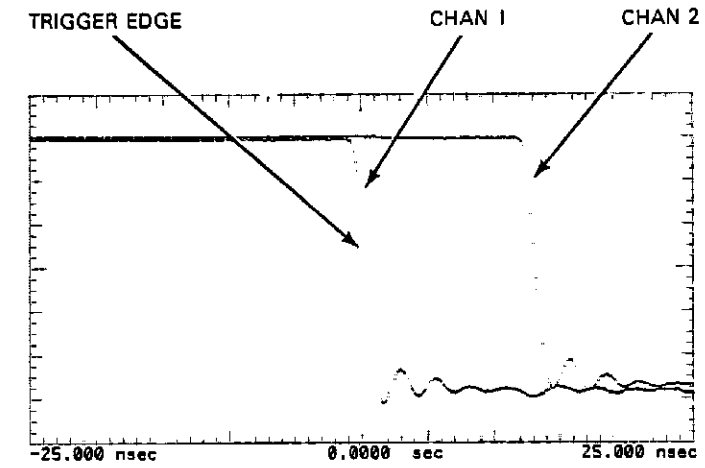


Figure 7-17. Pattern When Exited

This menu allows triggering when entering or exiting a defined logic pattern. If the When Entered function is selected, the unit will trigger on the last pulse edge that makes the pattern true (see figure 7-16). If the When Exited function is selected, the unit will trigger on the first pulse edge that makes the pattern false (see figure 7-17).

This trigger mode would be an advantage while troubleshooting logic circuitry, or any other application where it would be desirable to make parametric measurements while using logic sources for a trigger. In addition to the When Entered/Exited functions, the 54100D provides time qualification for the Pattern mode: When Present> and When Present<. The When Present> mode allows the user to specify that the trigger pattern must be present for a minimum period of time (that the user defines) before being accepted as a trigger. If the pattern does not remain true long enough it will be ignored. The When Present < mode is just the opposite. Here the pattern will generate a trigger only if it remains true for less than the time specified. If the pattern is true longer than this time it will be ignored. Both of these modes will generate a trigger when the pattern is exited but only if the time qualifier is true. The range of the time qualifier is from 10 ns to 5 sec.

For the case of the simplest pattern, HXX for the 54100A or HXXX for the 54100D, the pattern is true when Chan 1 is high and it is false when Chan 1 is low. The time qualification can then be used to trigger on pulses that are wider than a specified time and ignore shorter ones (When Present>) or it can be used to trigger on pulses that are shorter than the time qualifier and ignore the longer ones (When Present<).

Try this exercise to become familiar with this time qualification feature:

1. Connect the cal signal to channels 1&2.
2. Press AUTO-SCALE.
3. Select the Trigger menu.
4. Select the Pattern Trigger mode.
5. Set the Trig On PATTERN to read HHXX.
6. Select the When Present> function.
7. Set TIME to 1.5 μs. This requires that the pattern be present for greater than 1.5 μs to generate a trigger. In this example this will not be true as the + portion of the cal signal is approximately 1 μs duration.

8. Set TIME to .5 μs. The display will now trigger.

The ability of this unit to qualify the trigger pattern with a min-max time interval provides an excellent technique for glitch detection.

7-9. STATE MODE (54100D only)

The next Trigger mode is the State mode. This mode allows using simple edge detection combined with pattern recognition to generate a trigger. When this mode is selected, one of the four inputs is chosen as the edge source and the user determines a 3-bit pattern defined over the remaining three inputs.

A trigger will be generated when an appropriate (±) edge occurs only when the pattern is true (When Present) or false (When Not Present) as specified by the user. The State function differs from the Pattern Entered/Exited function in that the trigger is generated from a specified edge source for State, while in the Pattern Entered/Exited mode any input can initiate a trigger if it causes the pattern to be true/false. To become more familiar with this function, complete the following exercise:

1. Connect the cal signal to channels 1&2. For channel 1 use a 1 metre cable; for channel 2 use 2 or 3 metres.
2. Press AUTO-SCALE.
3. Select the Trigger menu.
4. Set the Trigger mode to State.
5. Set Trig On Edge to Pos.
6. Set On Chan When to Chan 1.
7. Set PATTERN to -XHX
   - = Input being used for Edge Source
   X = Don't care.
   H = High State (above trigger threshold)
   L = Low State (below trigger threshold)
8. Set the Present/Not Present function to Not Present. The display should be triggered.

With the instrument in this configuration it will generate a trigger on a positive edge on Chan 1 if Chan 2 is low Change Not Present to Present—the display will loose it's trigger.

7-10. DISPLAY

The display menu provides control of how data is displayed on the CRT:

1. Whether data on the display is Normal or Averaged.
2. The type of graticule that is to be used, grid, frame or axis.
3. The format of the display, split screen On/Off.

7-11. NORMAL MODE

When the Normal mode is used, high speed A to D converters digitize the incoming signal and write it to a display memory that in turn provides information to the CRT. The data points that are acquired from the A to D converters are displayed on the CRT for a user-defined period of time from 200 ms to Infinity. To become more familiar with the Normal mode functions, complete the following exercise:

1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Select the Display menu.
4. Select the Normal mode.

5. Set DISPLAY TIME to 200 ms. Data points written on the CRT will fade shortly thereafter unless they are refreshed by new input data.
6. Select the Timebse menu.
7. Change the sweep speed to 100 ps/div. This faster sweep speed allows the user to more easily see the effects of changing the DISPLAY TIME.
8. Select the Display menu.
9. Change DISPLAY TIME to 1 sec. Notice the change in the persistence of the data points.
10. Change DISPLAY TIME to 11 sec. The unit will now have infinite persistence (any DISPLAY TIME greater than 10 sec defaults to Infinite).

The Infinite persistence mode causes all acquired data to remain on the CRT until the function is changed.

Long persistence times work well for capturing low repetition rate, relatively fast or narrow (low duty cycle) signals. Infinite persistence also allows viewing worst case jitter, noise, and timing variations; or to view extremely infrequent glitches or other anomalies.

To see the effect of persistence on a low rep rate signal, go to the Timebse menu and use 1.6 sec DELAY. Return to the Display menu and vary the DISPLAY TIME from 200 ms to 11 sec and notice the differences.

In the infinite persistence mode the data points will remain on the display until the CLEAR DISPLAY key is pressed or until the display is moved with an instrument control such as, sweep speed, vertical sensitivity, or trigger level. Move one of these controls while in the infinite mode and notice the results.

7-12. AVERAGED

As the input signal is digitized, each data point is assigned a time coordinate relative to the trigger. In the averaging mode the unit calculates the average of the most recent data point with the previous values in the same time bucket. You can define the number of data points that are to be averaged from 2 to 2048 in powers of 2. Each average is calculated from data acquired for each time slot—data for adjacent time slots is not averaged together.

If 8 is chosen for the number of averages, 1/8 of the vertical value of each new data point will be added to 7/8 of the value previously in that time bucket. If 16 averages had been selected, 1/16th of the new data would be averaged with 15/16ths of the previous value.

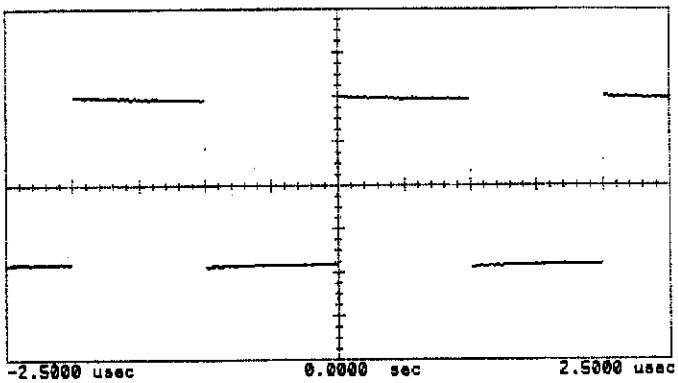
The effect of using the averaged mode is to cancel out all phenomena that are not time related to the trigger event, i.e., noise and nonrecurring events.

To demonstrate some of the differences between the Normal mode and the Averaged mode, complete the following exercise:

1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Select the Display menu.
4. Select the Averaged mode.
5. Set NUMBER OF AVERAGES to 8 (see figure 7-18).
6. Select the Normal mode (see figure 7-19). Compare figures 7-18 and 7-19 and notice the reduction of noise on the Averaged display. The larger the number of averages the greater the reduction of the displayed noise and the longer it takes to respond to any change in the input signal.

The next exercise shows the effect of the averaged mode and the use of the Averaged mode in conjunction with the Magnify mode.

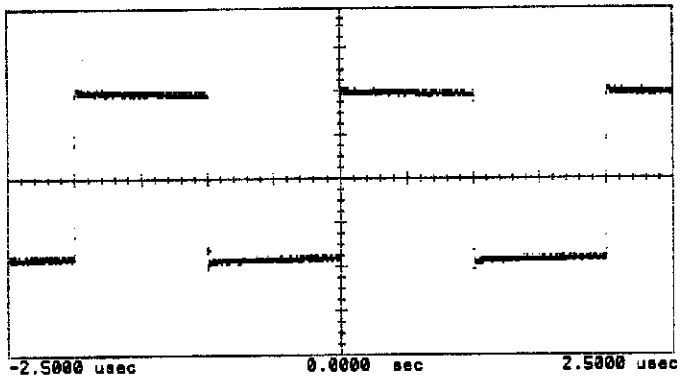
1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Select the Display menu.
4. Select the Normal Mode.




```
Ch. 1      =   200.00 mvolts/div          Offset     =   -392.00 mvolts
Timebase   =   500.00 nsec/div            Delay      =    0.0000  sec

      Trigger  mode  :  Edge
Ch. 1      =   Positive   Slope  at  -392.00 mvolts
Holdoff    =    70.000 nsec
```

Figure 7-18. Averaged Mode (8 Averages)




```
Ch. 1      =   200.00 mvolts/div          Offset     =   -392.00 mvolts
Timebase   =   500.00 nsec/div            Delay      =    0.0000  sec

      Trigger  mode  :  Edge
Ch. 1      =   Positive   Slope  at  -392.00 mvolts
Holdoff    =    70.000 nsec
```

Figure 7-19. Normal Mode

5. Select Chan 1 menu.
6. Select the Magnify mode and adjust the WINDOW SIZE and POSITION so that the window is near the top of the cal signal (see figure 7-20).
7. Turn Magnify On (see figure 7-21).
8. Select the Display menu.
9. Set NUMBER OF AVERAGES = 2 (see figure 7-22).
10. Change NUMBER OF AVERAGES = 512 (see figure 7-23). Notice that with a greater NUMBER OF AVERAGES there will be less noise on the signal and the display will appear to be more stable.

NOTE

With only 2 or a small number of averages, the quantization levels of the A/D converter are also very evident. With a larger number of averages, the actual usable resolution increases as the display fills between quantization levels with averaged data.

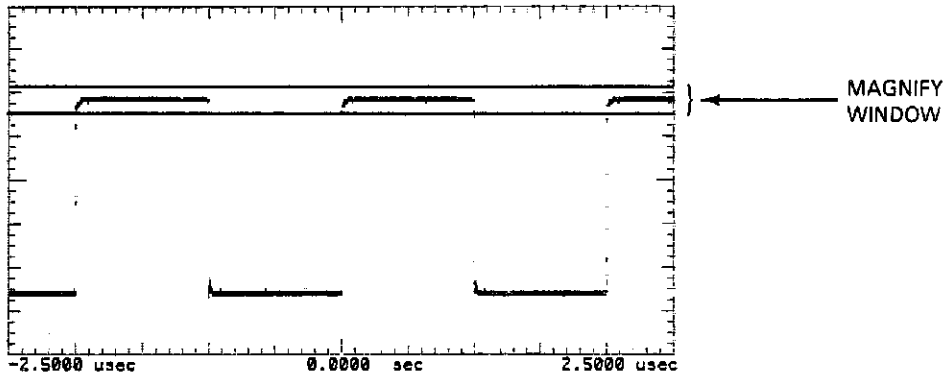


Figure 7-20. Magnify Window in the Normal Mode

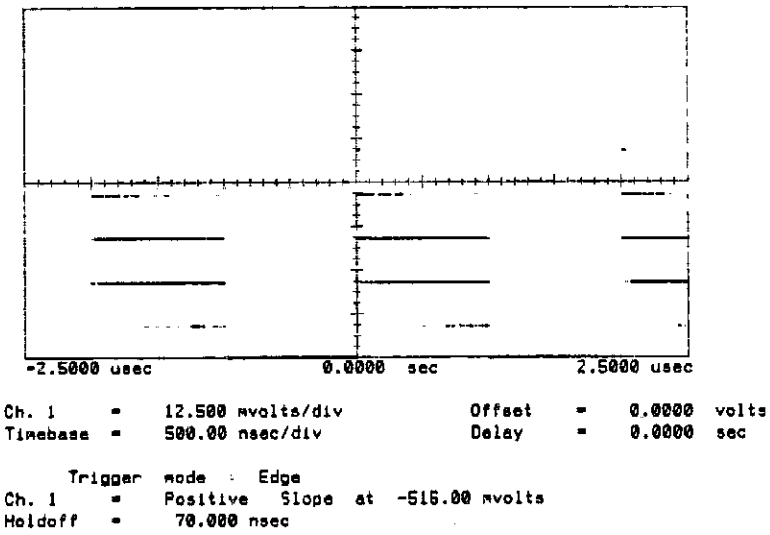


Figure 7-21. Magnify Using Normal Mode

The next exercise will help illustrate how averaging works:

1. Connect the cal signal to channel 1.
2. Press AUTO-SCALE.
3. Select the Display menu.
4. Set NUMBER OF AVERAGES to 256.
5. Remove the Cal signal from Chan 1 and notice the reaction of the display.

As the input signal was removed, the existing values in each time bucket are now being averaged with the new data which is "0". If the number of averages were reduced, the display would converge to the new signal levels in a shorter period of time.

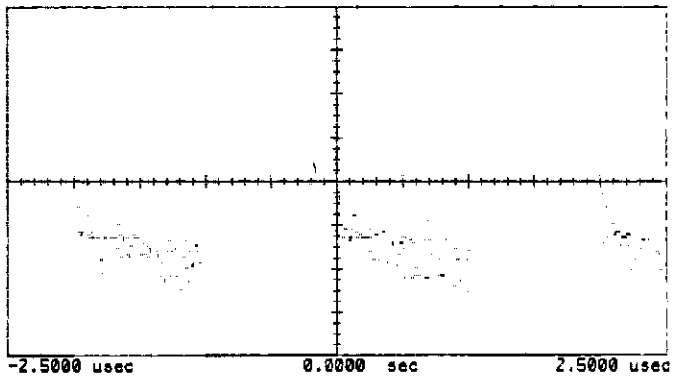


Figure 7-22. Magnify in the Averaged Mode With 2 Averages

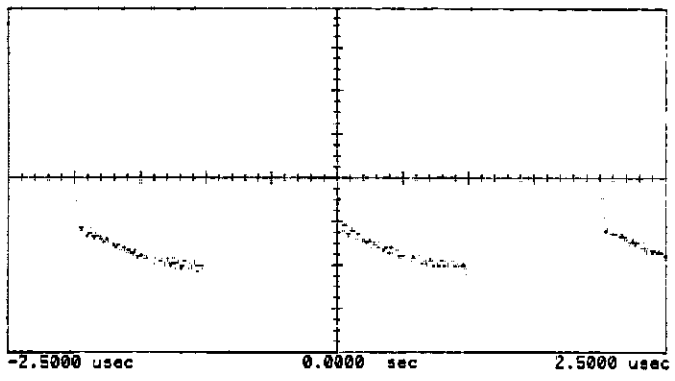


Figure 7-23 Magnify in the Averaged Mode With 512 Averages

7-13. PROBES

The 54100A/D provides you with the capability of changing the attenuation factor on any input. When this attenuation factor is changed, the actual voltage division ratio of the inputs does not change; however, the scale factors in firmware that are used to generate the answers for the automated parametric measurements and voltage related items on the screen are modified appropriately.

The variable Atten Factors would be used so that the display factors would accurately reflect the actual voltage levels at the source when accessory probes or voltage dividers are being used.

The Atten Factors are saved with the rest of the front panel setup when the Save/Recall registers are used. When the power is cycled the Atten Factors will automatically set themselves to the value appropriate for the input pod that is installed in each input. For the 54002A and the 54003A, the Atten Factors would be set to 1:1. If the 10:1 accessory probe that is supplied with the 54003A is used, set the Atten Factor for that input to 10:1. This will insure that the correct answers are provided in the factors area on the screen, and that the vertical scale factors previously set (VOLTS/DIV and OFFSET) are correctly referenced to the probe tip.

When the 54001A active probe is used, the Atten Factors will automatically be set to 10:1 when the instrument power is turned on.

Use the following exercise to see the effect of changing the Atten Factors:

1. Connect the cal signal to channel 1 and press AUTO-SCALE.
2. Select the Delta V menu.
3. Select the Vmarkers for Chan 1 and press Auto Top-Base. Notice the voltage readings in the factors area.
4. Select the Probes menu. The Ch1 Atten Factor will be set to 1:1 (if the 54002A or 54003A is used).
5. Set the Ch 1 Atten Factor to 10:1 by using the entry devices. Notice that as the Atten Factor is changed, the voltage readings in the factors area will change to reflect the new ratio.
6. Connect the cal signal to channel 1 and Trig 3.
7. Select the Trigger menu.
8. Set the Trig Src to Trig 3 and the TRIG LEVEL to approximately -200 mV (the signal should be triggered).
9. Return to the Probes menu and set the Trig 3 PROBE ATTEN to 10:1.

NOTE

Factors can also be used, if you have a known source, to calibrate out systematic errors in gain and attenuation ratio of the 54001A, 54003A or other divider probes. The Atten Factor could be arbitrarily set to yield the correct answer. That factor can be stored in non-volatile memory.

10. Return to the Trigger menu and notice that the Trig 3 level reflects the new ratio.
11. Select the Param menu and press the All function key. Notice that all of the voltage related factors reflect the 10:1 ratio that has been chosen.

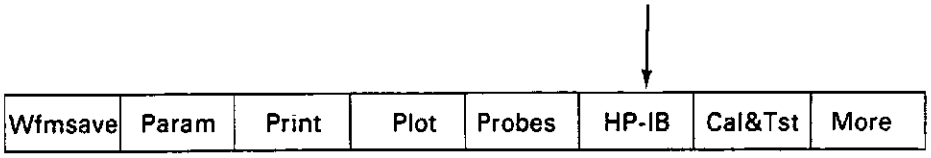
The range of the Atten Factor is from 1 to 1000. The Knob and the step keys will give you up to 3 digits of resolution and the key pad provides up to 4 digits of resolution for setting Atten Factor.

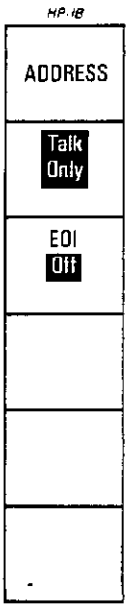
Section 8
Let's Make A Hard Copy Dump

8-1. INTRODUCTION

The 54100A/D has the capability of making a hardcopy dump to various HP-IB graphics printers and plotters without the use of a computer. This section will show you how to use the 54100A/D with a graphics printer or plotter.

8-2. SETTING UP THE 54100A/D





In all cases, without a controller on the system, when you want to dump to a graphics printer or a plotter from the 54100A/D, select the HP-IB menu and set the HP-IB function key to "Talk Only".

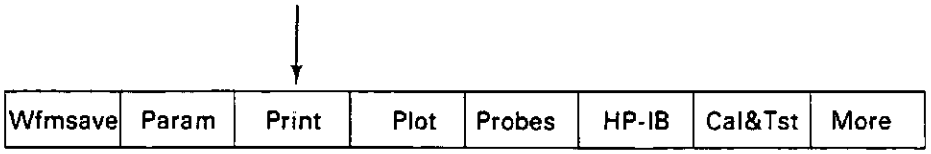
If you are operating the 54100A/D and a graphics printer/plotter on a system with a controller, refer to Section 11 for a sample program.

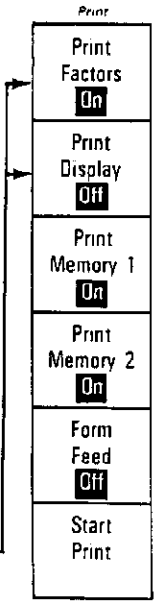
8-3. GRAPHICS PRINTER

The 54100A/D will interface directly with a graphics printer that uses the Hewlett-Packard Raster Graphics Standard and the HP-IB.

Connect the graphics printer to the 54100A/D with an HP-IB interface cable (refer to figure 4-4 for a list of available HP-IB mating cables). Before the graphics printer is energized, locate the HP-IB configuration switch on the printer and set the LISTEN ALWAYS (LISTEN ONLY) switch to the true (1) position. Refer to the printer manual. It is important that you set this switch before power is applied to the printer as most printers only read these switch settings when the power is first turned on; therefore, you must turn the printer off for several seconds and then back on before printing if these switches have been changed.

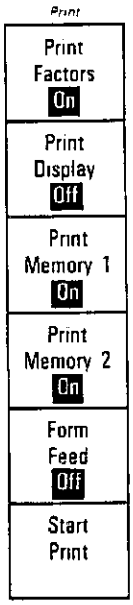
After you have connected the 54100A/D to the graphics printer and set the configuration switch to the LISTEN ALWAYS mode, select the Print menu on the 54100A/D.





The Print menu will be displayed on the right side of the screen. The factors (listed beneath the signal display area) and the Display can be printed separately or at the same time depending on whether they are keyed On or Off.

The next options on this menu are whether or not to print the waveforms stored in either of the waveform memories.



Data from all sources, i.e., the active display, memory 1 or 2, or the factors area, that you have selected for output will be printed at the same time when the Start Print key is pressed. Waveform acquisition stops while printing data is output to the printer.

If you choose to stop the print while it is in process, press the Abort Print key.

If you are printing data from one of the display memories, the data will first be transferred to the active display then output to the printer. The original data will remain available in the waveform memory.

8-4. COMPATIBLE PRINTERS

The Hewlett-Packard printers that are compatible with the 54100A/D include:

2225A	2932A
2671G	2933A
2673A	2934A
82906A	

8-5. PLOTTERS

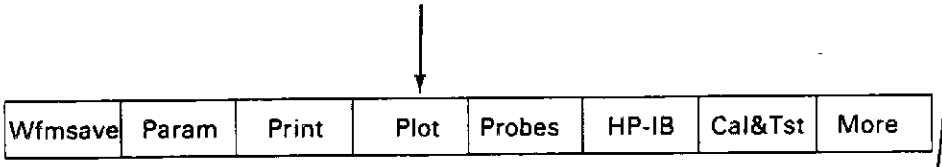
The 54100A/D will interface directly with plotters that use the HEWLETT-PACKARD GRAPHICS LANGUAGE (HP-GL) and an HP-IB interface.

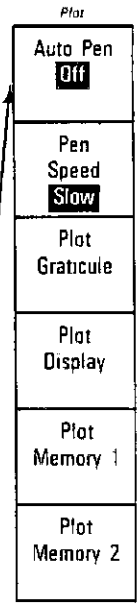
The 54100A/D must be in the "Talk Only" mode when making a graphics dump to a plotter. The status of the HP-IB on the 54100A/D is listed at the top of the display; "Talk Only", "Listen Only", or the HP-IB address will be listed if the unit is in the Talk/Listen mode. The status of the HP-IB interface can be changed if you select the HP-IB menu (see paragraph 8-2).

The plotter must be in the Listen Always (Listen Only) mode. Check the plotter manual for the location of the HP-IB configuration switch and set the Listen Always switch to the true (1) position. Set this switch before the plotter is energized as most plotters read these switch settings when the power is first turned on.

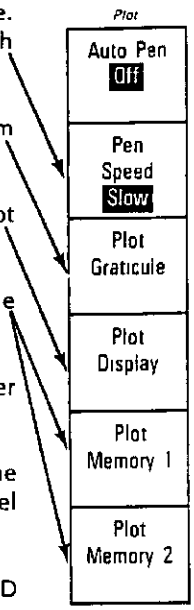
Connect the 54100A/D to the plotter using one of the HP-IB interface cables listed in figure 4-4.

After you have connected the 54100A/D to the plotter and set the correct HP-IB configuration for each instrument, select the Plot menu. Once you've done this, the Plot function menu will be present to the right of the display.





When the Auto Pen function is On, a new pen will be selected when a different function is chosen to be plotted, if the plotter has multi-pen capability. If Auto Pen is Off, the plotter will not load or change pens when the Plot function is selected; this means that you will have to load a pen before you start the plot.



The next function key, Pen Speed, allows you to select Fast or Slow, if your plotter has this feature. Slow is normally chosen when you are making overheads or transparencies. For best results with Leroy pens use the slow pen speed.

The next key allows you to plot the displayed graticule including the display factors at the bottom of the screen.

When Plot Display is selected, all on-screen waveforms will be output to the plotter. This does not include the graticule and the display factors.

The next two keys allow you to output the stored waveforms from either memory 1 or 2 to the plotter.

If the Display menu is in the Averaged mode, the output from the 54100A/D will cause the plotter to draw a continuous line plot of the displayed waveform.

If the Display menu is in the Normal mode, or if you are plotting from one of the memories, the output from the 54100A/D is formatted such that the plotter will plot the waveform(s) in a pixel format, i.e., dot by dot.

When you are plotting from the waveform memories, it is important to note that the 54100A/D will plot the memories based on the Split Screen On/Off state of the active waveform display. Waveform memories that were stored with Split Screen On should be plotted with Split Screen On. Likewise, waveform memories that were stored with Split Screen Off should be plotted with Split Screen Off. If this precaution is not taken, there may be misalignments of data and graticule such as vertical shift of the data with respect to the graticule in the lower half of the screen.

8-6. COMPATIBLE PLOTTERS

The Hewlett-Packard plotters that are compatible with the 54100A/D include:

7470A	7580B
7475A	7585B
7550A	7586A
7480A	7090A
9872T	

Section 9
Remote Control

9-1. REMOTE OPERATION, HEWLETT-PACKARD INTERFACE BUS

The 54100A/D can be operated through the Hewlett-Packard Interface Bus (HP-IB). Menu functions, remote only functions, and all front panel oscilloscope functions (except the LINE switch) are programmable through the HP-IB. Bus compatibility, programming, and data format are described in the following paragraphs.

The notation used in this section to describe bus communications is defined in paragraph 9-25, Notation Conventions and Definitions.

In this manual, the 54100A/D program codes are listed in ASCII code. Table 9-1, Commonly Used Code Conversions, includes a listing of ASCII characters and some commonly used equivalent codes.

For more information about HP-IB, refer to IEEE Std 488-1978 (or the identical ANSI Standard MC1.1), "IEEE Standard Digital Interface for Programmable Instrumentation."

9-2. HP-IB COMPATIBILITY

The 54100A/D's complete bus compatibility as defined in IEEE Std 488-1978 is presented in table 9-2.

The programming capability of the instrument is further described by the twelve HP-IB meta messages in the left hand column of table 9-2. Foremost among these is the Data message. Data messages contain the program codes that set the instrument's mode of operation.

9-3. HP-IB STATUS DISPLAY

The status of the 54100A/D on the HP-IB is enunciated on the CRT by an HP-IB status message. This message describes the 54100A/D's remote/local status, address status, and whether or not the instrument is requesting service via the SRQ bus control line.

9-4. REMOTE MODE

Remote Capability: The 54100A/D communicates on the bus in both remote and local modes. In remote, all front panel oscilloscope controls but the LINE switch and the LOCAL key are disabled. When Local Lockout is in effect, the LOCAL key is also disabled.

The 54100A/D can be addressed to listen or talk while in remote mode. When addressed to listen, the instrument automatically stops talking and responds to DATA messages. When addressed to talk, the instrument stops listening and sends either a Data message or the Status Byte. Whether addressed or not, the 54100A/D responds to the Local, Local Lockout, Clear Lockout/Set Local, Trigger, and Abort Messages and, in addition, the instrument may issue the Require Service message.

Local-to-remote Mode Changes: The 54100A/D switches to remote upon receipt of the Remote message The Remote message has two parts:

- Remote Enable (REN) bus control line true
- Device listen address (MLA) received once while REN is true

Table 9-1. Commonly Used Code Conversions

HP-IB

HP-IB		ASCII	Decimal	Binary	Octal	Hexa-decimal
Addressed Command Group (ACG)	GTL	NUL	0	00 000 000	000	00
		SOH	1	00 000 001	001	01
		STX	2	00 000 010	002	02
		ETX	3	00 000 011	003	03
	SDC	EOT	4	00 000 100	004	04
	PPC	ENQ	5	00 000 101	005	05
		ACK	6	00 000 110	006	06
		BEL	7	00 000 111	007	07
	GET	BS	8	00 001 000	010	08
	TCT	HT	9	00 001 001	011	09
		LF	10	00 001 010	012	0A
		VT	11	00 001 011	013	0B
		FF	12	00 001 100	014	0C
		CR	13	00 001 101	015	0D
		SO	14	00 001 110	016	0E
		SI	15	00 001 111	017	0F
Universal Command Group (UCG)	LLO	DLE	16	00 010 000	020	10
		DC1	17	00 010 001	021	11
		DC2	18	00 010 010	022	12
		DC3	19	00 010 011	023	13
	DCL	DC4	20	00 010 100	024	14
	PPU	NAK	21	00 010 101	025	15
		SYN	22	00 010 110	026	16
		ETB	23	00 010 111	027	17
	SPE	CAN	24	00 011 000	030	18
	SPD	EM	25	00 011 001	031	19
		SUB	26	00 011 010	032	1A
		ESC	27	00 011 011	033	1B
		FS	28	00 011 100	034	1C
		GS	29	00 011 101	035	1D
		RS	30	00 011 110	036	1E
		US	31	00 011 111	037	1F
Listen Address Group (LAG) Note 1	L0	SP	32	00 100 000	040	20
	L1	!	33	00 100 001	041	21
	L2	"	34	00 100 010	042	22
	L3	#	35	00 100 011	043	23
	L4	$	36	00 100 100	044	24
	L5	%	37	00 100 101	045	25
	L6	&	38	00 100 110	046	26
	L7	'	39	00 100 111	047	27
	L8	(	40	00 101 000	050	28
	L9	)	41	00 101 001	051	29
	L10	*	42	00 101 010	052	2A
	L11	+	43	00 101 011	053	2B
	L12	,	44	00 101 100	054	2C
	L13	-	45	00 101 101	055	2D
	L14	.	46	00 101 110	056	2E
	L15	/	47	00 101 111	057	2F
	L16	0	48	00 110 000	060	30
	L17	1	49	00 110 001	061	31
	L18	2	50	00 110 010	062	32
	L19	3	51	00 110 011	063	33
	L20	4	52	00 110 100	064	34
	L21	5	53	00 110 101	065	35
	L22	6	54	00 110 110	066	36
	L23	7	55	00 110 111	067	37
	L24	8	56	00 111 000	070	38
	L25	9	57	00 111 001	071	39
	L26	:	58	00 111 010	072	3A
	L27	;	59	00 111 011	073	3B
	L28	<	60	00 111 100	074	3C
	L29	=	61	00 111 101	075	3D
	L30	>	62	00 111 110	076	3E
	UNL	?	63	00 111 111	077	3F

HP-IB		ASCII	Decimal	Binary	Octal	Hexa-decimal
Talk Address Group (TAG) Note 2	T0	@	64	01 000 000	100	40
	T1	A	65	01 000 001	101	41
	T2	B	66	01 000 010	102	42
	T3	C	67	01 000 011	103	43
	T4	D	68	01 000 100	104	44
	T5	E	69	01 000 101	105	45
	T6	F	70	01 000 110	106	46
	T7	G	71	01 000 111	107	47
	T8	H	72	01 001 000	110	48
	T9	I	73	01 001 001	111	49
	T10	J	74	01 001 010	112	4A
	T11	K	75	01 001 011	113	4B
	T12	L	76	01 001 100	114	4C
	T13	M	77	01 001 101	115	4D
	T14	N	78	01 001 110	116	4E
	T15	O	79	01 001 111	117	4F
	T16	P	80	01 010 000	120	50
	T17	Q	81	01 010 001	121	51
	T18	R	82	01 010 010	122	52
	T19	S	83	01 010 011	123	53
	T20	T	84	01 010 100	124	54
	T21	U	85	01 010 101	125	55
	T22	V	86	01 010 110	126	56
	T23	W	87	01 010 111	127	57
	T24	X	88	01 011 000	130	58
	T25	Y	89	01 011 001	131	59
	T26	Z	90	01 011 010	132	5A
	T27	[	91	01 011 011	133	5B
	T28	\	92	01 011 100	134	5C
	T29	]	93	01 011 101	135	5D
	T30	^	94	01 011 110	136	5E
	UNT	—	95	01 011 111	137	5F
Secondary Command Group (SCG) Note 3	S0	`	96	01 100 000	140	60
	S1	a	97	01 100 001	141	61
	S2	b	98	01 100 010	142	62
	S3	c	99	01 100 011	143	63
	S4	d	100	01 100 100	144	64
	S5	e	101	01 100 101	145	65
	S6	f	102	01 100 110	146	66
	S7	g	103	01 100 111	147	67
	S8	h	104	01 101 000	150	68
	S9	i	105	01 101 001	151	69
	S10	j	106	01 101 010	152	6A
	S11	k	107	01 101 011	153	6B
	S12	l	108	01 101 100	154	6C
	S13	m	109	01 101 101	155	6D
	S14	n	110	01 101 110	156	6E
	S15	o	111	01 101 111	157	6F
	S16	p	112	01 110 000	160	70
	S17	q	113	01 110 001	161	71
	S18	r	114	01 110 010	162	72
	S19	s	115	01 110 011	163	73
	S20	t	116	01 110 100	164	74
	S21	u	117	01 110 101	165	75
	S22	v	118	01 110 110	166	76
	S23	w	119	01 110 111	167	77
	S24	x	120	01 111 000	170	78
	S25	y	121	01 111 001	171	79
	S26	z	122	01 111 010	172	7A
	S27	{	123	01 111 011	173	7B
	S28	|	124	01 111 100	174	7C
	S29	}	125	01 111 101	175	7D
	S30	~	126	01 111 110	176	7E
	S31	DEL	127	01 111 111	177	7F

NOTES
1. L<n>#MLA assigned to device number <n>
2. T<n> = MTA assigned to device number <n>
3. Meaning defined by Primary Command Group code

Table 9-2. HP-IB Message Reference Table

HP-IB Meta Message	Applicable	Instrument Response	Related Commands and Control Lines	Interface Functions
Data	Yes	All front panel, menu, and remote functions except LINE switch. Also, all instrument settings may be read via the HP-IB.	DAB MLA EOI UNL EOS MTA UNT OTA	L3 T5
Trigger	Yes	Responds as if the "RUN" System command were issued.	GET MLA	DT1
Clear	Yes	Responds by: • Terminating bus communication • Clearing serial poll bits • Clearing input and output buffers • Clearing error queue and key register • Stopping measurements and acquisitions.	DCL SDC	DC1
Remote	Yes	Enabled to remote mode when the REN bus control line is true. However, it remains in local until it is addressed to listen the first time.	REN MLA	RL1
Local	Yes	Returns from remote to local when it receives the Local message or the LOCAL key is pressed. Settings remain unchanged after the remote-to-local transition.	GTL MLA	RL1
Local Lockout	Yes	When in remote, and local lockout is in effect, the front panel is disabled. Only the system controller can return the instrument to local.	LLO	RL1
Clear Lockout Set/ Local	Yes	Returns to local and local lockout is clear when the REN bus control line goes false.	REN	RL1
Pass/ Take Control	No	The controller subset is not implemented.	TCT	C0
Require Service	Yes	Sets the SRQ line true when on of the service request conditions occur, if it has been enabled to send the RQS message for that condition.	SRQ	SR1

Table 9-2. HP-IB Message Reference Table (continued)

HP-IB Meta Message	Applicable	Instrument Response	Related Commands and Control Lines	Interface Functions
Status Byte	Yes	Responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when it is addressed to talk. Bit 6 (RQS bit) is true if the 54100A/D has set the SRQ bus control line true. The byte is cleared after it is read by the HP-IB controller if the RQS bit was set.	SPE SPD STB	T5
Status Bit	No	Does not respond to a parallel poll.	PPE PPC PPD PPU	PP0
Abort	Yes	Is unaddressed to listen or talk.	IFC	T5 L3

1. Commands, Control lines and Interface functions are defined in IEEE Std 488-1978. Knowledge of these might not be necessary if your controller's manual described programming in terms of the twelve HP-IB Messages shown in the left column.
2. The 54100A/D Digitizing Oscilloscope's complete bus capability as defined in IEEE Std 499-1978 is: SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

All instrument settings remain unchanged with the local-to-remote transition. However, the remote-to-local transition does disable the front panel with the exceptions mentioned above. The HP-IB status display will show "Remote" to indicate remote mode.

If the instrument is set to listen-only or talk-only mode, the local-to-remote transition is inhibited.

9-5. LOCAL MODE

Local Capability: In local, the 54100A/D's front panel controls are operational. Although it will not respond to input Data messages in local mode, if addressed to talk, the instrument can send Data messages and the Status Byte. Whether addressed or not, the instrument responds to the Remote, Local, Local Lockout, Clear Lockout/Set Local, Trigger and Abort messages. It also can issue the Require Service message in local mode.

Remote-to-Local Mode Changes: The instrument always switches to local from remote whenever it receives the Local message (GTL) or the Clear Lockout/Set Local message. (The Clear Lockout/Set Local message sets the Remote Enable control line (REN) false.) If it is not in Local Lockout mode, the instrument also switches to local when the front panel LOCAL key is pressed.

The instrument's settings remain unchanged during remote-to-local transitions. The "Remote" indication on the HP-IB status display will disappear as the remote-to-local change is made.

9-6. LOCAL LOCKOUT

When program control is interrupted, which can happen by returning the instrument to local via the front panel LOCAL key, data or settings could be changed. This would leave the instrument in an unknown state. To prevent this, a local lockout may be used. Local lockout allows return-to-local only under program control.

NOTE

Return-to-local can also be accomplished by turning the instrument off, then on again with the LINE switch. However, this technique has two potential disadvantages:

- *It defeats the purpose of local lockout (that is, the system controller may lose control of the instrument).*
- *Other HP-IB conditions reset to default states at power-on.*

9-7. ADDRESSING

The 54100A/D interprets the byte on the eight bus data lines as an address or a bus command if the bus is in the command mode (Attention control line (ATN) true). In addressable mode, the instrument may be addressed to listen or to talk.

Once addressed to listen, the instrument remains configured to listen until it receives an Abort message (IFC), its own talk address (MTA), or a universal unlisten command (UNL) from the controller. Once addressed to talk, the instrument remains configured to talk until it receives an Abort message (IFC), another instrument's talk address (OTA), its own listen address (MLA), or a universal untalk command (UNT). The HP-IB status display indicates on the CRT when the instrument is addressed to talk ("Talk") or addressed to listen ("Listen").

The 54100A/D is shipped from the factory in the addressable mode, with its talk and listen addresses set to "7" (i.e., T7 and L7). Refer to table 9-1 for equivalent address codes. The instrument can also be configured in the talk-only or listen-only mode. These modes enable limited bus operation without an HP-IB system controller. The instrument's address and addressing mode may be displayed or changed from the front panel. Complete instructions for these procedures are in Section 6 of this manual.

Listen-only Mode: If the instrument is set to listen-only mode, it is always configured as a listener and responds to all Data messages sent on the HP-IB. However, it cannot output Data messages and it is inhibited from responding to the Remote, Local, Local Lockout, Clear Lockout/Set Local, or Abort messages. Also, it is disabled from issuing the Require Service message and cannot respond to a serial poll.

NOTE

In listen-only mode, the front panel is enabled (the instrument does not enter remote mode). Therefore, settings can be changed while a program is executing.

Talk-only Mode: If the instrument is set to talk-only mode, it is always configured as a talker and does not respond to any of the bus messages. This mode must be selected if the 54100A/D is to drive a printer or a plotter without the aid of an HP-IB controller. Refer to Section 6 of this manual for more information on the use of the 54100A/D with a printer or plotter.

9-8. HP-IB TURN-ON DEFAULT CONDITIONS

Several HP-IB parameters are reset at power-on. However, both the instrument's address and addressing mode are preserved in nonvolatile memory.

HP-IB parameter default conditions are:

- HP-IB local mode
- Local-lockout cleared
- Unaddressed (if in normal addressing mode)
- RQS mask set to decimal 32546 (bits 1, 5, 8-14 set)
- Status byte register cleared
- WAVE FORMAT set to WORD
- EOI is asserted at the end of messages sent by 54100A/D
- LONGFORM is OFF
- HEADERs are OFF
- ARGUMENTS are NUMERIC

See Section 10 of this manual for a complete description of the WAVE FORMAT, EOI, LONGFORM, HEADER, and ARGUMENT commands.

9-9. DATA MESSAGES

The 54100A/D communicates on the HP-IB primarily with Data messages. The instrument interprets a byte on the eight bus data lines as a Data message when the bus is in the data mode (Attention control line (ATN) false).

The instrument can both receive and send Data messages. Input Data messages include the instrument's program commands (device-dependent commands) used to program front panel functions, menu functions, and all remote functions. Output Data messages include instrument status information, the settings of specific functions, measurement results and the Learn and Cal Strings.

Of special consideration are the Learn String and Cal String which can be sent and received by the instrument. They are binary data strings that contain a condensed coding of the entire instrument state and the delay cal factors. The Learn String and Cal String are described in paragraph 9-12 of this manual and in the descriptions of the "SETUP", "SETUP?", "CALIBRATE", and "CALIBRATE?" programming commands in Section 10 of this manual.

9-10. RECEIVING THE DATA MESSAGE

The 54100A/D responds to Data messages when it is in the remote mode (REN control line true) and is addressed to listen or when it is in the listen-only mode.

Input Data Message Format: Input Data messages contain a string of device dependent commands (program commands) and an End-of-String (EOS) message. The program codes within a Data message are executed after the EOS message is received. The following format rules must be observed for all input Data messages:

- A linefeed (<LF>) or an EOI are used as the End-of-String (EOS) message. Each Data message must be terminated by a <LF>, or by asserting the EOI bus signal line with the last byte in the message.

- The carriage return character (<CR>) is not required before <LF>. Preceding <LF>, <CR> is treated as "no operation" and may be repeated as many times as permitted by the maximum string length limitation.

- When several program commands are sent in a Data message, a semicolon (preferred), colon or space must be used to separate the program commands from each other

- Multiple arguments for a command must be separated by commas.

- The maximum length of a Data message string is 300 characters (including: semicolons, commas, <SP>, <CR>, and <LF>).

Errors in Data messages syntax are trapped and can be reported via the HP-IB. For details about detecting and reporting format errors refer to the "STATUS?" and "ERR?" programming commands in Section 10 of this manual.

Errors in Data messages syntax are trapped and can be reported via the HP-IB. For details about detecting and reporting format errors refer to the "STATUS?" and "ERR?" programming commands in Section 10 of this manual.

Program Order Considerations: Commands are interpreted and setups are changed in the 54100A/D's memory as they are received and found to be syntactically correct. The actual hardware settings are changed at the end of a message (EOS) unless a command to initiate a process is encountered. Processes include Autoscale, System commands such as "DIGITIZE" and Measurement commands. In these cases, hardware affected by commands preceding the process command is changed before the process is initiated. Hardware affected by commands after process commands is changed when the EOS is detected. Commands preceeding an error in multi-command messages are executed up to the point where the error is detected. This provides consistent operation whether commands are sent one per message or several per message.

If multiple pulse parameter measurement queries are sent in one message, the answers from those measurements will be queued for output in the order that the queries were received. Outputs in response to other queries are not queued. The last query will determine the message output by the 54100A/D when it is next addressed to talk.

Program Command Format: Program commands consist of a header followed by a parameter field. Headers may be of a Long or Short (abbreviated) form. This allows the programmer to use full words or abbreviations for program commands. Command parameters can be words, or numbers in most cases. This allows one programmer to generate readable code, and allows another programmer to generate code that is more efficient in the use of space in his computer.

Program Command Parameters may be of four types:

Strings - Any collection of ASCII characters, excluding quotation marks (decimal 34), surrounded by quotation marks.

Blocks - A block of binary data in the #A format as defined in IEEE Std 728-1982. This format is a binary block with the format:

<#><A><length word><DAB...DAB>

The length word is a 15-bit binary integer representing the number of DABs. DABs are the data bytes themselves. <#> and <A> are ASCII bytes.

Numeric - Any integer, floating point, or exponential value. The character <E> or <e> may be used to delimit the mantissa of exponential parameters. Spaces are allowed between the <+>, <-> or <E> and digits but not between digits or <.> and digits.

Alpha - Some commands require or allow alpha arguments such as "ON" or "OFF". These arguments are ASCII strings that start with an alpha character and are followed by printable character except a <SP>, <;>, <,>, <#>, <">, or <_> (delete).

The general rules of program command format are:

- The 54100A/D sends and receives Data messages in standard ASCII code.
- The instrument responds equally to upper and lower case characters
- Parameter fields containing multiple parameters require a comma (,) to delimit individual parameters

Errors in Data messages syntax are trapped and can be reported via the HP-IB. For details about detecting and reporting format errors refer to the "STATUS?" and "ERROR?" programming commands in Section 10 of this manual.

9-11. SENDING THE DATA MESSAGE

The 54100A/D can send Data messages in local or remote mode, when it is addressed to talk, or in the talk-only mode.

NOTE

Before the instrument is addressed to talk, the desired output data must be specified with the appropriate input Data message. Otherwise, the instrument outputs the overrange value "1E38" by default to complete the bus transaction. If the ERR service request is enabled, a service request will be generated with the "Output Buffer Empty" error in the ERRor queue.

Output Data Message Format: Output Data messages include the settings of individual functions, instrument status information and binary Learn String or Cal String Data. Excluding the Learn String and Cal String, there are two output data types: Integer and exponential. All output Data messages contain a leading space (<SP>) or minus sign (<–>) followed by the function value or status data. <CR> and <LF> are sent as the EOS message for all output data. An EOI can be sent with the <LF> if selected by the front panel control or by the "EOI" program command.

Refer to the "LONGFORM", "HEADER", and "ARGUMENT" programming commands in Section 10 of this manual for more information on output format selection.

NOTE

Exponential values are sent by the 54100A/D with the ASCII character "E" (uppercase) as the separator between the mantissa and the exponent.

9-12. LEARN AND CAL STRINGS

If the 54100A/D receives a "SETUP?" (Setting query) programming command and is then addressed to talk, it sends the Learn String. The Learn String consists of 236, 8-bit bytes containing information about front panel configuration. This binary data can be stored in the controller's memory for future use. The Learn String includes only those parameters that determine the front panel setup of the instrument.

If the 54100A/D receives a "CALIBRATE?" (Cal factor query) programming command and is then addressed to talk, it sends the CAL String. The CAL String consists of 24, 8-bit bytes containing the delay cal factors. This binary data can be stored in the controller's memory for future use.

The combination of the Learn String and the Cal string comprise the same information that is saved in the internal Save/Recall registers. The contents of the Save/Recall registers, however, are not included in the Learn String or Cal String. Refer to the "Save/Recall" Detailed Operating Instruction in Section 6 of this manual for more information.

These binary data blocks can be returned to the 54100A/D by preceding the data blocks with the "SETUP" or "CALIBRATE" commands as appropriate. Refer to the "SETUP" and "CALIBRATE" programming commands in Section 10 of this manual for more detailed information.

9-13. RECEIVING THE CLEAR MESSAGE

The 54100A/D responds to the Clear message <DCL> and Selected Device Clear message <SDC> by:

1. Clearing all serial poll status bits.
2. Clearing the input and output buffers.
3. Clearing the error queue and key register.
4. Stopping any measurement or acquisition processes except the normal background acquire-display cycle.

9-14. RECEIVING THE TRIGGER MESSAGE

The 54100A/D responds to the Trigger message (GET bus command) in the same way that it responds to a "RUN" system command. If the timebase mode is in "SINGLE", a trigger message will cause the instrument to behave as if the front panel STOP/SINGLE key were pressed. If the timebase mode is "AUTO" or "TRiGgereD", a trigger message will cause the instrument to behave as if the front panel RUN key were pressed. For more information on the "RUN" system command, see Section 10 of this manual.

9-15. RECEIVING THE REMOTE MESSAGE

The Remote message has two parts. First, the remote enable bus control line (REN) is held true, then the device listen address <MLA> is sent by the controller. The 54100A/D is enabled to go into remote when REN goes true but it does not actually switch into remote until addressed to listen the first time. No instrument settings are changed by the transition from local to remote. When actually in remote mode, the instrument displays "Remote" in the HP-IB status display to indicate remote mode.

9-16. RECEIVING THE LOCAL MESSAGE

The Local message returns the 54100A/D to front panel control. The Local message (GTL bus command) addresses the instrument to listen and then switches it from remote to local mode. The remote indicator ("Remote") in the HP-IB status display will turn off when the Local message is received. No instrument settings are changed by the remote-to-local transition.

Although the Local message returns front panel control, it does not clear local lockout. Unless the instrument receives the Clear Lockout/Set Local message, if local lockout is in effect, it will return to local lockout mode the next time it goes to remote.

9-17. RECEIVING THE LOCAL LOCKOUT MESSAGE

The Local Lockout message (LLO bus command) disables the 54100A/D's front panel LOCAL key. Local lockout is accepted when the instrument is in either remote or local mode. Afterwards, whenever the instrument is in remote mode, lockout is in effect. While the instrument is in local lockout, the remote-to-local transition can only be made from the system controller by sending the Clear Lockout/Set Local message or the Local message

9-18. RECEIVING THE CLEAR LOCKOUT/SET LOCAL MESSAGE

The Clear Lockout/Set Local message (REN control line false) returns the Measurement System from remote to local mode and clears the local lockout condition. No instrument settings are changed by this message It is accepted while the instrument is in either remote or local mode. If the instrument is in remote mode, the remote indicator ("Remote") in the HP-IB status display is blanked when the Clear Lockout/Set Local message is received.

9-19. RECEIVING THE PASS CONTROL MESSAGE

The 54100A/D does not implement the controller subset, therefore, it does not respond to the Pass Control message.

9-20. SENDING THE REQUIRE SERVICE MESSAGE

The 54100A/D sends the Require Service message (by setting the SRQ bus control line and bit 6 of the status byte true) when a previously programmed condition occurs. The instrument can send the Require Service message in either local or remote mode. The Require Service message is cleared when a serial poll is executed by the system controller During serial poll, the SRQ control line is reset immediately before the instrument places the Status Byte message on the bus. Table 10-1 (see Section 10) includes the conditions that can be selected to cause the Require Service message. If no conditions are selected, the Require Service message is disabled.

The 54100A/D indicates having sent the Require Service message by displaying "SRQ" in the HP-IB status display. This indicator is turned off during the serial poll when the SRQ control line is reset.

If the 54100A/D is set to either listen-only or talk-only modes, it cannot send the Require Service message.

9-21. THE STATUS WORD

The instrument status word is a 16-bit integer containing information about the instrument conditions that set the ready bit in the status byte and/or generate a Require Service message. See tables 10-1 and 10-2 in Section 10 for a description of the bits in the Status Word. The upper 8 bits of the Status Word are known collectively as the ready byte, while the lower 8 bits correspond to the status byte sent during a serial poll.

A companion 16-bit word, the request mask, is used to specify both those conditions in the ready byte that set the ready bit in the status byte, and those conditions in the status byte that generate a Require Service message. The bits in the request mask have the same meanings as those in the instrument status word. The ready bit in the status byte is set when all of the conditions corresponding to bits in the ready mask are true at the same time. This bit is actually set on the transition of the last condition to become true.

The "REQuest" programming command is used to specify the request mask while the "STATus" programming command can be used to read the instrument status word. For more information refer to these two commands in Section 10 of this manual.

9-22. SENDING THE STATUS BYTE MESSAGE

The Status Byte message consists of one 8-bit byte in which the bits are set according to the conditions described by table 10-1 (see Section 10). The 54100A/D sends the Status Byte message when it is addressed to talk and it receives the Serial Poll Enable (SPE) bus command from the HP-IB system controller.

If the instrument is set to either listen-only or talk-only mode, it does not respond to the SPE or SPD (Serial Poll Disable) commands and cannot send the Status Byte.

Bits in the status byte are set depending on the instrument state. If a condition occurs that causes one of the bits in the status byte to be set and if its corresponding bit in the request mask is set, the Require Service message will be sent.

If the RQS bit is set, indicating that the instrument sent the Require Service message, and a serial poll is executed, all bits in the status byte will be cleared. If the RQS bit is clear and a serial poll is executed, the status byte will be left unchanged.

If a condition that caused one of the bits in the status byte to be set is removed and if the corresponding bit in the request mask is clear, the corresponding bit in the status byte will be cleared.

To supplement the information in the Status Byte, the "ERRor" query can be used to determine what specific error occurred.

9-23. SENDING THE STATUS BIT MESSAGE

The 54100A/D does not respond to a Parallel Poll Enable (PPE) bus command; it cannot send the Status Bit message.

9-24. RECEIVING THE ABORT MESSAGE

The Abort message (IFC control line true) halts all bus activity. When the 54100A/D receives the Abort message, it becomes unaddressed and stops talking or listening. The Require Service message and the Status Byte are unaffected by the Abort message.

9-25. NOTATION CONVENTIONS AND DEFINITIONS

The following conventions are used in this manual in descriptions of remote (HP-IB) operation:

< > Angular brackets enclose descriptive words or characters that are used to symbolize a program code parameter or an HP-IB command. <A> represents the ASCII character "A".

... An ellipsis (trailing dots) is used to indicate that the preceeding element may be repeated one or more times.

[ ] Square brackets indicate that the enclosed items are optional.

The following definitions are used:

d : : = A single ASCII numeric character, 0-9

n : : = A single ASCII nonzero, numeric character, 1-9

<LF> : : = ASCII linefeed (decimal 10)

<CR> : : = ASCII carriage return (decimal 13)

<SP> : : = ASCII space (decimal 32)

Section 10
HP-IB Programming Commands

10-1. GENERAL

HP-IB commands are divided into three types: system commands, subsystem commands, and subsystem selectors. System commands refer to general scope functions and may be issued at any time. They do not change the subsystem selection. Subsystem commands are legal only when the subsystem has been previously selected and control a particular portion of the scope, for example the timebase. Only one subsystem may be selected at a time, and any command which is not a system command or a subsystem selector is assumed to be a command for the selected subsystem. Subsystem selectors are commands that switch from one subsystem to another and are valid at any time with one important exception: certain subsystem selector commands also look like subsystem parameters (for example CHANNELn or TRIGGER). The convention is that if one of these was preceded by the keyword SOURCE then it is a subsystem parameter; otherwise it is a subsystem selector.

10-2. COMMAND ABBREVIATIONS

Every command and every alpha parameter has at least two forms, a short form and a long form, although in some cases these are identical. The short form is obtained by truncating the longform using the following rule:

If the longform has more than 4 characters,
then if the 4th character is a vowel or the same as the 3rd character,
then truncate to 3 characters,
else truncate to 4 characters.

EXAMPLE - LONGFORM abbreviates to LONG.
- SERIAL abbreviates to SER.
- YOFFSET abbreviates to YOF.

In the case where two short forms would be identical, one of them will be changed slightly to differentiate between the two. In the command descriptions that follow, each command is given in both long and short forms. In addition, some commands also have industry standard forms and these have been included in the instruction set too.

10-3. ARGUMENT ENUMERATION

Most of the programming commands that require parameters can use either ALPHA or NUMERIC arguments as their parameters. For these commands, an enumeration is given with the description of the command that gives the relationship between the NUMERIC and ALPHA arguments.

EXAMPLE - OFF is the same as 0
- ON is the same as 1

10-4. DATA OUTPUT FORMAT

All output fields are an even number of bytes in length. There are three types of output arguments: (1) Headers and Alpha arguments, (2) Integers and (3) Reals. There are also enumerated types. Enumerated types may be Alpha or Integer when they are output depending on whether the ARGUMENT command has set them to ALPHA or NUMERIC.

Headers and Alpha arguments:
Longforms are of varying length.
<alpha>...<alpha><SP>[SP]

Abbreviations are six characters long
<alpha>...<alpha><SP>[SP>...<<SP>]

Integers: Always six characters in length.
[<SP>...<SP>]<<SP>|<->><d>...<d>
NOTE: Trigger Events Holdoff is twelve characters in length.

Reals: Always twelve characters in length.
<<SP>|<->><d><.><d><d><d><d><d><E><>>+>|<->><d><d>

10-5. COMMAND EXECUTION

Most commands are not order sensitive. For the few commands that are, the following convention has been adopted: all commands prior to an order sensitive command will be executed before the order sensitive command is executed. If an error is detected and parsing is halted, all commands up to the erroneous one will have been executed.

Queries, when executed, cause their replies to be placed in the output buffer. Multiple queries on one line result in the last reply overwriting the previous replies. The exception to this is when multiple parameter measurement queries are sent on one command line. In this case the replies to the measurement queries are buffered in the order that the queries occurred in the command line.

10-6. DEFAULT SETTINGS

Instrument turn-on causes several interface parameters to be preset. Specifically the request mask (RQS mask) is set to 32546 (bit 1, 5, 8-14 set).

Holding a key down while powering on the instrument causes a more extensive set of parameters to be initialized. These include selecting arguments to be numeric, headers off and longform off, and EOI to be asserted with the last data byte of messages. This has the same effect as sending a "RESET" command except that the reset command does not change the EOI selection.

10-7. THE STATUS WORD

Instrument status word is a 16-bit integer containing information about the instrument conditions that set the ready bit in the status byte and/or generate a Require Service message. See Tables 10-1 and 10-2 for a description of the bits in the Status Word. The upper 8 bits of the Status Word are known collectively as the ready byte, while the lower 8 bits correspond to the status byte sent during a serial poll.

A companion 16 bit word, the request mask, is used to specify both those conditions in the ready byte that set the ready bit in the status byte, and those conditions in the status byte that generate a Require Service message. The bits in the request mask have the same meanings as those in the instrument status word. The ready bit in the status byte is set when all of the conditions corresponding to bits in the ready mask are true at the same time. This bit is actually set on the transition of the last condition to become true.

The "REQuest" programming command is used to specify the request mask while the "STAtus" programming query can be used to read the instrument status word.

Bit	Mask Weight	Status bit condition
7	128	MSG = Message in DSP area - High indicates that a message was displayed in the advisory line.
6	64	RQS = Requesting service - High indicates that this instrument requested service.
5	32	ERR = Error - High indicates an error occurred. An ERROR query is used to determine what specific error occurred.
4	16	RDY = Ready - High indicates the instrument is ready. This is based on the ready mask (see REQUEST).
3	8	LCL = Local switch or power cycle - High indicates that the instrument has been operated locally or that cycling the power caused it to change state.
2	4	FPS = Front panel service request - High indicates a front panel key has been pressed.
1	2	PWR = Power fail - High indicates that the 54100A/D's non volatile memory was corrupt at powerup. This is probably due to battery failure.
0	1	RQC = Request control - This bit is not set by the 54100A/D.

Table 10-1. The Lower Byte of the Status Word (The Status Byte)

Notes:
1. To set the RQS bit and SRQ bus control line true, the condition must be enabled in the RQS mask.
2. If no condition is enabled, the 54100A/D can not set the SRQ bus control line or the RQS bit true. However, bits 0-5 and 7 of the status byte are set to indicate which conditions have occurred.
3. The Ready bit (bit 4) is set when all conditions in the Ready Byte (Table 10-2) enabled in the request mask are true.

Bit	Mask Weight	Ready bit condition
14	16384	Cal = Calibration Complete - This bit is not set by the 54100A/D.
13	8192	Tst = Test complete - High indicates that the requested test has completed execution
12	4096	Hard = Hardcopy complete - High indicates that the last byte of printer or plotter dump has been sent and received.
11	2048	Data = Data available - High indicates that something is in the buffer waiting to be sent.
10	1024	Acq = Acquisition complete - High indicates that the last bus acquisition command has completed.
9	512	Trig = Triggered - High indicates that the instrument is generating triggers (THIS BIT WILL NOT SET RDY).
8	256	Parse = Parse complete - High indicates that the last command has completed parsing.

Table 10-2. The Upper Byte of the Status Word (The Ready Byte)

Note: The Ready bit (bit 4) of the Status Byte (Table 10-1) is set when all conditions in the Ready Byte enabled in the request mask are true.

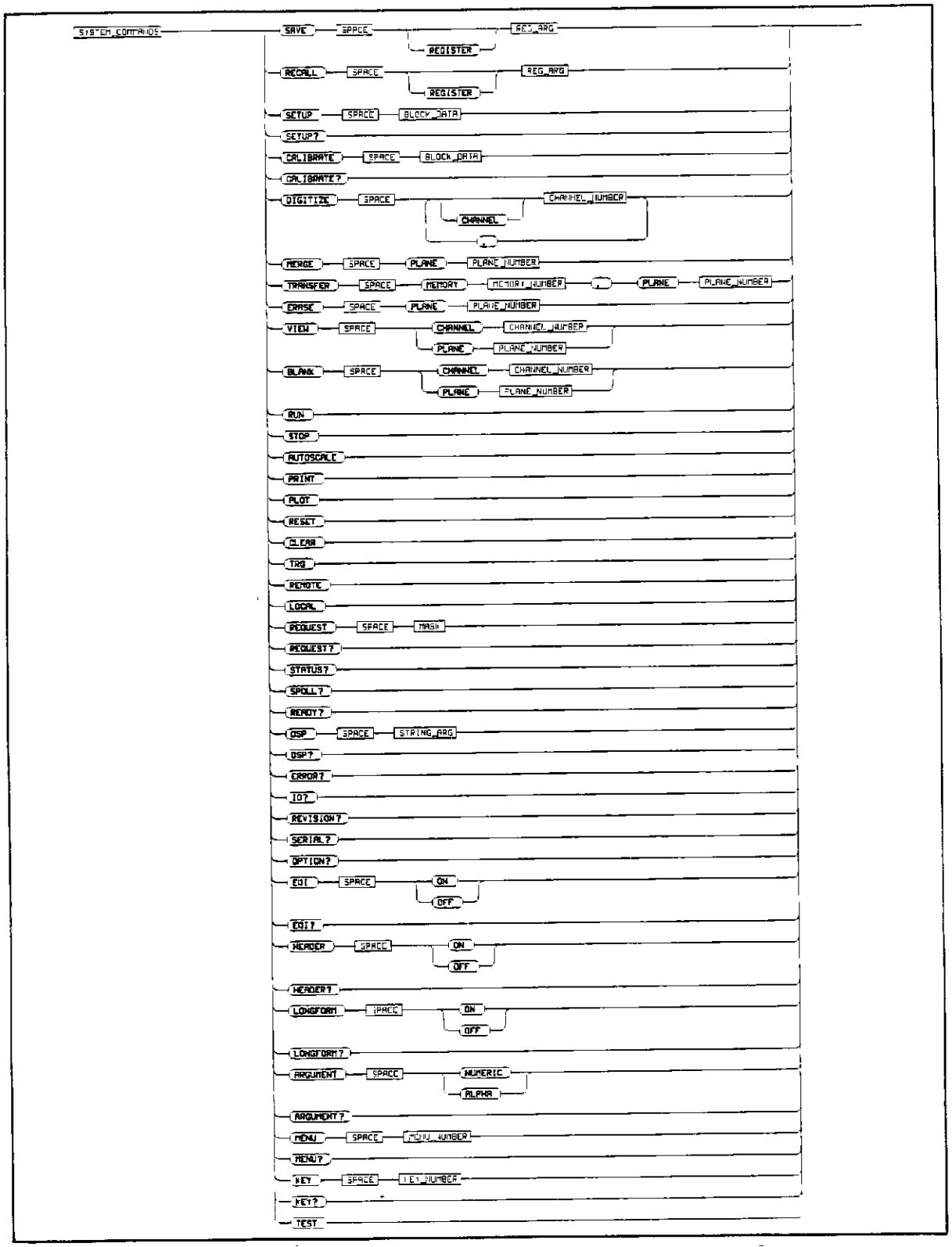


Figure 10-1. Systems Commands

MENU_NUMBER = An integer from 1 to 14

KEY_NUMBER = An integer from 1 to 63 (see table 10-4 for keycodes).

STRING_ARG = Any collection of ASCII characters excluding quotes, surrounded by quotes.

REG_ARG = An integer from 0 to 9

MASK = An integer between 0 and 65535. This number is the sum of all the bits in the request mask corresponding to conditions that are to be enabled. See tables 10-1 and 10-2 for the bit definitions in the request mask.

BLOCK_DATA = A block of data in #A format as defined in IEEE Std 728-1982.

CHANNEL_NUMBER = An integer 1 or 2.

PLANE_NUMBER = An integer from 0 to 2.

Figure 10-1. Systems Commands (continued)

10-8. SYSTEM COMMANDS

This group of commands may be sent when in any subsystem. When one of these commands is encountered in a program command message, any changes to the hardware that were specified prior to the system command are executed first, and the system command is executed second. After execution of a system command, the 54100A/D HP-IB returns to whatever subsystem was active when the system command was received. Refer to Figure 10-1 for syntax of these commands.

ARGUMENT
ARG **command/query**

This command specifies how enumerated types are returned from the 54100A/D. For example if ARGUMENT is NUMERIC then the ARGUMENT query returns a 0, while if ARGUMENT is ALPHA then the ARGUMENT query returns ALPHA.

Enumeration: NUMERIC = 0
ALPHA = 1

EXAMPLE: ARGUMENT NUMERIC - Tells the 54100A/D to return enumerated types as numeric parameters in response to queries.

ARGUMENT? - Queries the 54100A/D for the argument type.

AUTOSCALE
AUT **command**

This command causes the scope to scale the timebase, channel and trigger systems for optimum viewing of any input signals. If no signal is found, the instrument defaults to 1 us/div and 1 V/div.

EXAMPLE: AUTOSCALE - Instructs the 54100A/D to perform an Autoscale operation.

BLANK
BLAN **command**

This command causes the scope to turn off the active channel displays or waveform display memories. The command has one parameter in the form of: CHANNELn, or PLANEn where n = 1 or 2. CHANNELn refers to the active display of one of the input channels. PLANEn refers to one of the waveform memories. This command does not erase the waveform memories (See ERASE) or change their contents. The converse of this command is "VIEW".

EXAMPLE: BLANK PLANE 1 - Instructs the 54100A/D to shut off the display of waveform memory 1.

CALIBRATE
CAL **command/query**

This command sends a Cal String to the instrument. A Cal String consists of 24 8-bit bytes containing the Delay Calibration factors that are setup in the Cal Menu on the front panel. These Cal factors are also saved during a front panel SAVE operation and are recalled during a front panel RECALL operation. The "CALIBRATE?" query sends the Cal String to the controller using the same format as is required by the "CALIBRATE" command so no modifications need be made to the string between the time that it is received from the instrument after the "CALIBRATE?" query and the time that it is sent back with the "CALIBRATE" command.

EXAMPLE: CALIBRATE <Cal String> - Sends a Cal string to the 54100A/D
CALIBRATE? - Queries the 54100A/D for its current Cal factors.

CLEAR **command**

Performs an operation similar to a Device Clear <DCL> or Selected Device Clear <SDC>. The 54100A/D responds to the Clear message and Selected Device Clear message by:

1. Terminating all bus communications in process by untalking and unlistening.
2. Clearing all serial poll status bits.
3. Clearing the input and output buffers.
4. Clearing the error queue and key register
5. Stopping any measurement or acquisition processes except the normal background acquire-display cycle.

This command is provided for use by controllers that have a limited HP-IB control capability. If available, the HP-IB <DCL> or <SDC> messages are the preferred method of performing a device clear.

EXAMPLE: CLEAR - Tells the 54100A/D to execute a Device Clear.

DIGITIZE
DIG **command**

This command is used to acquire waveform data for transfer over the bus. It causes an acquisition to take place on the specified channel(s) with the resulting data being stored in the corresponding memory (ie channel 1 is stored in memory 1, etc). These memories are internal to the HP-IB system and are not to be confused with the waveform display memories. If more than one source is specified in the command, the acquisitions occur simultaneously. The ACQUIRE subsystem commands are used to setup conditions such as TYPE, COMPLETION criteria, # of POINTS and the average COUNT for the next DIGITIZE command. Refer to Paragraph 10-9 for a description of these commands.

EXAMPLE: DIGITIZE CHANNEL1,CHANNEL2 - Tells the 54100A/D to acquire waveform data on both channel 1 and channel 2.

DSP command/query

This command writes a string to the advisory line (line 15). The query returns the string last written to the advisory line. This may be a string written with a DSP command or a internally generated advisory.

EXAMPLE: DSP "Hi Mom!" - Tells the 54100A/D display "Hi Mom!" on line 15 of the display.
DSP? - Queries line 15 of the display.

EOI command/query

This command specifies whether or not the last byte of a reply from the scope is to be sent with the EOI bus control line set true or not. The query returns the value last specified for this.

Enumeration: off = 0
on = 1

EXAMPLE: EOI ON - Tells the 54100A/D to assert EOI on the last byte of a reply.
EOI? - Queries the EOI on/off state.

ERASE
ERAS command

This command erases (clears) the specified display plane. The command has one parameter in the form of: PLANEd where d = 0...2. Plane0 is the active display. Plane1 is waveform display memory 1 and Plane2 is waveform memory 2. Erasing Plane0 is same as pressing the CLEAR DISPLAY key on the front panel. If the scope is running and triggering, Plane0 will start filling up with data again after this command.

EXAMPLE: ERASE PLANE1 - Tells the 54100A/D to clear waveform memory 1.

ERROR
ERR query

This query pulls the next error number out of the error queue and returns it. The 54100A/D has an error queue that is 16 errors deep and operates on a first-in first-out basis. Successively sending the query, ERROR? returns these error numbers in the order that they occurred until the queue is empty. Any further queries then return 0's until another error occurs. See Table 10-3 for a list of ERRor numbers.

EXAMPLE: ERROR? - Queries the 54100A/D for the next error in the error queue.

HEADER
HEAD command/query

Query replies from the 54100A/D optionally return an ASCII header labeling the value returned. The headers are the same as the command to set the value. For example: if headers are on and OFFSET is queried, the reply from the instrument will be "OFFSET" followed by the offset value. This assumes that LONGFORM is also on. If LONGFORM is off, the reply will be "OFFS" followed by the offset value The HEADER command is used to enable or disable this option, while the query returns the header on/off state.

Enumeration: off = 0
on = 1

EXAMPLE: HEADER ON - Tells the 54100A/D to return headers with query replies.
HEADER? Queries the HEADER on/off state.

The error numbers and definitions below are the ones reported during an ERROR? query.

ERROR NUMBER	DESCRIPTION
-100	Unknown command
-101	Invalid character received
-110	Command header error
-119	Command header expected
-120	Numeric argument error
-121	Numeric data expected
-123	Numeric overflow
-125	Numeric syntax error
-130	Non-numeric argument error
-131	Character data expected
-132	String data expected
-133	Block data (binary data) expected
-134	String length error
-135	Block length error
-142	Too many arguments
-143	Argument delimiter error
-144	Message unit delimiter error
-149	Missing argument
-150	Query expected
-151	Query not allowed
-201	Command not executable in local mode
-202	Settings lost on power on
-211	Settings conflict
-212	Argument out of range
-222	Insufficient capability/configuration
-230	Transmission aborted
-231	Input buffer full or overflow
-233	Output buffer empty
-301	Interrupt fault
-302	System error
-311	RAM failure (hard error)
-312	RAM data loss (soft error)
-321	ROM checksum error
-340	Self test failed
-350	Timer error
-360	Analog hardware error
-370	Digital hardware error
-399	Power supply failure

Table 10-3 Error Numbers

Positive error numbers are reported after a Self Test Failed error (-340). These refer to the internal self test loops that failed to pass selftest.

ID query

This query returns the instrument model number, 54100A or 54100D

EXAMPLE: ID? - Queries the 54100A/D for its model #

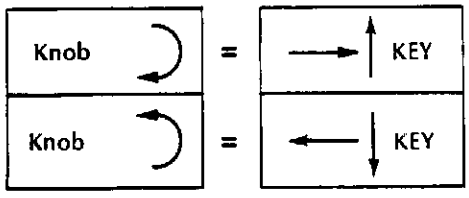
KEY command/query

This command simulates the pressing of a front key. Keys may be pressed in any order that is legal from a front panel operational standpoint. Caution must be taken when using this command to insure that the instrument is really in the desired state before pressing a key. The query returns the key code for the last key pressed. Key codes range from 1 to 63 with 0 representing nokey (returned after power-on). See Table 10-4 for a list of key codes.

EXAMPLE: KEY 48 - Presses the AUTOSCALE key
KEY? - Queries the instrument for the last key pressed.

KEY	KEYCODE (decimal)	KEY	KEY CODE (decimal)
Menu Select 1	1	"." (decimal pt)	23
Menu Select 2	2	0	24
Menu Select 3	3	1	25
Menu Select 4	4	2	26
Menu Select 5	5	3	27
Menu Select 6	6	4	28
Menu Select 7	8	5	29
Menu Select 8	9	6	30
Function Select 1	15	7	31
Function Select 2	14	8	32
Function Select 3	13	9	33
Function Select 4	12	CLEAR DISPLAY	40
Function Select 5	11	RUN	41
Function Select 6	10	STOP/SINGLE	42
sec/Volt	16	SAVE	43
msec/mV	17	RECALL	44
usec	18	LOCAL	45
nsec	19	AUTOSCALE	48
psec	20	→	56
CLEAR	21	←	63
"-" (minus)	22	no key pressed	0

Note:



Menu Select Keys are located at the bottom of the screen with menu select 1 at the lower left of the screen The Function Select keys are located at the right of the screen with Function Select 1 at the upper right of screen.

TABLE 10-4. 54100A/D FRONT PANEL KEY CODES

LOCAL command

This command performs a similar operation to the Clear Lockout/Set Local message. It is provided for use by controllers that have a limited HP-IB control capability. If available, the HP-IB Clear Lockout/Set Local message is the preferred method of switching the instrument from Remote to Local and clearing the Local Lockout condition. See paragraphs 9-6 and 9-18 of this manual for more information on Local Lockout and the Clear Lockout/Set Local message.

EXAMPLE: LOCAL - Switches the instrument from REMOTE to Local and clears the Local Lockout condition.

LONGFORM
LONG command/query

Query responses can return alpha arguments and headers (see HEADER and ARGUMENT commands). The LONGFORM command is used to select the format of these responses. Assuming that HEADER is on, if LONGFORM is on, the whole keyword is returned; otherwise the short form abbreviation is returned. The query returns the last specified LONGFORM value.

Enumeration: off = 0
on =1

EXAMPLE: LONGFORM OFF - Tells the 54100A/D to respond to queries with abbreviated headers if HEADER is on.
LONGFORM? - Queries the LONGFORM on/off state.

MENU command/query

This command has the same affect as selecting one of the 14 menus on the front panel. Note that it will not change any other front panel settings or modes. The knob will be assigned to the function it was assigned when the specified menu was last selected. The query returns the menu that is currently selected. See Table 10-5 for a list of menu numbers.

EXAMPLE: MENU 3 - Selects the Timebse Menu on the 54100A/D
MENU? - Queries the instrument for the current menu number.

Menu Number	Menu
1	Channel 1
2	Channel 2
3	Timebase
4	Trigger
5	Display
6	Delta V
7	Delta t
8	Waveform Save
9	Parameter Measurements
10	Print
11	Plot
12	Probes
13	HP-IB
14	Calibrate & Test

TABLE 10-5. Menu Numbers

MERGE command

This command stores the contents of the active display area into the specified waveform display memory. The command has one parameter in the form of: PLANEn where n=1 or 2. Plane 1 is waveform memory 1 and Plane 2 is waveform memory 2. This command has the same affect as "Store to Memory 1" or "Store to Memory 2" keys in the "Wfmsave" menu.

EXAMPLE: MERGE PLANE1 - Tells the 54100A/D to store the contents of the active display into waveform memory 1.

OPTION
OPT query

This query returns a list of installed options in the instrument as a series of integers, separated by commas. In the 54100A/D, no options are present so a zero is returned.

EXAMPLE: OPTION? - Queries the 54100A/D as to it's installed options.

PLOT command

This command causes the instrument to output the contents of its active display and/or its waveform memories in a format acceptable to an HPGL plotter as soon as it is next addressed to talk. The content of the output is controlled with programming commands in the HARDCOPY subsystem, paragraph 10-13. Examples of HPGL plotters are HP7550A, HP 7480A, HP9872C. An example of the use of the PLOT instruction can be found in Section 11 of this manual. See Section 8 for additional compatible HP plotters.

EXAMPLE: PLOT - Tells the 54100A/D to output to an HPGL plotter.

PRINT
PRIN command

This command causes the instrument to output the contents of its active display and/or its waveform memories in a format acceptable to a printer compatible with the HP RASTER GRAPHICS STANDARD as soon as it is next addressed to talk. The content of the output is controlled with programming commands in the HARDCOPY subsystem, paragraph 10-13. Examples of raster graphics printers are: HP 2225A, 82906A. An example of the use of the PRINT instruction can be found in Section 11 of this manual. See Section 8 for additional compatible HP printers.

EXAMPLE: PRINT - Tells the 54100A/D to output to a raster graphics printer.

READY
READ
RDY query

This query returns the ready byte (the upper byte of the status word). See Table 10-2 for a complete description of the ready byte.

EXAMPLE: READY? - Queries the 54100A/D for the ready byte

RECALL
REC command

This command recalls an instrument setup from the specified save-recall register. Its action is exactly the same as performing a RECALL operation from the front panel.

EXAMPLE: RECALL 1 - Tells the 54100A/D to recall a setup and delay cal factors from save-recall register 1.

REMOTE command

This command performs a similar operation as a Remote message followed by a Local Lockout message. It is provided for use by controllers that have a limited HP-IB control capability. If available, the HP-IB Remote and Local Lockout messages are the preferred method of switching the instrument from Local to Remote and invoking Local Lockout. See paragraphs 9-4, 9-6, and 9-17 for more information on the Remote Mode and Local Lockout. Note that if the REN line is false, the REMOTE command will have no affect.

EXAMPLE: REMOTE - Tells the 54100A/D to make a Local to Remote transition and go to Local Lockout.

REQUEST
RQS command/query

This command sets the request mask (RQS mask). The request mask is a 16 bit integer that determines what combinations of bits in the status register set the ready flag and/or generate a require service message. Setting a bit in the request mask to a 1 enables its corresponding condition in the instrument status word. See paragraph 10-7 and Tables 10-1 and 10-2 for a complete description of the bits in the request mask.

Another form of this command allows the programmer to follow the REQUEST command with ON or OFF. This command enables or disables the ability of the 54100A/D to generate the require service message without changing the request mask. Any unmasked conditions that occur with REQUEST OFF will be saved until the REQUEST ON command is received. At that time, unmasked conditions that occurred before and after the REQUEST ON command will generate the require service message.

EXAMPLE: REQUEST 36 - Tells the 54100A/D to issue a require service message when an ERRor occurs or if a front panel key is pressed.
REQUEST? - Queries the 54100A/D for its request mask.

RESET
RES
RST command

This command presets the instrument to default settings. These settings are the same as those preset if a front panel key is held down during powerup. Refer to Table 10-6 for a list of the preset conditions.

EXAMPLE: RESET - Tells the 54100A/D to perform a reset.

RESET CONDITIONS FOR THE 54100A/D

Ch1/Ch2 Mode	- Normal
Ch1/Ch2 Display	- On
Ch1/Ch2 Volts Per Div	- 1.0 volts/div
Ch1/Ch2 Offset	- 0.0 volts
Ch1/Ch2 ECL/TTL Preset	- Off
Ch1/Ch2 Magnify	- Off
Ch1/Ch2 Magnify Window Size	- 7.0 volts
Ch1/Ch2 Magnify Window Position	- 0.0 volts
Seconds Per Division	- 1.0 usec/div
Delay	- 0.0 sec
Delay Reference	- Center Screen
Auto/Triggered Sweep	- Auto
Trigger Mode	- Edge
Trigger Source (Edge Mode)	- Channel 1
Ch1/Ch2/Trig3 Trigger Level	- 0.0 volts
Ch1/Ch2/Trig3 Trigger Slope	- Positive
Holdoff Mode (Edge Mode)	- Time
Holdoff Time (Edge Mode)	- 70.0 nsecs
Holdoff Events (Edge Mode)	- 2
Trigger Pattern (Pattern Mode)	- Ch1: High - Ch2: Don't Care - Trig3: Don't Care
Pattern Edge (Pattern Mode)	- Entering
Holdoff Mode (Pattern Mode)	- Time
Holdoff Time (Pattern Mode)	- 70.0 nsecs
Holdoff Events (Pattern Mode)	- 2
Display Mode	- Normal
Display Time/Persistence	- 0.5 secs
Number of Averages	- 8
Split Screen	- Off
Graticule Mode	- Axes
Stop Criteria (For HP-IB DIGITIZE command)	- 100%
Voltage Markers	- Off
Marker1 Position	- -2.5 volts
Marker2 Position	- +2.5 volts
Top Base Reference	- 100%
Time Markers	- Off
Start Marker Position	- -3.5 usecs
Stop Marker Position	- +3.5 usecs
Start Marker Edge Slope	- Positive
Stop Marker Edge Slope	- Negative
Start Marker Edge Number	- 1
Stop Marker Edge Number	- 1
Waveform Memory 1	- Off
Waveform Memory 2	- Off

TABLE 10-6. Reset Conditions

ADDITIONAL RESET CONDITIONS FOR THE 54100D	
Trig4 Trigger Slope	- Positive
Trig4 Trigger Level	- 0.0 volts
Pattern Trigger for Trig4	- Don't Care
Pattern Duration	- 10.0 nsecs
Trigger Slope (Pattern/Edge Mode)	- Positive
Trigger Chan. (Pattern/Edge Mode)	- Channel 1
Pattern (Pattern/Edge Mode)	- Ch1: Clock - Ch2: Don't Care - Trig3: Don't Care - Trig4: Don't Care
Pattern Present/Not Present	- Present
Holdoff Time (Pattern/Edge Mode)	- 70.0 nsecs
Arming Slope (Time Delayed Mode)	- Negative
Arming Channel (Time Delayed Mode)	- Channel 1
Time Delay (Time Delayed Mode)	- 20.0 nsecs
Trigger Slope (Time Delayed Mode)	- Positive
Trigger Channel (Time Delayed Mode)	- Channel 1
Arming Slope (Event Delayed Mode)	- Negative
Arming Chan. (Event Delayed Mode)	- Channel 1
Events Delay (Event Delayed Mode)	- 1
Trigger Slope (Event Delayed Mode)	- Positive
Trigger Chan. (Event Delayed Mode)	- Channel 1
RESET VALUES FOR THE HP-IB FOR THE 54100A/D	
Service request mode	- disabled (RQS OFF)
Service request mask	- decimal 32546 (bits 1, 5, and 8-14 set)
Serial poll status byte	- clear
Error queue	- empty
WAVE FORMAT	- WORD
EOI	- ON
LONGFORM	- OFF
HEADER	- OFF
ARGUMENT	- NUMERIC

Table 10-6. Reset Conditions (continued)

REVISION
REV query

This query returns an integer corresponding to the revision date of the internal firmware.

EXAMPLE: REVISION? - Queries the 54100A/D for its revision numbers.

RUN command

This command causes the instrument to acquire data for the active waveform display on the CRT based on the timebase mode. If the timebase mode is in "SINGLE", the RUN command will cause the instrument to enable the trigger once and display the data it acquires in the active display on the CRT. This is the same thing that happens when the front panel STOP/SINGLE key is pressed when the instrument is STOPPED. If the timebase mode is "AUTO" or "TRIGGERED", the RUN command will cause the instrument to enable the trigger repeatedly and display the data it acquires continuously on the display. This is the same thing that happens when the front panel RUN key is pressed.(see MODE under the TIMEBASE, subsystem paragraph 10-15, subsystem for a description of the various modes).

EXAMPLE: RUN - Tells the 54100A/D to acquire data for the display.

SAVE command

This command saves an instrument setup in the specified save-recall register. Its action is exactly the same as performing a SAVE operation from the front panel.

EXAMPLE: SAVE 1 - Tells the 54100A/D to save its front panel setup and delay cal factors in save-recall register 1.

SERIAL
SER query

This query returns the instrument serial number as a quoted string. The serial # is saved in battery backed up non-volatile memory. If the battery should fail, the serial number will be lost. A user can replace this information by sending the command "SERIAL" <serial #> where <serial#> is a string containing the serial number from the rear panel of the instrument.

EXAMPLE: SERIAL? - Queries the 54100A/D for its serial #

SETUP
SET command/query

This command sends a Learn String to the instrument. A Learn String consists of 236 8-bit bytes containing information about front panel setups. Sending a Learn String is similar to performing a RECALL from the front panel. The difference between the two operations lies in the fact that the learn string contains instrument settings only, whereas the the front panel RECALL also recalls the delay cal factors. The "SETUP?" query sends the Learn String to the controller using the same format as is required by the "SETUP" command so no modifications need be made to the string between the time that it is received from the instrument after the "SETUP?" query and the time that it is sent back with the "SETUP" command.

EXAMPLE: SETUP <Learn String> - Sends a Learn String the the 54100A/D
SETUP? - Queries the 54100A/D for its current front panel setup.

SPOLL
STB
SPOL

query

This query returns the status byte (the lower byte of the status word). See Table 10-1 for a complete description of the status byte. This command is similar in operation to conducting a Serial Poll operation from the controller except that all bits in the byte returned by this query are dynamic in nature and reflect the state of the instrument at the time of the query. Bits in the byte returned by a Serial Poll stay set if the require service message was sent and are cleared after a Serial Poll. This command is provided for use by controllers that have a limited HP-IB control capability. If available, Serial Polling should be used to read the status byte.

EXAMPLE: SPOLL? - Queries the 54100A/D for the status byte

STATUS
STA

query

This query returns the instrument status word. The instrument status word is a 16 bit integer containing information about the instrument conditions that set the ready bit in the status byte and/or generate a Require Service message. See paragraph 10-7 and Tables 10-1 and 10-2 for a complete description of the instrument status word.

EXAMPLE: STATUS?

STOP

command

This command causes the instrument to stop acquiring data for the active waveform display on the CRT. The RUN command must be executed in order to re-start the acquisition of data for the active display.

EXAMPLE: STOP - Stops acquisition of data for the active waveform display.

TEST
TST

command

This command causes the instrument to perform a self-test. This test is the same as is performed when the instrument power is turned on. The Tst bit in the Status Word (bit 13) will go to a 1 when the test is complete.

For service purposes the TEST command also accepts numeric parameters. **These should not be used by persons unfamiliar with the internal test loops as a "locked up" condition of the bus and front panel can occur that can only be corrected by turning the power to the instrument off.**

EXAMPLE: TEST - Starts a powerup self-test.

TRANSFER
TRAN
XFER

command

This command allows the movement of waveform data from one of the internal HP-IB memories to one of the waveform display memories so that it may be viewed on the CRT. The waveform data may have come from a recent DIGITIZE command or sent back to the instrument from a controller with the waveform DATA command (see paragraph 10-17). This command has two parameters. The first is MEMORYn where n = 1 or 2. This specifies the source of the data as HP-IB memory 1 or 2. The second parameter is PLANEn where n = 1 or 2. This specifies the destination of the data as waveform display memory 1 or 2. When this transfer takes place, it is a merging operation that performs a logical OR of the new data from the HP-IB memory with the data that was already in the waveform display memory.

EXAMPLE: TRANSFER MEMORY 1,PLANE 1 - Tells the 54100A/D to transfer the contents of HP-IB memory 1 into waveform storage memory 1.

TRG
GET **command**

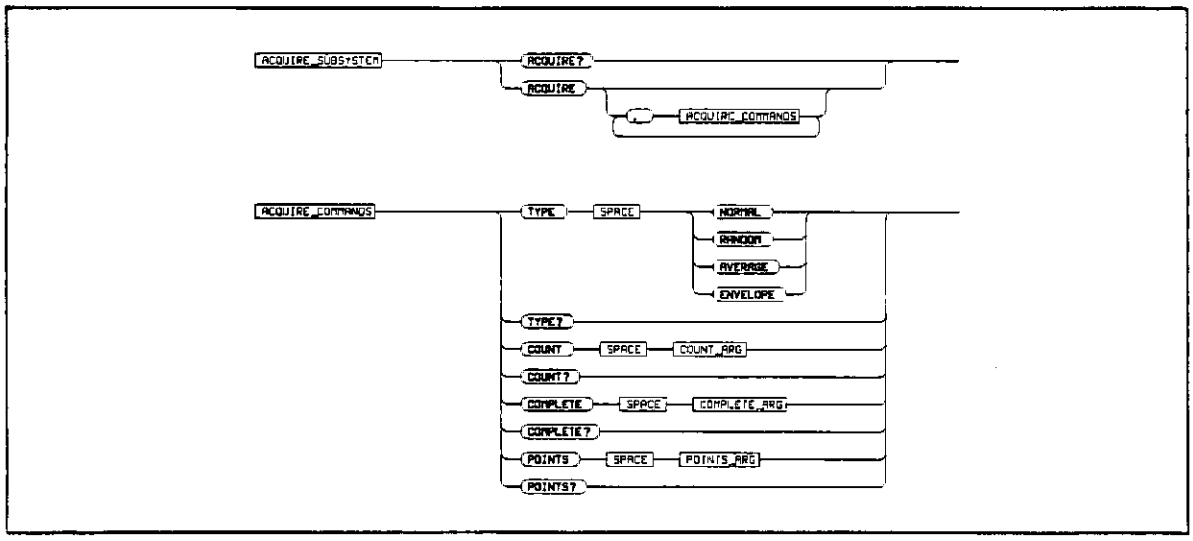
This command performs the same operation as a group execute trigger bus command. Refer to paragraph 9-14 for an explanation of what happens when the group execute trigger message is received. This command is provided for those HP-IB controller with limited bus control capability. The HP-IB <GET> command is the preferred way of sending this command to the 54100A/D.

EXAMPLE: TRG - Tells the 54100A/D to execute a group execute trigger.

VIEW **command**

This command causes the scope to turn on the active channel displays or waveform display memories. The command has one parameter in the form of: CHANNELn, or PLANEn where n = 1 or 2. CHANNELn refers to the active display of one of the input channels PLANEn refers to the waveform memories. This command does not or change the contents of the waveform memories. The converse of this command is "BLANK".

EXAMPLE: VIEW PLANE 1 - Instructs the 54100A/D to turn on the display of waveform memory 1.



COMPLETE_ARG = An integer from 50 to 100, specifying, in percent, the number of buckets that must be filled before acquisition is considered complete

COUNT_ARG = An integer from 1 to 2048 specifying the number of values to average for each point when in averaged, and the number of values to use for each point when constructing the envelope

POINTS_ARG = An integer specifying the number of points to be collected for each waveform record Acceptable values are 128, 256, 512, or 1024.

Figure 10-2. Acquire Subsystem Commands

10-9 THE ACQUIRE SUBSYSTEM

The Acquire subsystem commands are used to setup conditions that are used when a DIGITIZE system command is executed. This subsystem is used to select the type of of data, the number of points desired, the completion criteria, and the number of averages. See Figure 10-2 for the syntax of the Acquire subsystem.

It should be noted that the Acquire subsystem is used for setting up what is the desired outcome of a DIGITIZE command. There is one case (the POINTS command) where what the user asked for may be different from what the instrument actually does. The WAVEFORM subsystem lets the user determine the actual values for the data obtained after a DIGITIZE command.

ACQUIRE
ACQ **command/query**

This command selects the acquisition subsystem. The query (ACQUIRE?) returns the values for all parameters for this subsystem in the following order: (this list assumes that HEADERS and LONGFORM are on and ARGUMENTs are alpha)

ACQUIRE <CR><LF>
TYPE integer <CR><LF>
POINTS integer <CR><LF>
COUNT integer <CR><LF>
COMPLETE integer <CR><LF>

COMPLETE
COMP **command/query**

This command specifies the completion criteria for an acquisition. The single integer parameter corresponds to what percentage of the acquisition buckets specified by the POINTS command must be "full" before the acquisition is considered complete. The parameter has a range of 50 to 100 "Full" has slightly different meanings depending on the TYPE selected. If the type is NORMAL, "full" means that a bucket has a data point in it. If the type is AVERAGED, "full" means that the specified number of data values (the COUNT) has been acquired to compute an average value for that point. If the the type is ENVELOPE, "full" means that the specified number of data values (the COUNT) has been acquired to compute an envelope for that time bucket. If the type is RANDOM, the value specified by the COMPLETE command is not used at all (see TYPE for more information). The query returns the last specified completion criteria.

EXAMPLE: COMPLETE 95 - Tells the 54100A/D to use a 95% completion criteria.
COMPLETE? - Queries the 54100A/D for the completion criteria.

COUNT
COUN **command/query**
CNT

When the acquisition type is AVERAGE, this command specifies the number of values to be averaged at each bucket in time before the acquisition is considered complete for that bucket. When the acquisition type is ENVELOPE, this command specifies the number of values to be used in each bucket when constructing the envelope. This command has no effect if the TYPE is NORMAL or RANDOM. The query returns the last specified count value.

EXAMPLE: COUNT 32 - Tells the 54100A/D to average 32 values per time bucket if the TYPE is AVERAGED or collect 32 values per time bucket to construct an envelope is the TYPE is ENVELOPE.
COUNT? - Queries the 54100A/D for the COUNT

POINTS
POIN
PNTS **command/query**

This command specifies the number of points to be collected for each acquisition record. The command has one parameter and may be specified to be 128, 256, 512, or 1024. There are two cases where the POINTS command has no affect:

* For sweep speeds faster than 2 ns/div, the number of points is based upon the 10ps resolution of the instrument's timebase. This means:

  If (2.0 ns/div) > (time per division) >= (1.0 ns/div) then POINTS = 1000
  If (1 ns/div) > (time per division) >= (500 ps/div) then POINTS = 500
  If (500 ps/div) > (time per division) >= (200 ns/div) then POINTS = 200
  If (200 ps/div) > (time per division) then POINTS >= 100

* If the TYPE is RANDOM, the number of points is based upon the number of complete data records (the points collected on each trigger) that can be gathered such that the number of data points does not exceed 1024. The random sampling nature of the data acquisition hardware is such that the number of points gathered after one trigger varies with time per division and delay. It can also vary by one point from one trigger to the next. This makes it difficult to predict the number of points that will be gathered for any DIGITIZE command when the TYPE is RANDOM. Before the data is read from the instrument with the WAVEFORM DATA? query, the WAVEFORM POINTS? query may be used to determine the actual number of points collected.

The POINTS? query returns the last specified value.

EXAMPLE: POINTS 1024 - Tells the 54100A/D to collect 1024 points
POINTS? - Queries the 54100A/D for the number of points desired.

TYPE **command/query**

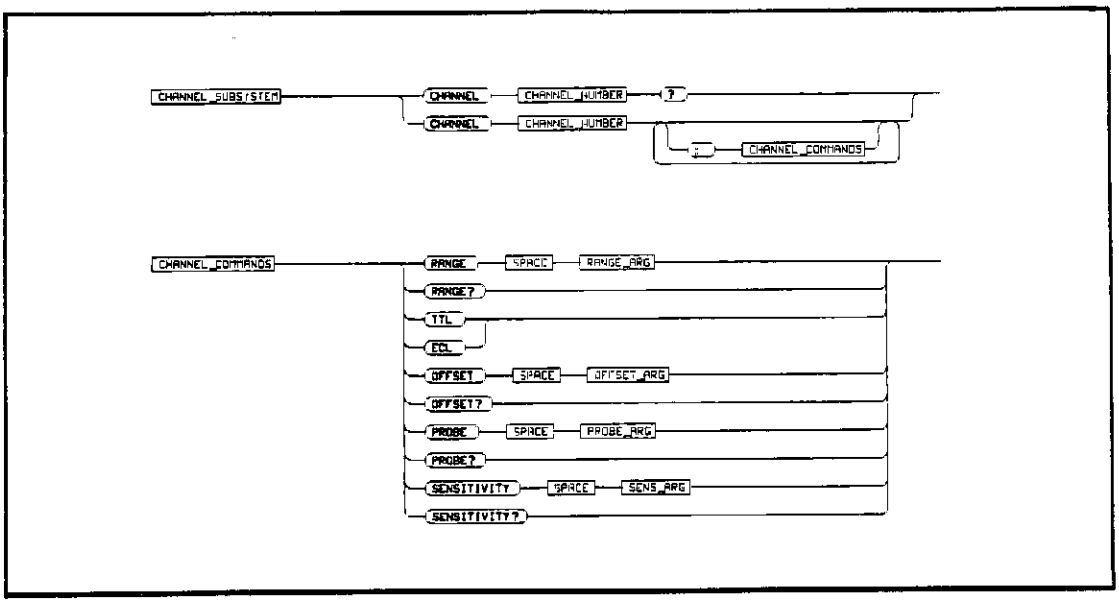
This command lets the user select what type of acquisition is to take place when a DIGITIZE system command is executed. This command has one parameter and may be one of the following:

NORMAL = Last data value to be collected in each acquisition bucket. The data is returned to the controller as a series of voltage values evenly spaced across the screen window.
RANDOM = This mode simulates the way the instrument collects data for display on the screen. The data is returned to the controller as a list of time-voltage pairs.
AVERAGE = The average of the data values collected in each acquisition bucket. The data is returned to the controller as a series of voltage values evenly spaced across the screen window.
ENVELOPE = The max and min value in each acquisition bucket. The data is returned to the controller as two series of voltage values equally spaced across the screen window, the min values first and then the max values.

Switching the TYPE to AVERAGE also switches the front panel Display Mode to Averaged. Switching the TYPE to NORMAL, ENVELOPE, or RANDOM also switches the front panel Display Mode to Normal.

Enumeration: NORMAL = 1
AVERAGE = 2
ENVELOPE = 3
RANDOM = 4

EXAMPLE: TYPE NORMAL - Tells the 54100A/D to collect data in NORMAL mode
TYPE? - Queries the 54100A/D for the acquisition type



CHANNEL_NUMBER = 1 or 2

OFFSET_ARG = A real number representing the voltage at the center of the voltage range smaller than 1.5 times the voltage range.

PROBE_ARG = A real number from 0 to 1000 specifying the probe attenuation with respect to 1.

RANGE_ARG = A real number specifying the size of the acquisition window in volts. Acceptable values are 0.08, 0.16, 0.4, 0.8, 1.6, 4.0 or 8.0.

SENS_ARG = A real number specifying the size of the acquisition window in volts/div. Acceptable values are 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, or 1.0 when the display format is SINGLE. When the display format is DUAL, value should be one of 0.02, 0.04, 0.1, 0.2, 0.4, 1.0, or 2.0.

Figure 10-3. Channel Subsystem Commands

10-10. CHANNEL SUBSYSTEM

This subsystem is used to control one of the two input channels on the 54100A/D. Parameters controlled include the OFFSET and RANGE of the channels as well as control of the probe attenuation factor used in labeling the display on the CRT. See Figure 10-3 for the syntax of the CHANNEL subsystem commands.

CHANNELn
CHANn
CHn **command/query**

This command selects the vertical subsystem with the specified channel number as the recipient for the subsystem commands. The query returns all the parameters for that particular channel in the following order (assuming that HEADERS and LONGFORM are on and ARGUMENTs are alpha):

CHANNELn <CR><LF> (n= 1 or 2) (n is output when HEADERS are off)
PROBE real <CR><LF>
RANGE real <CR><LF>
OFFSET real <CR><LF>
COUPLING DCFIFTY <CR><LF>

EXAMPLE: CHANNEL1 - Selects the Channel subsystem and selects channel 1.
CHANNEL1? - Queries the 54100A/D for the Channel 1 parameters.

ECL **command**

This command presets the vertical range and offset and the trigger level for the selected channel for optimum viewing of ECL signals. Offset and trigger level will be set to -1.30 volts and the range will be set to 1.6 volts.

EXAMPLE: ECL - Sets the selected channel for optimum viewing of ECL signals.

OFFSET
OFFS **command/query**

This command sets the voltage that is represented at center screen for the selected channel. The range of legal values for OFFSET is ± 1.5X RANGE for the selected channel. The query returns the voltage value at center screen for the selected channel.

EXAMPLE: OFFSET 1.0E-3 - Sets the offset to 1 mV
OFFSET? - Queries the 54100A/D for the offset on the selected channel.

PROBE
PROB **command/query**

This command specifies the probe attenuation factor for the selected channel. For example, PROBE 10.0 specifies a 10X attenuation or a 10:1 attenuation factor. The range of legal values for probe attenuation factor is from 1.0 to 1000.0 The query returns the probe attenuation factor for the selected channel.

EXAMPLE: PROBE 10.0 - Sets the probe attenuation factor for the selected channel to 10:1.
PROBE? - Queries the selected channel for its probe attenuation.

RANGE
RANG **command/query**

This command specifies the full scale range for a channel's display. RANGE is a safer way of programming the vertical than SENSITIVITY because it is independent of the DISPLAY FORMAT (SINGLE or DUAL). For example: 1 volt/div would correspond to an 8 volt range if the DISPLAY FORMAT was set to SINGLE but would correspond to a 4 volt range if the display was set to DUAL. RANGE commands take the probe attenuation into account when setting up the instrument so the RANGE value programmed should be the desired range at the probe tip. The single parameter of this command is a real number representing the number of volts full scale that are desired. Legal RANGE values for a 1:1 probe are. 0.08, 0.16, 0.4, 0.8, 1.6, 4.0, and 8.0. For a 10:1 probe, these values are multiplied by 10. The query returns the current range setting.

EXAMPLE: RANGE 8.0 - Sets the full scale range at the probe tip to 8.0 volts on the specified channel.
RANGE? - Queries the 54100A/D for its current vertical range on the specified channel.

TTL **command**

This command presets the vertical range and offset and the trigger level for the selected channel for optimum viewing of TTL signals. Offset and trigger level will be set to 1.60 volts and the range will be set to 8.0 volts.

EXAMPLE: TTL - Sets the selected channel for optimum viewing of TTL signals.

SENSITIVITY
SENS **command/query**

This command, like RANGE, specifies the full scale range for a channel's display. Since the DISPLAY FORMAT changes the number of divisions on screen, the SENSITIVITY command does not explicitly specify the vertical range by itself. RANGE is a safer way of programming the vertical than SENSITIVITY because it is independent of the DISPLAY FORMAT (SINGLE or DUAL). For example: 1 volt/div would correspond to an 8 volt range if the DISPLAY FORMAT was set to SINGLE but would correspond to a 4 volt range if the display was set to DUAL. SENSITIVITY commands take the probe attenuation into account when setting up the instrument so the SENSITIVITY value programmed should be the desired sensitivity at the probe tip. The single parameter of this command is a real number representing the number of volts per division that are desired. Legal SENSITIVITY values for a 1:1 probe and DISPLAY FORMAT SINGLE are: 0.010 0.020, 0.050, 0.100, 0.200, 0.500, and 1.000. For a 10:1 probe, these values are multiplied by 10. The query returns the current sensitivity setting.

EXAMPLE: SENSITIVITY 1.0 - Sets the sensitivity at the probe tip to 1 v/div on the specified channel.
SENSITIVITY? - Queries the 54100A/D for its current vertical sensitivity on the specified channel.

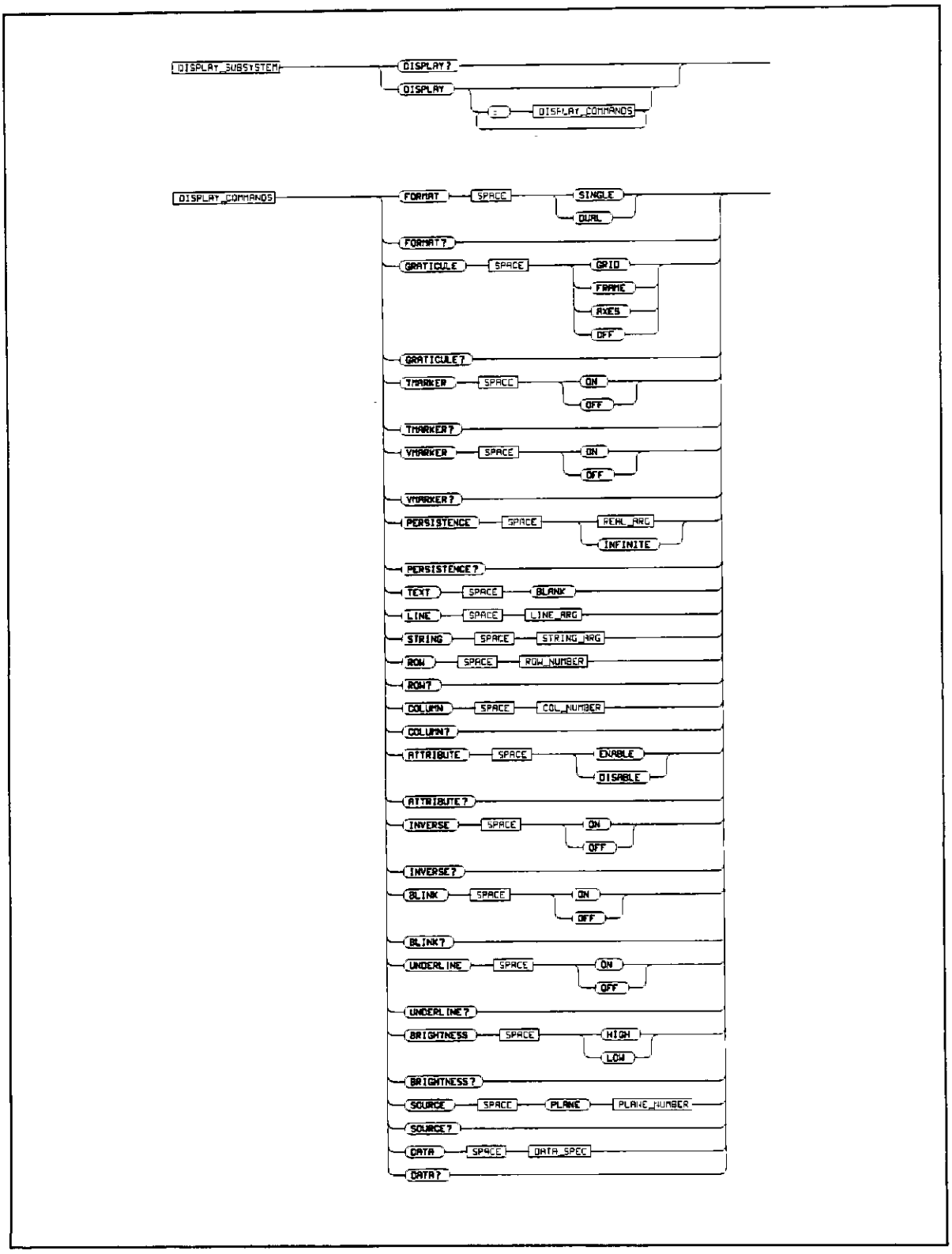


Figure 10-4. Display Subsystem Commands

DATA_SPEC = A block of data in EA format as defined in IEEE Std 728-1982

PLANE_NUMBER = An integer from 0 to 2

REAL_ARG = A real number from 0.2 to 10.0 in steps of 0.1

COL_NUMBER = An integer from 0 to 63.

LINE_ARG = Any quoted string.

ROW_NUMBER = An integer from 0 to 22

STRING_ARG = Any quoted string.

Figure 10-4. Display Subsystem Commands (continued)

10-11. DISPLAY SUBSYSTEM

The Display subsystem is used to control the display of data, markers, text and graticules on the 54100A/D CRT. See Figure 10-4 for the syntax of the Display subsystem commands.

DISPLAY
DISP

This command selects the display subsystem as the recipient for the subsystem commands. The query returns all the parameters for this subsystem in the following order (assuming that HEADERS and LONGFORM are on and ARGUMENTs are alpha):

DISPLAY <CR><LF>
FORMAT enumerated type <CR><LF>
GRATICULE enumerated type <CR><LF>
ROW integer <CR><LF>
COLUMN integer <CR><LF>
ATTRIBUTE enumerated type <CR><LF>
INVERSE enumerated type <CR><LF>
BLINK enumerated type <CR><LF>
UNDERLINE enumerated type <CR><LF>
BRIGHTNESS enumerated type <CR><LF>
VMARKERS enumerated type <CR><LF>
TMARKERS enumerated type <CR><LF>
PERSISTENCE real <CR><LF>

EXAMPLE: DISPLAY - Selects the DISPLAY subsystem.
DISPLAY? - Queries the 54100A/D for the Display subsystem parameters.

ATTRIBUTE
ATTR **command/query**

This command is used to control whether or not attributes embedded in strings sent with the LINE or STRING commands will be used to override previous attribute commands. Attributes are qualities that each of the characters displayed on the 54100A/D CRT have. The 54100A/D implements any combination of BLINK, INVERSE video, UNDERLINE and half-BRIGHTNESS as character attributes. A list of attribute characters can be found in Figure 10-11. The query returns the enable/disable state this command.

Enumeration: DISABLE = 0
ENABLE =1

EXAMPLE: ATTRIBUTE ENABLE - Specifies that attributes embedded in strings sent with the LINE or STRING commands will be used to override previous attribute controls.
ATTRIBUTE? - Queries the 54100A/D for the enable/disable state of this command.

BLINK
BLIN **command/query**

This command specifies whether or not subsequent characters sent with the LINE or STRING commands are to be written with the BLINK attribute On. The query returns the On/Off state of the BLINK attribute.

Enumeration: OFF = 0
ON = 1

EXAMPLE: BLINK ON - Specifies that subsequent characters are to be written with the BLINK attribute on.
BLINK? - Queries the 54100A/D for the current on/off state of the BLINK attribute

---

BRIGHTNESS
BRIG **command/query**

This command specifies whether or not subsequent characters sent with the LINE or STRING commands are to be written with the BRIGHTNESS attribute set to LOW or HIGH. LOW brightness refers to a half-bright character where HIGH brightness refers to a full-bright character. The query returns the HIGH/LOW state of the BRIGHTNESS attribute.

Enumeration: LOW = 0
HIGH = 1

EXAMPLE: BRIGHTNESS HIGH - Specifies that subsequent characters are to be written with the BRIGHTNESS attribute set to full-bright.
BRIGHTNESS? - Queries the 54100A/D for the current HIGH/LOW state of the BRIGHTNESS attribute.

COLUMN
COL **command/query**

This command specifies the starting column number on the CRT for subsequent STRING or LINE commands. This column number remains in effect until another COLUMN command is received. The single parameter of this command is an integer from 0 to 62 inclusive. The query returns the column that the next LINE or STRING will start writing in.

EXAMPLE: COLUMN 12 - Specifies that subsequent LINE or STRING commands will start writing text in column 12.
COLUMN? - Queries the 54100A/D for the current column number.

DATA **command/query**

The DATA? query instructs the 54100A/D to send a binary block of data representing the data in one of the three pixel planes to the controller. The pixel plane desired is specified by the DISPLAY SOURCE command. This data is in the form of 16032 bytes preceded with four header bytes. The header consists of:

<#> (decimal 35)
<A> (decimal 65)
(decimal 62)
(decimal 160)

The third and fourth bytes make up a 16-bit integer whose value is decimal 16032, or the length of the binary block. This binary format complies with the "#A" Block Data Field in IEEE 728-1982.

Each bit in this binary block represents one pixel on screen. Since there are 256 pixels in each column of the data display, it takes 32 bytes (256/8) to represent one column of the display. 32 bytes * 501 columns = 16032 bytes for the entire data array. The most significant bit (bit 7) of the first byte is the pixel in the upper left corner of the data display. Bit 6 is the second pixel in the first column and so on through to bit 0 of the 32nd byte being the bottom pixel of the first column. Bit 7 of the 33rd byte is the uppermost pixel of the second column and so on through the entire pixel array.

The DATA command returns a pixel block to a plane specified by the same SOURCE command as the DATA? query uses.

EXAMPLE: DATA binary block - Sends a block of pixel data to a plane specified by the DISPLAY SOURCE command.
DATA? - Queries the 54100A/D for a block of pixel data from a plane specified by the DISPLAY SOURCE command.

FORMAT
FORM command/query

This command specifies the number of waveform display areas to be set up on screen and functions like the Split Screen On/Off control in the front panel Display menu. FORMAT 1 shuts Split Screen Off while Format 2 turns Split Screen On. When Split Screen is Off, each channel's full scale range is divided into 8 divisions. When Split Screen is ON, each channel's full scale range is divided into 4 divisions. The query returns the current number of display areas on screen.

Enumeration: SINGLE = 1
DUAL = 2

EXAMPLE: FORMAT 2 - Specifies Split Screen On (2 display areas on screen)
FORMAT? - Queries the 54100A/D for the number of display areas on screen.

GRATICULE
GRAT command/query

This command specifies the type of graticule to be used in the waveform display area(s). The query returns the current graticule selection.

enumeration: off = 0
grid = 1
axes = 2
frame = 3

EXAMPLE: GRATICULE GRID - Selects a grid type graticule (8x10 in FORMAT 1)
GRATICULE? - Queries the 54100A/D for the current graticule selection.

INVERSE
INV command/query

This command specifies whether or not subsequent characters sent with the LINE or STRING commands are to be written with the INVERSE-video attribute On. The query returns the On/Off state of the INVERSE attribute.

Enumeration: off = 0
on = 1

EXAMPLE: INVERSE ON - Specifies that subsequent characters are to be written with the INVERSE attribute on.
INVERSE? - Queries the 54100A/D for the current on/off state of the INVERSE attribute.

LINE command/query

This command causes the string parameter to be written to the screen, starting at the location determined by the ROW and COLUMN commands. Text may be written up to column 54. If the string is shorter than the remaining space on the current line, the line is blanked from the end of the text up to and including column 54. If the line is longer than the remaining space on the current line, the extra part of the string is discarded. In any case, ROW is incremented by one and COLUMN remains unchanged so the next LINE command will write on the next line in the display. After writing line 21 (the last line in the display area), the ROW gets set back to 2. The LINE? query reads from the current ROW and COLUMN location up to and including column 54 and increments the ROW by one. The LINE command and query only works on rows 2 thru 21.

EXAMPLE: LINE "Hi Mom!!" - Writes "Hi Mom!!" on the CRT at the location determined by the ROW and COLUMN commands and increments the ROW by one.
LINE? - Queries the screen for a line of text starting in the location defined by the ROW and COLUMN commands and increments the ROW by one.

PERSISTENCE
PERS command/query

This command sets the Persistence for the CRT display in the Normal display mode. The display mode is switched to Normal when the ACQUIRE TYPE is NORMAL, ENVELOPE, or RANDOM. The parameter for this command may be a real number from 0.2 to 10.0 representing the persistence in seconds or the keyword INFINITE. Values greater than 10.0 will also set the PERSISTENCE to Infinite. The query returns the current persistence value.

EXAMPLE: PERSISTENCE 1.0 - Sets the persistence in the normal mode to 1 second.
PERSISTENCE? - Queries the 54100A/D for the current persistence value.

ROW command/query

This command specifies the starting row number on the CRT for subsequent STRING or LINE commands. This row number remains in effect until another ROW command is received or it is incremented by a LINE command. The single parameter of this command is an integer from 0 to 22 inclusive. The query returns the row that the next LINE or STRING will start writing in.

EXAMPLE: ROW 12 - Specifies that subsequent LINE or STRING commands will start writing text on row 12.
ROW? - Queries the 54100A/D for the current row number.

SOURCE
SOUR
SRC command/query

This command specifies the source or destination for the DISPLAY DATA? and DISPLAY DATA query and command. The command has one parameter in the form of PLANEn where n = 0, 1, 2 or 3. PLANE 0 is the active display, PLANE 1 is waveform memory 1, and PLANE 2 is waveform memory 2. The query returns the currently specified SOURCE. PLANE 3 is graticule plus any wave display memories (PLANE 1 or 2) that are on. This is Good for getting combined data output.

EXAMPLE: SOURCE PLANE1 - Specifies that the source or destination for the the DATA? query or DATA command is to be waveform memory 1.
SOURCE? - Queries the 54100A/D for the currently specified source.

STRING
STR command/query

This command causes the string parameter to be written to the screen, starting at the location determined by the ROW and COLUMN commands. Text may be written up to column 63. If the line is longer than the remaining space on the current line, the extra part of the string is discarded. The STRING? query reads from the current ROW and COLUMN location up to and including column 63.

EXAMPLE: STRING "Go Away!!" - Writes "Go Away!!" on the CRT at the location determined by the ROW and COLUMN commands.
STRING? - Queries the screen for a line of text starting in the location defined by he ROW and COLUMN commands.

TEXT command

This command allows the user to blank the user text area. The user text area is rows 2 through 17, columns 0 through 54 and rows 18 thru 21, columns 0 thru 63. In the 54100A/D, this command has only one parameter, BLANK or 2.

EXAMPLE: TEXT BLANK - Tells the 54100A/D to blank the user text area.

TMARKER
TMAR command/query

This command turns the Time markers on. It does not affect their position. The query returns their on/off state.

Enumeration: OFF = 0
ON = 1

EXAMPLE: TMARKER ON - Tells the 54100A/D to turn the time markers on.
TMARKER? - Queries the 54100A/D for the time marker on/off state.

UNDERLINE
UND command/query

This command specifies whether or not subsequent characters sent with the LINE or STRING commands are to be written with the UNDERLINE attribute On. The query returns the On/Off state of the UNDERLINE attribute.

Enumeration: OFF = 0
ON = 1

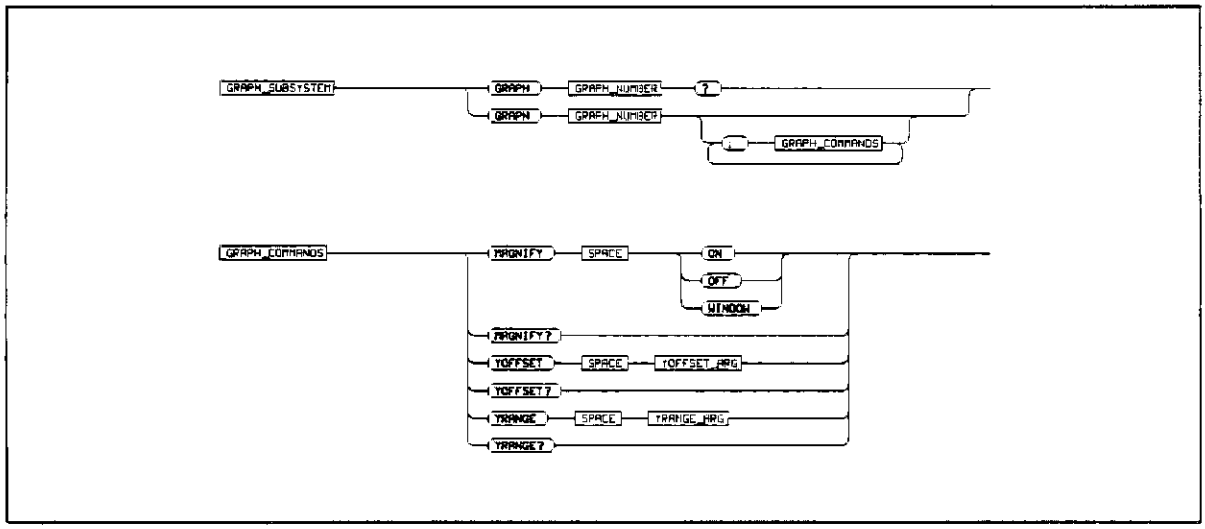
EXAMPLE: UNDERLINE ON - Specifies that subsequent characters are to be written with the UNDERLINE attribute on.
UNDERLINE? - Queries the 54100A/D for the current on/off state of the UNDERLINE attribute.

VMARKER
VMAR command/query

This command turns the Voltage markers on. It does not affect their position. The query returns their on/off state.

Enumeration: OFF = 0
ON = 1

EXAMPLE: VMARKER ON - Tells the 54100A/D to turn the voltage markers on.
VMARKER? - Queries the 54100A/D for the voltage marker on/off state.



YOFFSET_ARG = A real number less than or equal to the vertical range.

YRANGE_ARG = A real number between 1/16 (vertical range) and the veritcal range.

Figure 10-5. Graph Subsystem Commands

10-12. GRAPH SUBSYSTEM

The Graph subsystem is used to control the vertical magnifiers on one of the two input channels on the 54100A/D. Parameters controlled include the YOFFSET and YRANGE of the magnified display as well as control of the magnifier on/off state. See Figure 10-5 for the syntax of the GRAPH subsystem commands.

GRAPH
GRAP command/query

This command selects the graph subsystem with the specified graph number as the recipient for the subsystem commands. Graph1 refers to the display for Channel 1 and Graph2 refers to the display for Channel 2. The query returns all the parameters for this subsystem in the following order (assuming that HEADERS and LONGFORM are on and ARGUMENTs are alpha):

GRAPHn <CR><LF> (n=1 or 2) (n is output when HEADERS are off)
MAGNIFY enumerated type <CR><LF>
YOFFSET real <CR><LF>
YRANGE real <CR><LF>

EXAMPLE: GRAPH1 - Selects the Graph subsystem and selects Graph 1.
GRAPH1? - Queries the 54100A/D for the Graph1 parameters.

MAGNIFY
MAGN command/query

This command controls the magnifier for the specified channel. The command has one parameter: OFF, ON, or WINDOW. OFF specifies that the graph is to be displayed in unmagnified form. ON specifies that the graph is to be displayed in magnified form. WINDOW specifies the the graph is to be displayed in unmagnified form with the magnifier window displayed.

Enumeration: OFF = 0
ON = 1
WINDOW = 2

EXAMPLE: MAGNIFY ON - Tells the 54100A/D to display the specified graph in magnified form.
MAGNIFY? - Queries the 54100A/D for the current state of MAGNIFY.

YOFFSET
YOF command/query

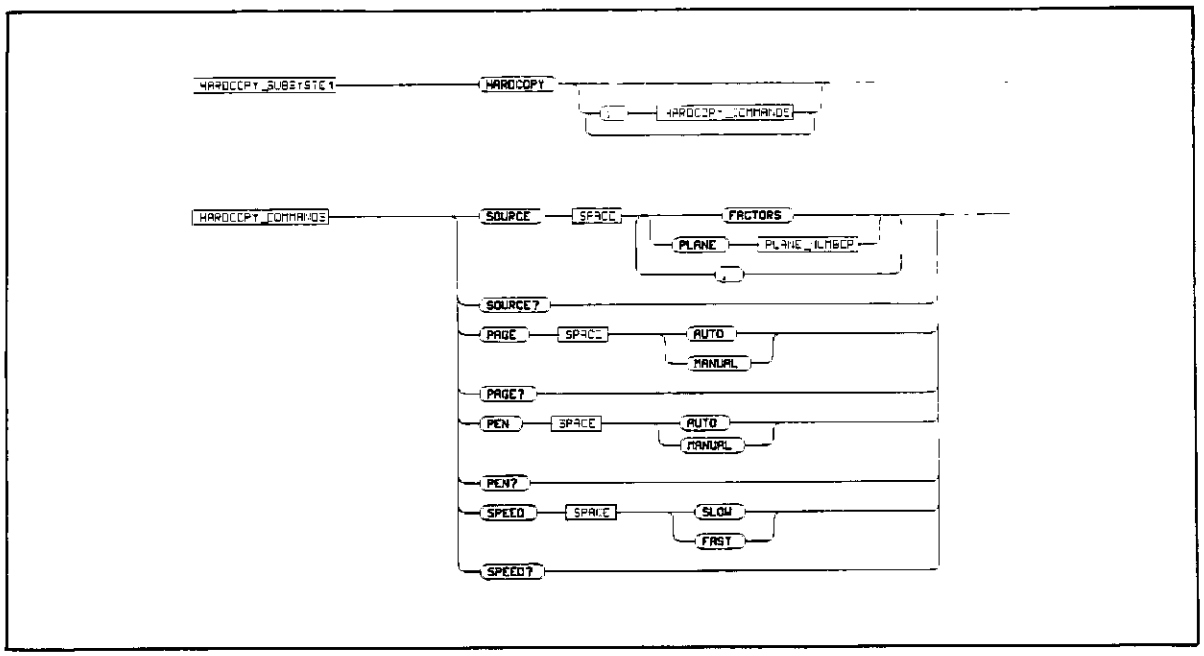
This command controls the voltage at the center of the magnification window. This voltage must be within the vertical range that is setup with the CHANNELn RANGE and OFFSET commands. The query returns the current value.

EXAMPLE: YOFFSET 1.2 - Specifies the voltage at the center of the magnification window to be 1.2 volts.
YOFFSET? - Queries the 54100A/D for the current value of the YOFFSET.

YRANGE
YRAN command/query

This command controls the size of the magnification window in volts. The combination of this command and the YOFFSET command must specify a window that is completely enclosed by the vertical range that is setup with the CHANNELn RANGE and OFFSET commands. The query returns the current value.

EXAMPLE: YRANGE 2.2 - Specifies a magnification window 2.2 volts in amplitude centered at the YOFFSET voltage.
YRANGE? - Queries the 54100A/D for the current value of YRANGE.



PLANE_NUMBER = An integer from 0 to 2

Figure 10-6. Hardcopy Subsystem Commands

10-13. HARDCOPY COMMANDS

The hardcopy commands set various parameters used during printing or plotting waveforms from the 54100A/D. Refer to figure 10-6 for the syntax of these commands.

HARDCOPY
HARD command/query

The HARDCOPY command selects the hardcopy subsystem. The hardcopy query returns the hardcopy subsystem parameters in the following form (assuming that LONGFORM and HEADER are on and ARGUMENT is ALPHA):

HARDCOPY <CR><LF>
PAGE enumerated type <CR><LF>
PEN enumerated type <CR><LF>
SPEED enumerated type <CR><LF>

PAGE command/query

The page command enables or disables sending a form feed after a hardcopy dump to the printer. This allows multiple dumps per page or only one dump per page at the user's discretion. Note that during the actual dump, the 54100A/D ignores page boundaries. The query returns the current value of the page parameter.

Enumeration: MANUAL = 0
AUTOMATIC = 1

EXAMPLE: PAGE AUTO - Instructs the 54100A/D to do a form feed after any printer dump.
PAGE? - Returns the currently selected paging method.

PEN command/query

The pen command enables or disables the 54100A/D pen control function. When enabled with the AUTO parameter, the instrument instructs the plotter to plot the graticule and scale factors using pen 1, the active display using pen 2, waveform memory 1 using pen 3, and waveform memory 2 using pen 4. When disabled with the MANUAL parameter, the plotter will not be instructed to select a pen, but pens will still be put away after a plot. The query returns the current state of the pen control parameter.

Enumeration: MANUAL = 0
AUTOMATIC = 1

EXAMPLE: PEN AUTO - Instructs the 54100A/D to send pen selection commands to the plotter during a plotter dump.
PEN? - Returns the current pen selection mode.

SOURCE
SOUR
SRC command

THE SOURCE command specifies the source(s) to be output during the hardcopy dump.

Enumeration: PLANE0 = 0
PLANE1 = 1
PLANE2 = 2
FACTORS = 4

EXAMPLE: SOURCE FACTORS, PLANE1, PLANE2 - Specifies that a hardcopy dump is to output both memory planes and the scale factors. The graticule is output when any PLANE is selected (on).

SPEED
SPE command/query

The speed command specifies the pen speed to be used during plotting. FAST is intended for use on normal paper, while SLOW is intended for use with transparencies. The query returns the currently selected pen speed.

Enumeration: SLOW = 0 (10 cm/second)
FAST = 1 (25 cm/second)

EXAMPLE: SPEED SLOW - Specifies that any plotter dump is to take place at a slower speed suitable for making transparencies.
SPEED? - Returns the current pen speed selection.

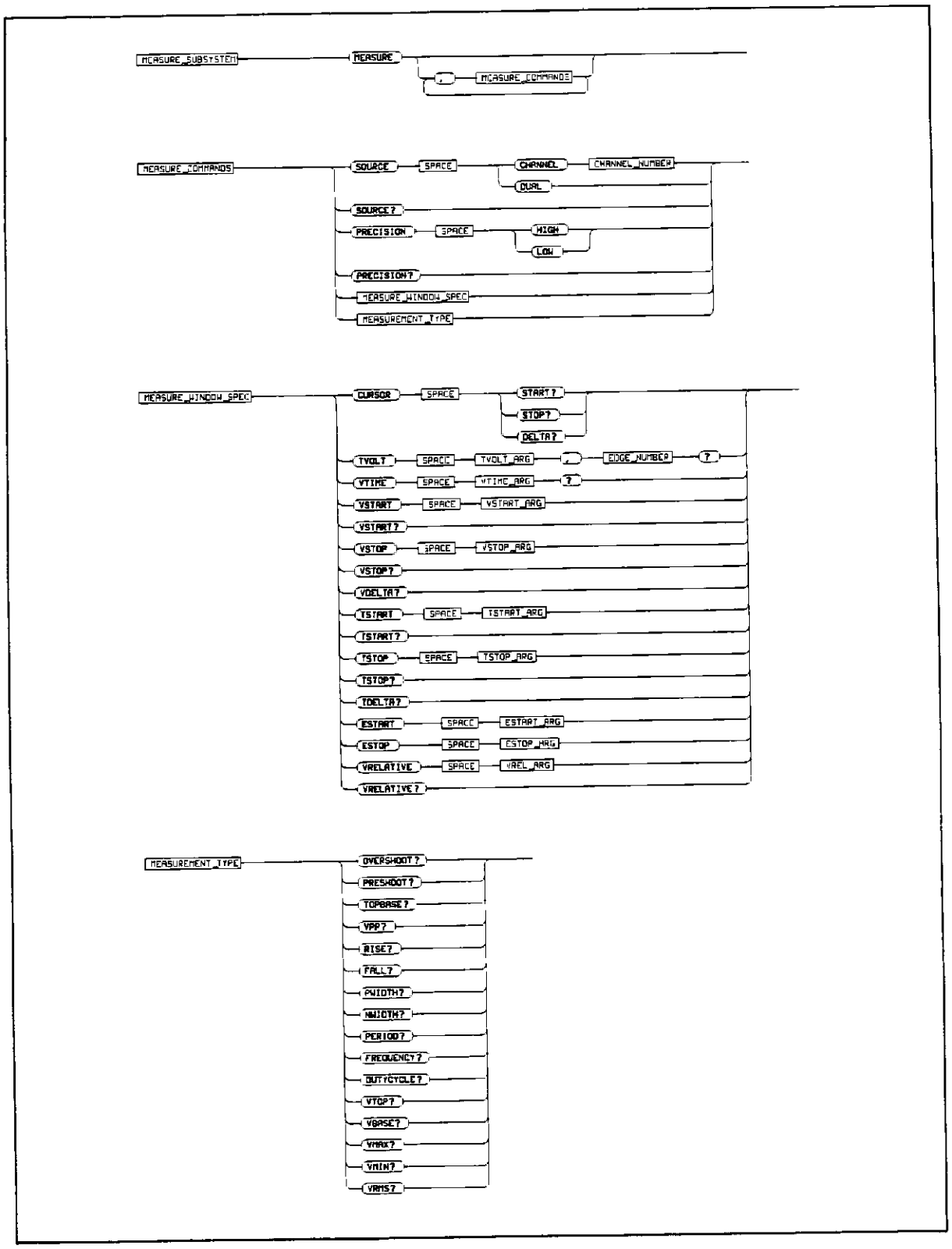


Figure 10-7. Measurement Subsystem Commands

CHANNEL_NUMBER = An integer, 1 or 2.

EDGE_NUMBER = An integer from 1 to 100.

VTIME_ARG = A real number that is within the horizontal screen window.

VSTART_ARG = A real number ≤ 2 × voltage range

VSTOP_ARG = A real number ≤ 2 × voltage range

TSTART_ARG = A real number with the following restrictions
The maximum value is 60,000 × timebase range or 1.6 sec, whichever is greater.
If the delay reference is left
then the minimum value is 200 ms or −(timebase range), whichever is smaller.
Else if the delay reference is center
then the minimum value is −5 (timebase range) or −200 ms + 5 (timebase range), whichever is smaller.
Else if the delay reference is right
then the minimum value is 0 or −200 ms + 10 (timebase range), whichever is smaller

TSTOP_ARG = A real number with the same restrictions as **tstart_ARG**.

ESTART_ARG = An integer between 0 and 100 preceded by a mandatory sign.

ESTOP_ARG = An integer between 0 and 100 preceded by a mandatory sign.

VREL_ARG = An integer chosen from 0, 10, 20, 50.

Figure 10-7. Measurement Subsystem Commands (continued)

10-14. MEASURE COMMANDS

The measurement commands enable the user to make the standard pulse parameter and voltage measurements or custom measurements using the markers. Pulse parameter measurements are made on the leftmost portion of the screen window. If not enough of the signal is on screen for the measurement to be made, 1E38 is returned as the answer. Measurements are made based on the previously specified PRECISION. If COARSE is specified, no expansion is done, while if PRECISE is specified, an attempt is made to make the measurement as precisely as possible by expanding the waveform. This can markedly slow down measurement throughput. All predefined pulse parameter measurements first do a TOPBASE of the screen window to determine the 10, 50, and 90 percent levels which are then used to make the measurement.

Refer to figure 10-7 for syntax diagrams of these commands.

MEASURE
MEAS command/query

The MEASURE command selects the measure subsystem. The query returns selected measurement parameters in the following format (assuming that LONGFORM and HEADER are ON and ARGUMENT is ALPHA):

MEASURE <CR><LF>
SOURCE enumerated type <CR><LF>
PRECISION enumerated type <CR><LF>
VDELTA real <CR><LF>
VSTART real <CR><LF>
VSTOP real <CR><LF>
TDELTA real <CR><LF>
TSTART real <CR><LF>
TSTOP real <CR><LF>

ALL query

This query makes as many measurements as possible on the signal within the screen window and buffers the answers, separated by carriage returns and line feeds, in the following manner (assuming that HEADER and LONGFORM are on and that ARGUMENT is ALPHA):

FREQUENCY real <CR><LF>
PERIOD real <CR><LF>
PWIDTH real <CR><LF>
NWIDTH real <CR><LF>
RISE real <CR><LF>
FALL real <CR><LF>
TOPBASE real <CR><LF>
VPP real <CR><LF>
PRESHOOT real <CR><LF>
OVERSHOOT real <CR><LF>
DUTYCYCLE real <CR><LF>
VRMS real <CR><LF>
VMAX real <CR><LF>
VMIN real <CR><LF>
VTOP real <CR><LF>
VBASE real <CR><LF>

If a measurement cannot be made, the answer is 1.00000 E + 38.

CURSOR
CURS query

This query returns the time and voltage values of the specified marker as an ordered pair of time/voltage values with the values separated by comma. If the START is specified, the positions of voltage marker 1 and the start marker are returned by the 54100A/D. If STOP is specified, the positions of voltage marker 2 and the stop marker are returned. If DELTA is specified, the instrument returns the value of delta V and delta T.

Enumeration: DELTA = 0
START = 1
STOP = 2

EXAMPLE: CURSOR 1? - This query returns the marker 1 voltage value and the start marker time value. separated by a comma.

DUTYCYCLE
DUTY query

This query causes the instrument to measure the period and positive pulse width of the selected source at the 50% level and to compute the duty cycle as

duty cycle = (+ pulse width / period) X 100

EXAMPLE: DUTYCYCLE? - This query returns the duty cycle of the previously specified source.

ESTART command

This command causes the instrument to position the start marker on the specified edge and slope at the voltage level corresponding to voltage marker 1. Voltage marker 1 is positioned with the VSTART and SOURCE commands in this subsystem.

EXAMPLE: ESTART +3 - This command moves the start marker to the third positive transition through voltage marker 1.

ESTOP command

This command causes the instrument to position the stop cursor on the specified edge and slope at the voltage level corresponding to voltage marker 2.

EXAMPLE: ESTOP -2 - This command moves the stop marker to the second negative transition through marker 2 of the previously specified source

---

FALL query

This query causes the instrument to measure the fall time of the first falling edge whose 10% and 90% points are on screen using the formula.

fall time = time at 10% point - time at 90% point

EXAMPLE: FALL? - This query returns the fall time of the previously specified source

---

FREQUENCY
FREQ query

This query causes the instrument to measure the frequency of the first complete period on screen using the 50% levels. The algorithm used is:

```
if first edge on screen is rising
    then
      frequency = 1 / (time at second rising edge - time at first rising edge)
    else
      frequency = 1 / (time at second falling edge - time at first falling edge)
```

EXAMPLE: FREQUENCY? - This query returns the frequency of the previously selected source.

NWIDTH
NWID query

This query causes the instrument to measure the negative pulse width of the first negative pulse on screen using the 50% levels. The algorithm used is:

```
if first edge on screen is rising
  then
    width = time at second rising edge -
            time at first falling edge
  else
    width = time at first rising edge -
            time at first falling edge
```

EXAMPLE: NWIDTH? - This query returns the negative pulse width of the previously selected source.

OVERSHOOT
OVER query

This query causes the instrument to measure the overshoot of the selected signal. Overshoot is defined based on the first edge on screen using the following algorithm:

```
if the first edge on screen is rising
  then
    overshoot = Vmax - Vtop
  else
    overshoot = Vbase - Vmin
```

EXAMPLE: OVERSHOOT? - This query returns the overshoot of the previously specified source

PERIOD
PER query

This query causes the instrument to measure the period of the first complete cycle on screen using the 50% levels. The algorithm used is:

```
if first edge at screen is rising
  then
    period = time at second rising edge -
             time at first rising edge
  else
    period = time at second falling edge -
             time at first falling edge
```

EXAMPLE: PERIOD? - This query returns the period of the previously specified source

---

PRECISION
PREC command/query

This command specifies the precision to be used to make subsequent measurements. When the precision is set to HIGH, any edges needed for a measurement are determined by making the timebase range smaller and smaller until either the edge has a slope of approximately 45 degrees, or the limit of the horizontal system has been reached. When the precision is set to LOW, no horizontal expansion is done. LOW precision allows the user to achieve higher measurement speed at the expense of accuracy.

Enumeration: LOW = 0
HIGH = 1

EXAMPLE: PRECISION HIGH - This command specifies that all future measurements will be made to the highest possible precision.

PRECISION? - This query returns the previously specified measurement precision.

PRESHOOT
PRES query

This query causes the instrument to measure the preshoot of the selected graph. Preshoot is defined based on the first edge on screen using the following algorithm:

```
if the first edge on screen is rising
  then
    preshoot = vbase - vmin
  else
    preshoot = vmax - vtop
```

EXAMPLE: PRESHOOT? - This query returns the preshoot of the previously specified channel.

PWIDTH
PWID query

This query causes the instrument to measure the positive pulse width of the first positive pulse on screen using the 50% levels. The algorithm used is:

```
if first edge on screen is falling
  then
    width = time at second falling edge -
            time at first rising edge
  else
    width = time at first falling edge -
            time at first rising edge
```

EXAMPLE: PWIDTH? - This query returns the positive pulse width of the previously selected source.

RISE query

This query causes the instrument to measure the rise time of the first rising edge whose 10% and 90% points are on screen using the formula

rise time = time at 90% point - time at 10% point

EXAMPLE: RISE? - This query returns the rise time of the previously selected source.

SOURCE
SOUR
SRC command/query

This command selects the source(s) to be used for subsequent measurements. If a source is specified of the form CHANNELn where n = 1 or 2, then that channel will be used as the source for subsequent measurements and marker commands. If DUAL is specified as the SOURCE, the pulse parameter measurements will be made using the last source specification of the form CHANNELn, n = 1 or 2, while the marker measurement commands will be executed with voltage marker 1 assigned to channel 1 and voltage marker 2 assigned to channel 2. Marker measurement commands that work in DUAL are: ESTART, ESTOP, TSTART, TSTOP, TDELTA, VSTART, VSTOP and VDELTA.

Enumeration: DUAL= 0
CHANNEL1 = 1
CHANNEL2 = 2

EXAMPLE: SOURCE CHANNEL1 - This command specifies that subsequent measurements and marker commands are to refer to channel 1
SOURCE? - This query returns the current measurement source(s).

TOPBASE
TOPB **query**

This query returns the signal amplitude using the formula:

amplitude = Vtop - Vbase.

Vtop and Vbase are found using a histogramming technique. First a waveform record is collected. The absolute top and bottom data values are determined and a histogram of the voltage values is done. Finally the waveform record is scanned from the 60% point to the top and from the 40% point to the bottom to find the voltage values with the largest number of data points. If the maximum number of data points is greater than the limit criteria (roughly 5% of the maximum number of points in the record) then that voltage value is used for the top or base; otherwise the absolute top or bottom is used.

EXAMPLE: TOPBASE? - This query returns the top-base voltage of the current measurement source.

TDELTA
TDEL **query**

This command returns the time difference between the start and stop time markers. In other words,

Tdelta = Tstop - Tstart

Where Tstart is the time at the start marker and Tstop is the time at the stop marker.

EXAMPLE: TDELTA? - This query returns the difference between the stop and start time markers

---

TSTART
TSTA **command/query**

This command moves the start marker to the specified time. The query returns the start marker position.

EXAMPLE: TSTART 1.0E-6 - This command sets the start marker to 1 microsecond past the trigger point.
TSTART? - This query returns the current start marker position.

TSTOP
TSTO **command/query**

This command moves the stop marker to the specified time. The query returns the stop marker position.

EXAMPLE: TSTOP 2.0E-6 - This command sets the stop marker to 2 microseconds past the trigger point.
TSTOP? - This query returns the current stop marker position.

TVOLT
TVOL query

This query returns the time at a voltage. The voltage is specified as a level (real number), type of transition (+ for rising, - for falling), and a transition number. If the specified crossing is not within the screen window, 1,00000 E + 38 will be returned.

EXAMPLE: TVOLT 1.0,+3? - This query returns the time of the third positive transition through a 1 volt level of the previously selected source.

VBASE
VBAS query

This query returns Vbase. Vbase is calculated by performing a histogram of the waveform data and looking for the voltage value below (Vmin + .4X Vpp) hit by the most data points. If the maximum number of hits is less than roughly 5% of the macimum number of points in the waveform data record, the absolute minimum is returned instead.

EXAMPLE: VBASE? - This query returns the voltage at the base of the waveform from the current measurement source.

VDELTA
VDEL query

This command returns the voltage difference between voltage marker 1 and marker 2. In other words,

Vdelta = Marker2 - Marker1

Where Marker1 is the voltage at marker 1 and Marker2 is the voltage at marker 2.

EXAMPLE: VDELTA? - This query returns the voltage difference between marker 1 and marker 2.

VMAX query

This query returns the absolute maximum voltage present in the selected source.

EXAMPLE: VMAX? - This query returns the absolute maximum voltage of the current measurement source.

VMIN query

This query returns the absolute minimum voltage present in the selected source.

EXAMPLE: VMIN? - This query returns the absolute minimum voltage of the current measurement source.

VPP **query**

This query returns the peak-to-peak voltage computed using the formula:

$$Vpp = Vmax - Vmin$$

Where Vmax and Vmin are the absolute maximum and minimum voltages present in the selected source.

EXAMPLE: VPP? - This query returns the peak-to-peak voltage of the current measurement source.

VRELATIVE
VREL **command/query**

This command moves the voltage markers to the position that they were last set to, either manually, after the VSTART or VSTOP commands, or after a TOPBASE operation. The VRELATIVE command takes the starting positions, calls them the 0% (voltage marker 1) and 100% (voltage marker 2) points, and moves the markers to levels corresponding to the specified percentage. For example, after a TOPBASE, the 0% point would be the base of the waveform and the 100% point would be the top of the waveform. VREL 10 would move marker 1 to a point corresponding to the 10% voltage of the waveform and marker 2 to a point corresponding to the 90% voltage of the waveform. VREL 20 would move the markers to the 20% and 80% points, VREL 50 moves both markets to the 50% point. VREL 100 moves the markers to the original starting points. The query returns the current relative position of the markers i.e. either 10, 20, 50, or 100.

EXAMPLE: VRELATIVE 20 - This command specifies that the voltage markers are to be positioned at 20% and 80% points based upon the original 0% and 100% values of the voltage markers.
VRELATIVE? - This query returns the current marker positions.

VRMS **query**

This query returns the RMS voltage of the selected graph. The RMS voltage is computed over one complete period using the formula

Where there are n time buckets in 1 period and Vj is the voltage at bucket j of the period data. Since it is rare for a period to fall precisely within an integral number of time buckets, the algorithm rounds to the nearest time bucket at the beginning and end and uses these as the limits.

EXAMPLE: VRMS? - This query returns the RMS voltage of the current measurement source

---

VSTART
VSTA **command/query**

This command moves voltage marker 1 to the specified voltage. The query returns voltage marker 1's position.

EXAMPLE: VSTART 1.0E-1 - This command moves voltage marker 1 to the 100 mV level.
VSTART? - This query returns the current position of voltage marker 1.

VSTOP
VSTO command/query

This command moves voltage marker 2 to the specified voltage. The query returns voltage marker 2's position.

EXAMPLE: VSTOP 2.0E-1 - This command moves voltage marker 2 to the 200 mV level.
VSTOP? - This query returns the current position of marker 2.

VTIME
VTIM query

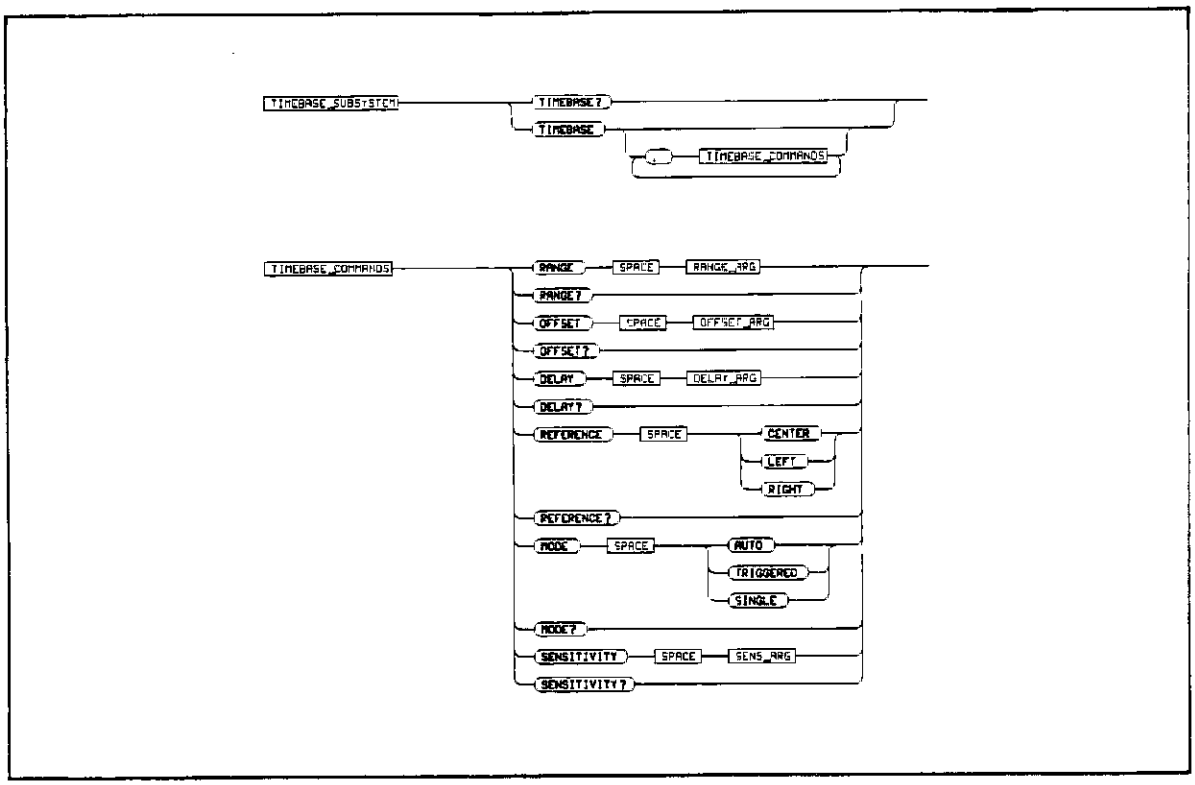
This query returns the voltage at a time. It only works on single-valued waveform records, and returns a single real value. If, due to completion criteria less than 100%, the time bucket has no associated voltage value, the value will be interpolated using linear interpolation between the closest points on each side of the time bucket. (Note that the time bucket must be within the screen window or the query will return 1E38.)

EXAMPLE: VTIME 1.0E-6? - This query returns the voltage at the time bucket 1 microsecond after the trigger point.

VTOP query

This query returns Vtop. Vtop is calculated by performing a histogram of the waveform data and looking for the voltage value above (Vmin + .6 x Vpp) hit by the most data points. If the maximum number of hits is less than roughly 5% of the maximum number of points in the waveform data record, the absolute maximum is returned instead.

EXAMPLE: VTOP? - This query returns the voltage at the top of the waveform from the measurement source.



RANGE_ARG = A real number with a range of 1 ns to 10 sec.

OFFSET_ARG = Same as **DELAY_ARG.**

DELAY_ARG = A real number with the following restrictions:
The maximum delay is 60,000 × (timebase range) or 1.6 sec, whichever is greater
If the delay reference is left
then the minimum delay is 200 ms or −(timebase range), whichever is smaller.
Else if the delay reference is center
then the minimum delay is −5 (timebase range) or −200 ms + 5 (timebase range), whichever is smaller.
Else if the delay reference is right
then the minimum delay is 0 or −200 ms + 10 (timebase range)

SENS_ARG = A real number between 100 ps and 1 sec

Figure 10-8. Timebase Subsystem Commands

10-15. TIMEBASE COMMANDS

The timebase commands are used to set up the horizontal section of the 54100A/D acquisition system. For syntax diagrams of these commands, see figure 10-8.

TIMEBASE
TIM command/query

This command selects the timebase subsystem. The query returns the timebase parameters in the following format (assuming that LONGFORM and HEADER are ON and ARGUMENT is ALPHA):

TIMEBASE <CR><LF>
MODE enumerated type <CR><LF>
RANGE real <CR><LF>
DELAY real <CR><LF>
REFERENCE enumerated type <CR><LF>

DELAY
DEL
DLY command/query

This command sets the timebase delay. This is the value between the trigger point and the screen window delay reference point. The query returns the current delay value.

EXAMPLE: DELAY -1.0E-3 - This command specifies the delay reference to be 100 ms before the trigger point.
DELAY? - This query returns the current delay value.

MODE command/query

This command selects the timebase mode. In the AUTO mode the 54100A/D generates internal triggers if the trigger system does not generate a trigger within approximately 1/20 second. (Slow triggers can be caused by using a long holdoff or having a signal with a slow rep rate.) In the TRIGGERED mode, data is acquired each time the trigger system generates a trigger, while issuing the SINGLE command causes the acquisition process to take place once on the next trigger occurrence. The query returns the current mode.

Enumeration: AUTO = 0
TRIGGERED = 1
SINGLE = 2

EXAMPLE: MODE TRIGGERED - This command sets the timebase mode to triggered
MODE? - This query returns the current timebase mode

OFFSET
OFFS command/query

This command sets the timebase delay. This is the value between the trigger point and the screen window delay reference point. The query returns the current delay value This command performs exactly the same function as the DELAY command.

Example: OFFSET - 1.E-3 - This command specifies the delay reference to be 100 ms before the trigger point.
OFFSET? - This query returns the current delay value.

REFERENCE
REF **command/query**

This command sets the delay reference to the left, center, or right side of the screen. The query returns the current delay reference.

Enumeration: LEFT = 0
CENTER = 1
RIGHT = 2

EXAMPLE: REFERENCE CENTER - This command specifies the center of the screen window as the delay reference point.
REFERENCE? - This query returns the current delay reference.

SENSITIVITY
SENS **command/query**

This command sets the time per division to the specified value. The time per division may also be set with the TIMEBASE RANGE command. The query returns the current time per division value.

EXAMPLE: SENSITIVITY 1.0E-7 - This command sets the timebase to 100 ns/div
SENSITIVITY? - This query returns the current sweep speed

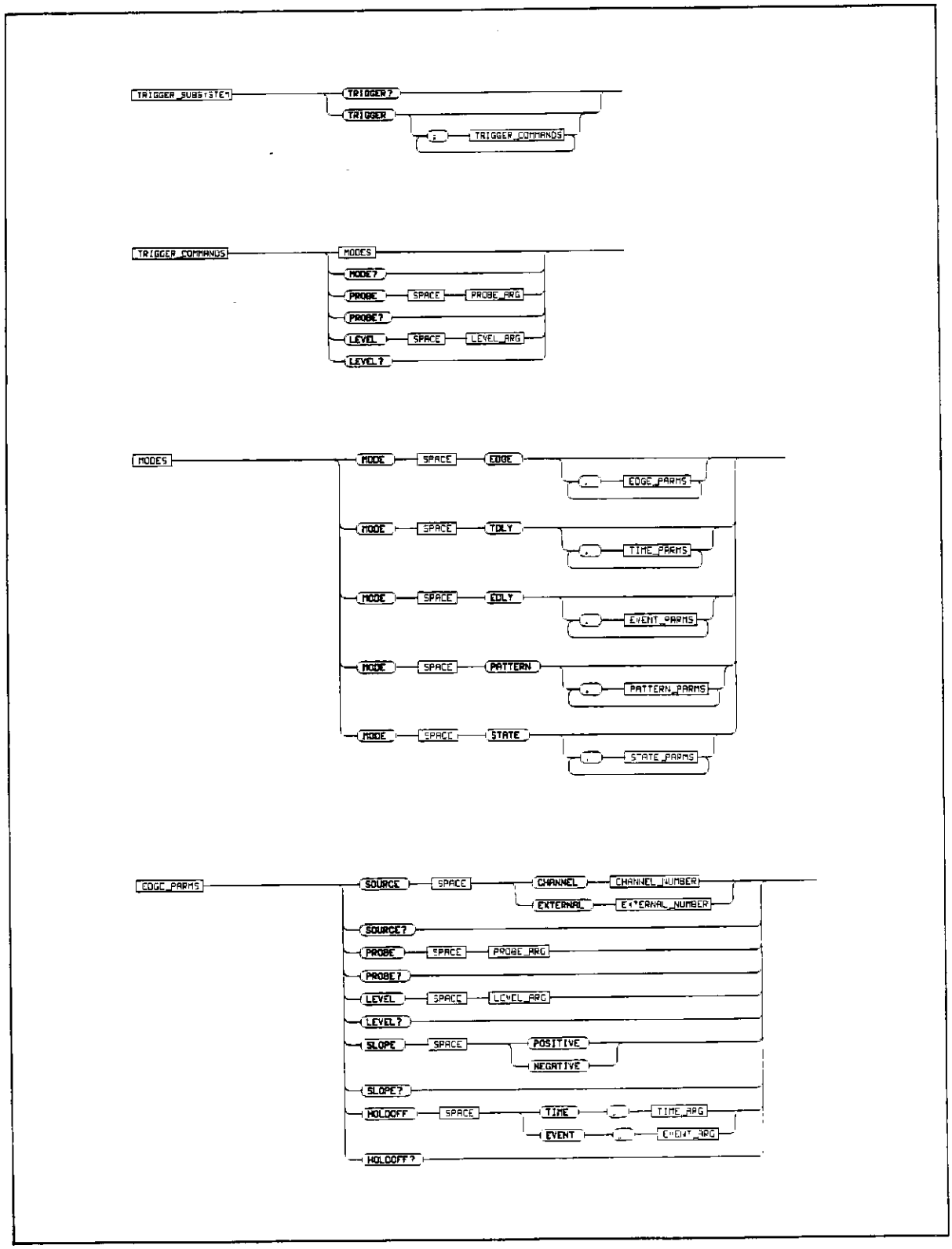


Figure 10-9(A). Trigger Subsystem Commands

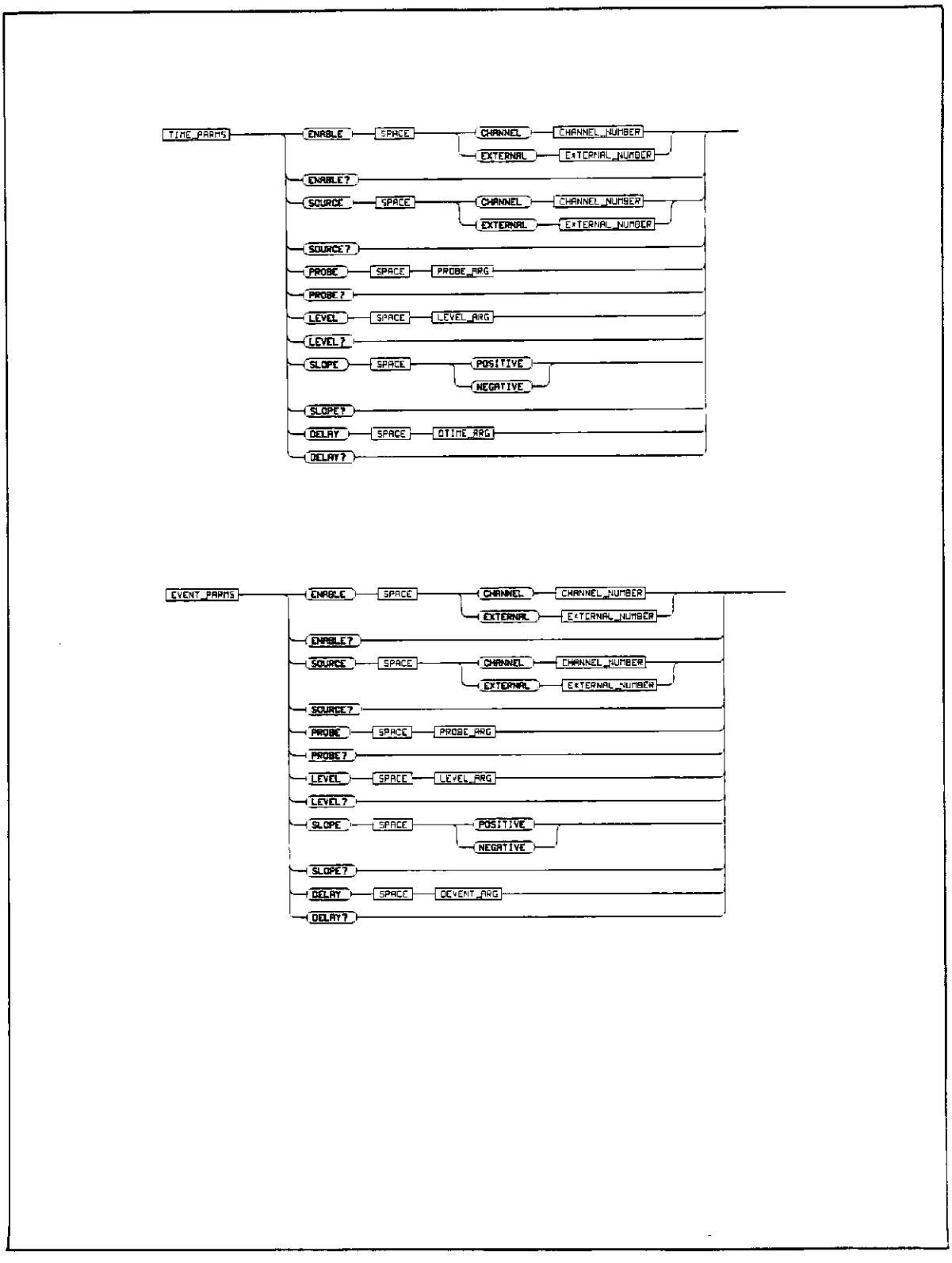


Figure 10-9(B). Trigger Subsystem Command

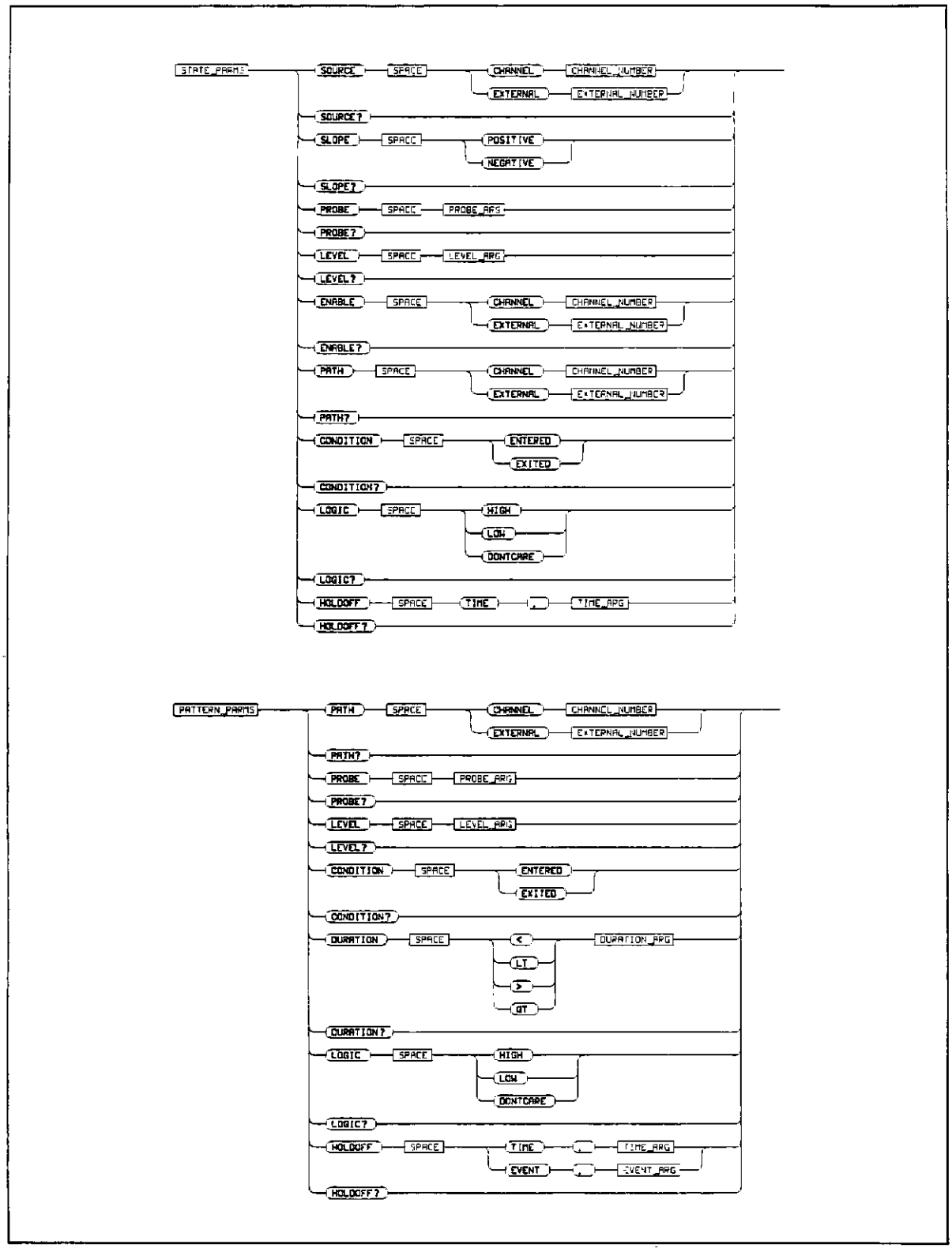


Figure 10-9(C). Trigger Subsystem Commands

PROBE_ARG = A real number from 1 to 1000

LEVEL_ARG = A real number ≤ 2 × voltage range.

CHANNEL_NUMBER = An integer 1 or 2.

EXTERNAL_NUMBER = An integer 1 or 2 for the 54100D The integer 1 for the 54100A

TIME_ARG = A real number from 70 ns to 670 ms.

EVENT_ARG = An integer from 2 to 67,000,000.

DURATION_ARG = A real number from 10 ns to 5 sec.

DTIME_ARG = A real number from 20 ns to 5 sec

DEVENT_ARG = An integer from 1 to 99,999,999

Figure 10-9. Trigger Subsystems Commands (continued)

10-16. TRIGGER COMMANDS

The trigger subsystem is used to set up the trigger portion of the acquisition system. In the 54100A there are two different modes, the EDGE mode and the pattern mode, while the 54100D adds three new modes (the EDLY, TDLY, and STATE modes) and enhances the PATTERN mode of the 54100A.

In the edge mode, each possible source will have an associated level, slope, and probe attenuation which will be used when it is selected as the trigger source. These levels and probe attenuations carry over to the other modes, although the slope will depend on the particular mode used.

The SOURCE, ENABLE and PATH commands are somewhat related in that they select the source for commands like LOGIC or LEVEL. However each is used in a slightly different way. The SOURCE command is used to specify the trigger source in the EDGE, STATE, TDLY, and EDLY modes. This is the source that the actual trigger is generated from. The ENABLE command is used in the TDLY and EDLY modes to specify the source to qualify the trigger. This is the source that is examined first to determine when to enable the trigger window. THE PATH command is used in the PATTERN and STATE modes to select a pattern element for setup.

Each individual trigger mode keeps track of the last referenced source and it is this source that is addressed by any SLOPE, LOGIC, etc. commands when that mode is re-entered.

Finally, note that while COUPLING can be sent as a command, the only legal argument is DCFIFTY (it is included only for future compatibility).

For details of the trigger subsystem command syntax see figure 10-9.

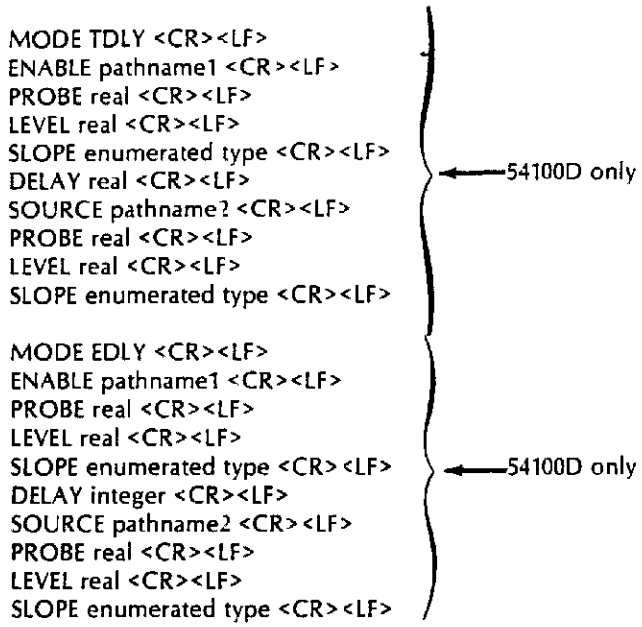
TRIGGER
TRIG command/query

The trigger command selects the trigger subsystem. The query returns the subsystem parameters for the current trigger mode in the following formats (assuming that LONGFORM and HEADER are ON and ARGUMENT is ALPHA):

MODE EDGE <CR><LF>
SOURCE pathname <CR><LF>
PROBE real <CR><LF>
LEVEL real <CR><LF>
SLOPE enumerated type <CR><LF>
HOLDOFF TIME real <CR><LF> or HOLDOFF EVENTS integer <CR><LF>

MODE PATTERN <CR><LF>
CONDITION enumerated type <CR><LF>
DURATION enumerated type, real <CR><LF> ← 54100D only
PATH pathname1 <CR><LF>
PROBE real <CR><LF>
LEVEL real <CR><LF>
LOGIC enumerated type <CR><LF>
PATH pathname2 <CR><LF>
PROBE real <CR><LF>
LEVEL real <CR><LF>
LOGIC enumerated type <CR><LF>
PATH pathname3 <CR><LF>
PROBE real <CR><LF>
LEVEL real <CR><LF>
LOGIC enumerated type <CR><LF>
PATH pathname4 <CR><LF> } ← 54100D only
PROBE real <CR><LF>
LEVEL real <CR><LF>
LOGIC enumerated type <CR><LF>
HOLDOFF TIME, real <CR><LF> or HOLDOFF EVENTS, integer <CR><LF>

MODE STATE <CR><LF>
CONDITION enumerated type <CR><LF>
PATH pathname1 <CR><LF>
PROBE real <CR><LF>
LEVEL real <CR><LF>
LOGIC enumerated type <CR><LF>
PATH pathname2 <CR><LF>
PROBE real <CR><LF>
LEVEL real <CR><LF>
LOGIC enumerated type <CR><LF> ← 54100D only
PATH pathname3 <CR><LF>
PROBE real <CR><LF>
LEVEL real <CR><LF>
LOGIC enumerated type <CR><LF>
SOURCE pathname4 <CR><LF>
PROBE real <CR><LF>
LEVEL real <CR><LF>
SLOPE enumerated type <CR><LF>
HOLDOFF TIME real <CR><LF>



CONDITION
COND **command/query**

This command/query is valid only when the trigger mode is PATTERN or STATE. It specifies whether the trigger is to be generated on entry to the specified logic pattern or when existing it. The query returns the currently selected condition.

Enumeration: ENTERED = ENT, = 0
EXITED = EXIT = 1

EXAMPLE: CONDITION ENTER - This command specifies that a trigger is to be generated as soon as all the parts of the pattern are valid.
CONDITION? - This query returns the currently specified condition.

DELAY
DEL
DLY **command/query**

This command/query is valid only in the events delay or time delay modes (54100D only). In the time delay mode, it specifies the time delay in seconds, while in the events delay mode it specifies the number of trigger events to wait for. The query returns the delay for the current mode.

EXAMPLE: DELAY 2.0E-7 - This command specifies the delay to be 200 ns (mode must be TDLY).
DELAY 30 - This command sets the delay to be 30 events (mode must be EDLY)
DELAY? - This query returns the present delay.

DURATION
DUR command/query

This command/query is valid only in the pattern mode for the 54100D. It specifies the time limit (minimum time for ">", maximum time for "<") for which a pattern must be true to generate a trigger. Pattern duration trigger is implicity an "EXITED" condition, that is, the trigger coincides with the first path which changes to make the pattern false. The query returns the current selections for duration type and time.

Enumeration: LT = 1
GT = 2

EXAMPLE: DURATION, >1.0E-6 - This command specifies that the pattern must be present for greater than 1 μs before it is considered valid.
DURATION? - This query returns the current duration type and value

---

ENABLE
ENAB command/query

This command/query is valid in the TDLY or EDLY modes of the 54100D. The command is used to specify the source to use as the trigger enable, which is also the source for subsequent SLOPE and PROBE commands. The query returns the current trigger enable source of the present mode.

enumeration: CHANNEL1 = 1
CHANNEL2 = 2
EXTERNAL1 = 3
EXTERNAL2 = 4

EXAMPLE: ENABLE CHANNEL1 - This command specifies that channel 1 is to be used as the trigger enable
ENABLE? - This query returns the trigger enable for the current mode

---

HOLDOFF
HOLD command/query

The holdoff command is used to specify the holdoff time in the EDGE, PATTERN, or STATE modes, or the holdoff number of events in the EDGE or PATTERN modes. Each mode has its own private holdoff parameters and "remembers" whether it was in holdoff by time or holdoff by events. The holdoff query is valid in the EDGE, PATTERN or STATE modes and returns the current holdoff setting for the presently selected mode.

EXAMPLE: HOLDOFF TIME,1.0E-6 - This command sets the holdoff to time mode, 1 us
HOLDOFF EVENT, 30 - This command sets the holdoff to events mode, 30 occurrences
HOLDOFF? - This command returns the current holdoff value and value

---

LEVEL
LEV
LVL command/query

This command sets the trigger level of the selected SOURCE or PATH to the specified voltage. The query returns the trigger level of the selected SOURCE or PATH.

EXAMPLE: LEVEL 1.6 - This command sets the trigger level of the previously specified source to 1.6 V
LEVEL? - this command returns the trigger level of the last selected source

---

LOGIC
LOG **command/query**

This command/query is valid in the STATE and PATTERN modes. The command is used to specify the relation between the signal and predefined voltage level that must exist before that part of the pattern is considered valid. The query returns the last specified logic level of the currently enabled source.

Enumeration: LOW = 0
HIGH = 1
DONTCARE = 2

EXAMPLE: LOGIC HIGH - This command specifies that the previously selected path is considered to be in a true condition when its level is greater than the trigger level for that source.
LOGIC? - This query returns the current logic specification for the previously selected path.

MODE **command/query**

This command selects the trigger mode. Valid modes in the 54100A are the EDGE and PATTERN modes, while all 5 modes are valid in the 54100D. The query returns the present trigger mode.

Enumeration: EDGE = 0
PATTERN = 1
STATE = 2
TDLY = 3
EDLY = 4

EXAMPLE: MODE EDGE - This command selects the edge mode.
MODE? - This command returns the current trigger mode.

PATH **command/query**

This command/query is valid in the PATTERN and STATE modes of the 54100A/D. The command is used to select a pattern bit as the source for future probe and logic commands. The query returns the current trigger source of the present mode.

Enumeration: CHANNEL1 = 1
CHANNEL2 = 2
EXTERNAL1 = 3
EXTERNAL2 = 4

EXAMPLE: PATH CHANNEL1 - This command selects channel 1 as the addressed path.
PATH? - This query returns the currently addressed path.

PROBE
PROB command/query

This command specifies the attenuation factor for the last specified SOURCE or PATH for the current trigger mode. If the trigger source is also a channel, the last specified probe attenuation for that channel is the one used. See the CHANNELn PROBE command paragraph 10-10. The query returns the current source's attenuation factor.

EXAMPLE: PROBE 10.0 - This command sets the probe attenuation of the previously selected source to be 10:1.
PROBE? - This query returns the probe attenuation of the currently selected source.

SLOPE
SLOP command/query

This command specifies the trigger slope for the previously specified source. The query returns the current slope for the last selected source of the present mode.

Enumeration: NEGATIVE = 0
POSITIVE = 1

EXAMPLE: SLOPE NEGATIVE - This command sets the slope for the previously specified source to negative.
SLOPE? - This command returns the slope of the previously specified source.

SOURCE
SOUR
SRC command/query

This command/query is valid in the EDGE, STATE, TDLY or EDLY modes of the 54100A/D. The command is used to specify the trigger source, which is also the source for subsequent SLOPE and PROBE commands. The query returns the current trigger source of the present mode.

Enumeration: CHANNEL1 = 1
CHANNEL2 = 2
EXTERNAL1 = 3
EXTERNAL2 = 4

EXAMPLE: SOURCE CHANNEL1 - This command selects channel 1 as the trigger source
SOURCE? - This query returns the current trigger source.

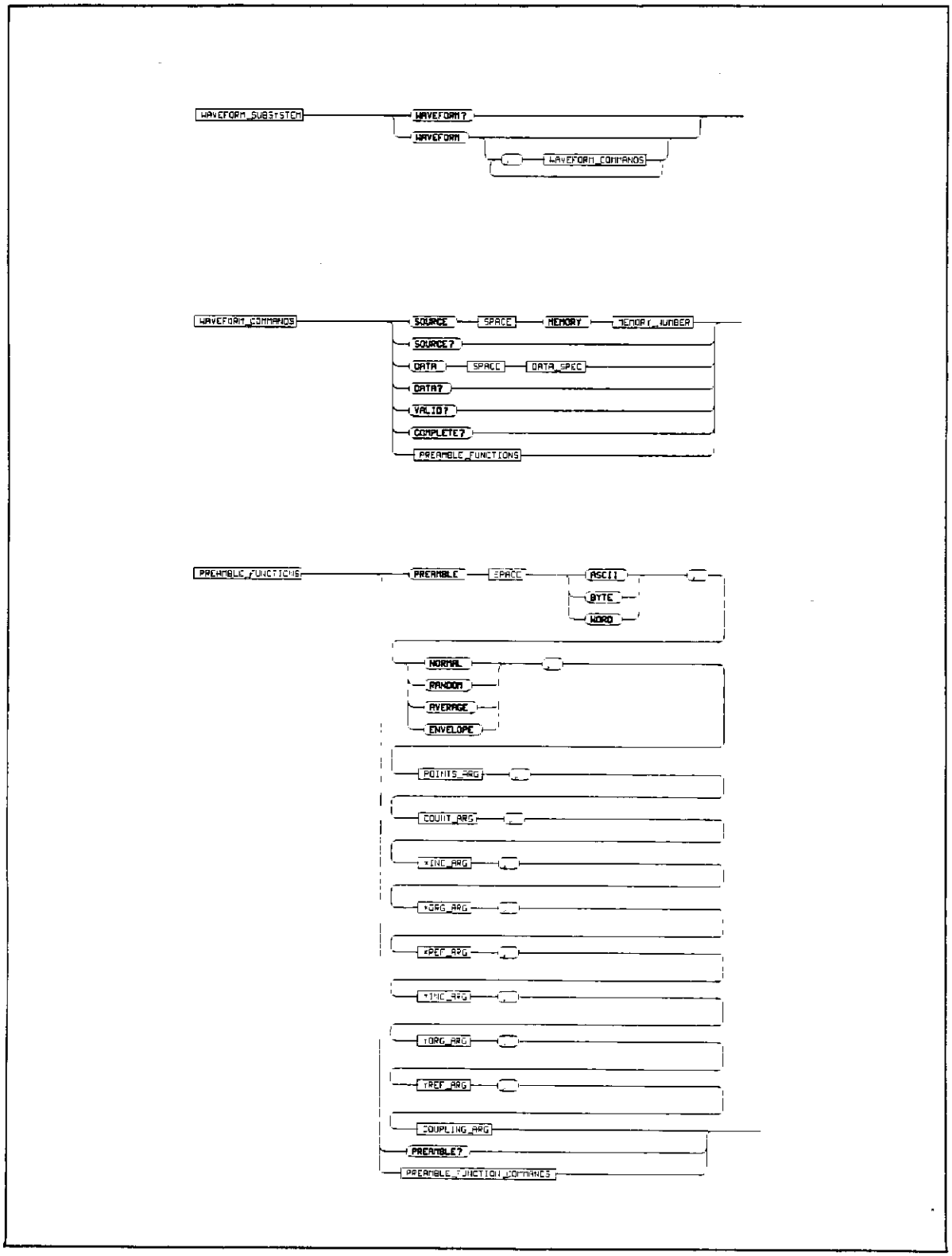
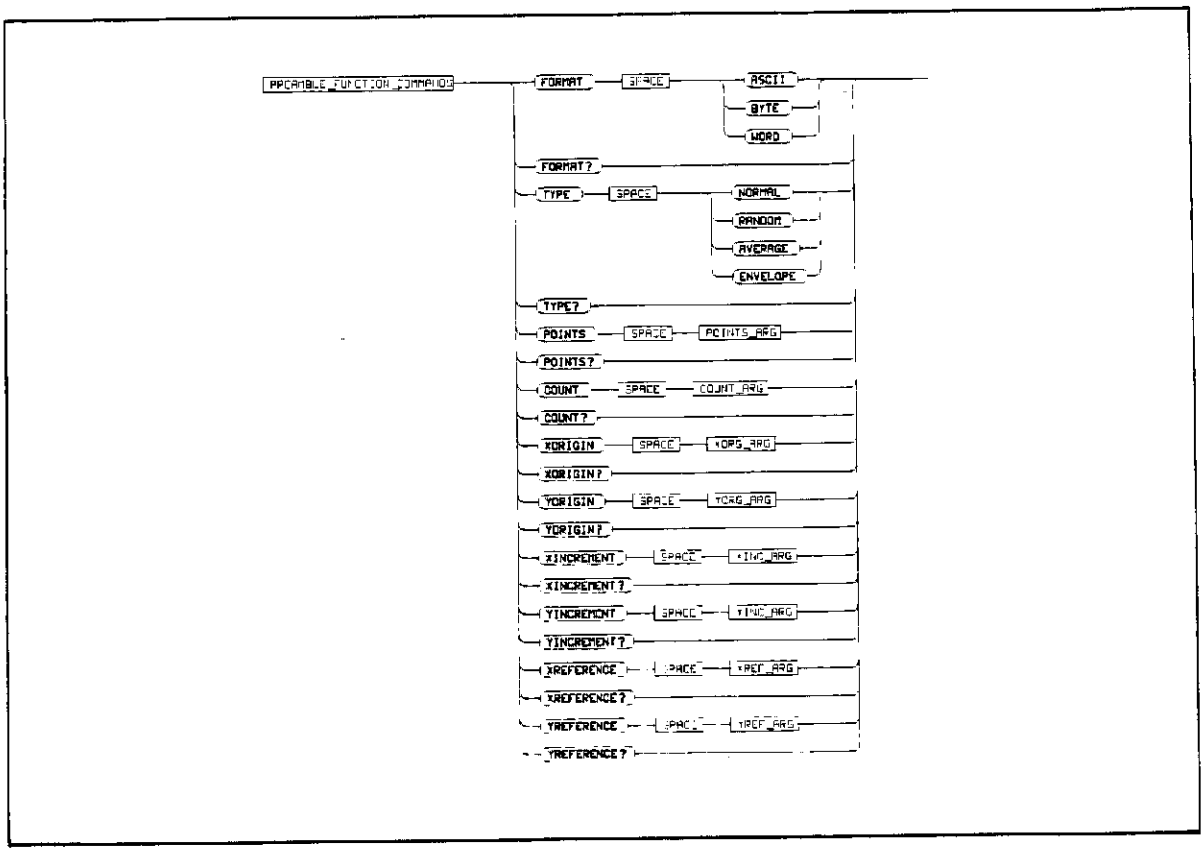


Figure 10A. Waveform Commands



MEMORY_NUMBER = An integer 1 or 2.

DATA_SPEC = A block of data in #A format as defined in IEEE Std. 728-1982.

POINTS_ARG = An integer = 128, 256, 512 or 1024

COUNT_ARG = An integer from 1 to 2048

XINC_ARG = A real number from 10 ps to 2 ms.

XORG_ARG = A real number with the following restrictions:
The maximum value is 60,000 × timebase range or 1.6 sec, whichever is greater.
If the delay reference is left
then the minimum value is −200 ms or − (timebase range), whichever is smaller
Else if the delay reference is center
then the minimum value is the lesser of −5 × (timebase range) and −200 ms + (5 × timebase range).
Else if the delay reference is right
then the minimum value is the lesser of 0 and −200 ms + (10 × timebase range).

XREF_ARG = 0.

YINC_ARG = A real number equal to 1/128 × voltage range.

YORG_ARG = A real number with a magnitude less than 1.5 × voltage range

YREF_ARG = 64 for byte format; 16384 for word or ASCII format

COUPLING_ARG = DCFIFTY or the integer 3

Figure 10B. Waveform Commands

10-17. WAVEFORM COMMANDS

The waveform subsystem commands are used to transfer waveforms to and from the HP-IB waveform buffer memories in the 54100A/D. These buffers are not to be confused with the waveform storage memories that are available for storage of pixel data from the front panel and with the MERGE command. The Waveform data consists of a preamble and a data record. The preamble contains scaling information useful for interpreting the data record while the data record contains the actual waveform data values.

In the interest of flexibility, each element of the waveform preamble is individually settable as well as capable of being queried. This can cause problems if done injudiciously. For example, setting POINTS in the preamble to a value different from the actual number of points in the waveform record could result in bad data being sent out. Because of this, only the query form of most of the preamble commands is documented here.

The actual values set in the preamble are determined when the DIGITIZE command is executed and are based on the settings of variables in the ACQUIRE subsystem. For more information on the DIGITIZE process and the ACQUIRE subsystem variables, see section 10-8. For syntax diagrams of the waveform subsystem commands, see figure 10-10.

There are four different waveform TYPES:

NORMAL data consists of the last hit in each time bucket. This data is transmitted over HP-IB in a linear fashion starting with time bucket 0 and going thorugh time bucket n, where n is the number returned by the WAVEFORM POINTS query. Any time buckets that have no data return -1 as the data for that time bucket. Only the voltage quantization values are sent, the time values correspond with the position in the data array. The first value corresponds to a point at the left side of the screen.

AVERAGE data consists of the average of the first n hits in a time bucket, where n is the value returned by the WAVEFORM COUNT query. Any time buckets that have fewer than n hits return the average of what they have, except that buckets with no hits return -1 as the data for that time bucket. This data is transmitted over HP-IB in a linear fashion starting with time bucket 0 and going through time bucket n-1, where n is the number returned by the WAVEFORM POINTS query. The first value corresponds to a point at the left side of the screen.

ENVELOPE data consists of two arrays of data, one containing the minimum of the first n hits in each time bucket and the other consisting of the maximum of the first n hits in each time bucket, where n is the value returned by the count query. If a time bucket does not have n hits in it, then -1 is returned for both the minimum and the maximum values. The two arrays are transmitted one after the other over HP-IB in a linear fashion, starting with time bucket 0 and going through time bucket m-1, where m is the value returned by the WAVEFORM POINTS query, with the minimum values being sent first. The first value in each array corresponds to a point at the left side of the screen.

RANDOM data consists of the largest number of points that can be gathered such that the number of points does not exceed 1024. See ACQUIRE POINTS (paragraph 10-9) for more information. The data is transmitted in the order acquired as time-voltage pairs. Note that one should not use the BYTE format for this mode since the time bucket numbers range up to 500 and it is impossible to represent numbers this large in a byte without loss of precision.

Data is transmitted over the HP-IB in one of three different FORMATS:

WORD format waveform records are transmitted using the binary block format (the #A format specified in IEEE Std 728-1982). The character string "#A" is first sent, followed by a 2 byte length value (16 bit binary) specifying the number of bytes to follow. The number of bytes is twice the number of words. The numbe of words is also the value returned by the WAVEFORM POINTS query. This is followed by a sequence of bytes representing the data words, with the most significant byte of each word being transmitted first. The A/D conversion in the 54100A/D yields a 7 bit result and this 7 bit result is contained in the upper half of the data words transmitted by the instrument. The lower byte contains zeros unless the TYPE was AVERAGE. In this case, any increased resolution achieved through averaging will show up in the lower byte of the data. Values are always positive and between 0 and 32767.

BYTE format waveform records are transmitted using the binary block format (the #A format specified in IEEE Std 728-1982). The character string "#A" is first sent, followed by a 2 byte length value (16 bit binary) specifying the number of bytes to follow. The number of bytes when the FORMAT is BYTE is also the value returned by the WAVEFORM POINTS query. BYTE transfers help cut the transfer time in half, but should be used with caution if there are any data values to be sent that are larger than decimal 127. If the data values have a larger range than 0 through 127, as is the case when the TYPE is RANDOM, the values are shifted until they fit within a byte. For example, when the TYPE is RANDOM, the X values normally range from 0 to 500. Trying to transmi RANDOM data in BYTE FORMAT results in the time bucket numbers being rescaled so that they range from 0 through 125. This lumps time buckets 0 through 3 into one X coordinate, time buckets 4 through 7 into the next X coordinate, etc.

ASCII format waveform records are transmitted one value at a time, separated by <CR><LF>'s. The data values transmitted are the same as would be sent in the WORD FORMAT except that they are converted to an integer ASCII format (six characters) before being sent over HP-IB.

WAVEFORM
WAV **command/query**

The waveform command selects the waveform subsystem. The waveform query returns the waveform subsystem parameters in the following order (assuming that LONGFORM and HEADER are ON and ARGUMENT is ALPHA):

WAVEFORM <CR><LF>
SOURCE enumerated type <CR><LF>
VALID enumerated type <CR><LF>
FORMAT enumerated type <CR><LF>
TYPE enumerated type <CR><LF>
POINTS integer <CR><LF>
COUNT integer <CR><LF>
XINCREMENT real <CR><LF>
XORIGIN real <CR><LF>
XREFERENCE integer <CR><LF>
YINCREMENT real <CR><LF>
YORIGIN real <CR><LF>
YREFERENCE integer <CR><LF>
COUPLING enumerated type <CR><LF>
COMPLETE integer <CR><LF>

COMPLETE
COMP command/query

This query returns the completion criterion that was used for the last acquisition to the currently selected memory, from its preamble.

EXAMPLE: COMPLETE? - This query returns the completion field of the previously selected preamble.

COUNT
COUN
CNT command/query

This query returns the count field of the waveform preamble, which is the number of averages if the TYPE is AVERAGED, or the number of points per bucket used to make the envelope if the TYPE is ENVELOPE.

EXAMPLE: COUNT? - This query returns the count field of the previously selected preamble.

DATA command/query

This command causes the instrument to accept a waveform data record and store it in the previously specified waveform memory. Note that the record format must match the format previously specified for the memory by its preamble. The query returns the waveform record stored in the previously specified waveform memory.

EXAMPLE: DATA <binary block> - This command causes the 54100A/D to accept a waveform data record.
DATA? - This command causes the 54100A/D to transmit a waveform data record

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FORMAT
FORM command/query

This command specifies the type of waveform transfers to be used for the following waveform commands. An ASCII formatted transfer causes the data to be sent as ASCII digits with each data value separated by a carriage return/line feed. A BYTE formatted transfer causes the data to be sent as one long string of bytes, while a WORD formatted transfer transfers the data as 16 bit integers. The query returns the current transfer format for the previously specified memory.

enumeration: ASCII = 0
BYTE = 1
WORD = 2

EXAMPLE: FORMAT WORD - This command specifies that all waveform data records are to be sent using the 16 bit integer format.
FORMAT? - This query returns the waveform transfer format for the previously selected source.

POINTS
POIN
PNTS command/query

This query returns the points value in the currently selected waveform preamble, which is the number of points acquired in the last DIGITIZE to the selected waveform memory.

EXAMPLE: POINTS? - This query returns the currently selected preamble's points parameter.

PREAMBLE
PRE command/query

This command sends a waveform preamble into the selected waveform memory in the instrument. The query returns the preamble of the previously specified memory. Preamble information is transmitted in the following order, separated by commas (the header keywords are included only to identify the fields and are not sent):

(FORMAT) enumerated type, (TYPE) enumerated type,
(POINTS) integer, (COUNT) integer, (XINCREMENT) real,
(XORIGIN) real, (XREFERENCE) integer, (YINCREMENT) real,
(YORIGIN) real, (YREFERENCE) integer, (COUPLING) enumerated type

EXAMPLE: PREAMBLE preamble information - This command causes the 54100A/D to store the accompanying preamble information in the currently selected preamble memory.
PREAMBLE? - This query returns the currently selected preamble.

SOURCE
SOUR
SRC command/query

This command selects the memory that is to be used as the source in following waveform commands. The query returns the currently selected source.

Enumeration: MEMORY1 = 1
MEMORY2 = 2

EXAMPLE: SOURCE MEMORY1 - This command specifies that any following waveform subsystem commands refer to waveform memory 1.
SOURCE? - This query returns the currently selected waveform source.

TYPE command/query

This query returns the TYPE from the currently selected waveform preamble.

Enumeration: INVALID = 0 (query response only)
NORMAL = 1
AVERAGE = 2
ENVELOPE = 3
RANDOM = 4

EXAMPLE: TYPE? - This query returns the type of the last acquisition from the currently selected waveform preamble.

VALID
VAL command/query

This query returns an integer depending on the status of the data in the waveform memory. If the value is greater than 0, then the memory contains valid data.

EXAMPLE: VALID? - This query returns the status of the data in the currently selected waveform memory.

XINCREMENT
XINC command/query

This query returns the x-increment value currently in the preamble. This value is the time difference between consecutive data points for NORMAL, AVERAGED, or ENVELOPED data.

EXAMPLE: XINCREMENT? - This query returns the currently selected preamble's x-increment value.

XORIGIN
XOR command/query

This query returns the x-origin value currently in the preamble. This value is the time between the trigger and the x-reference time bucket.

EXAMPLE: XORIGIN? - This query returns the currently selected preamble's x-origin value.

XREFERENCE
XREF command/query

This query returns the current x-reference value in the preamble. This value specifies the time bucket to which the x-origin value refers.

For example: If the x-reference is 37, the x-origin is -1 us and the x-increment is 150 ns, then a data point whose x value is 45 would correspond to a time of (45 - 37) * 150 μs + (-1μs) or 200 ns after the trigger.

EXAMPLE: XREFERENCE? - This query returns the x-reference value of the currently selected preamble. THE 54100A/D will always return a 0.

YINCREMENT
YINC command/query

This query returns the y-increment value currently in the preamble. This value is the voltage difference between consecutive data values.

EXAMPLE: YINCREMENT? - This query returns the currently selected preamble's y-increment value.

YORIGIN
YOR command/query

The YORIGIN query returns returns the y-origin value currently in the preamble. This value is the voltage at the data value whose number is returned by the YREFERENCE query.

EXAMPLE: YORIGIN? - This query returns the currently selected preamble's y-origin value

YREFERENCE
YREF command/query

This query returns the current y-reference value in the preamble. This value specifies the voltage level to which the y-origin value refers.

For example: If the y-reference is 64, the y-origin is 1.1 V and the y-increment is 150 mV, then a data point whose y value is 93 would correspond to a voltage of (93 - 64) * 150 mV + 1.1 volts or 5.45 volts.

EXAMPLE: YREFERENCE? - This query returns the y-reference of the currently selected preamble. In the 54100A/D, this will be 64 for byte formatted transfers and 16384 for word or ASCII formatted transfers

54100A/D QUICK REFERENCE GUIDE

SYSTEM COMMANDS

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
ARGUMENT	yes	yes	one . . . 0/1 or NUMERIC/ALPHA	ARGUMENT NUMERIC ARGUMENT?	Selects numeric format for enumerated types in query responses. Returns argument type.
AUTOSCALE	yes	no	none	AUTOSCALE	Rescales vertical, horizontal, and trigger systems in the instrument.
BLANK	yes	no	one of the form CHANNELn or PLANEn where n=1,2	BLANK PLANE1	Disables the display of memory plane 1.
CALIBRATE	yes	yes	one . . . binary block	CALIBRATE <cal string> CALIBRATE?	Sets the cal factors. Returns the current cal factors.
CLEAR	yes	no	none	CLEAR	Same as the HP-IB SDC or DCL commands.
DIGITIZE	yes	no	one or two in the form CHANNELn or n, separated by commas, where n = 1,2	DIGITIZE 1,CHANNEL2	Digitizes channel 1 and channel 2.
DSP	yes	yes	one . . . string	DSP "hi mom" DSP?	Writes "hi mom" to the advisory line. Returns the string last written to the advisory line.
EOI	yes	yes	one . . . 0/1 or OFF/ON	EOI ON EOI?	Sets EOI control state to ON. Returns EOI control state.
ERASE	yes	no	one of the form PLANEd where d = 0. . 2	ERASE PLANE1	Clears waveform memory 1.
ERROR	no	yes	none	ERROR?	Returns next error from error queue.
HEADER	yes	yes	one . 0/1 or OFF/ON	HEADER ON HEADER?	Turns headers on in query replies. Returns header status.

SYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
ID	no	yes	none	ID?	Returns instrument id . . ., e.g., HP54100A
KEY	yes	yes	one . . . integer 0. . 63	KEY 48 KEY?	"Pushes" the AUTOSCALE key. Returns the last key pushed.
LOCAL	yes	no	none	LOCAL	Same as the HP-IB Clear Lockout/Set, Local message.
LONGFORM	yes	yes	one . . . 0/1 or OFF/ON	LONGFORM ON LONGFORM?	Selects long headers for query replies. Returns header type.
MENU	yes	yes	one . . . integer from 1 to 14	MENU 3 MENU?	Selects the timebase menu. Returns the current menu number.
MERGE	yes	no	one of the form PLANEn where n = 1 or 2	MERGE PLANE1	Merges the contents of the active plane with the specified waveform memory plane.
OPTIONS	no	yes	none	OPTIONS?	Returns a string of integer option numbers, separated by commas . . . 0 if no options are installed.
PLOT	yes	no	none	PLOT	Starts a hardcopy output to plotter.
PRINT	yes	no	none	PRINT	Starts a hardcopy output to printer.
READY	no	yes	none	READY?	Returns upper byte of status word.
RECALL	yes	no	one . . . integer 0 . . 9	RECALL 1	Recalls instrument setup from memory 1.
REMOTE	yes	no	none	REMOTE	Same as the Remote message followed by a Local Lockout message.

SYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
REQUEST	yes	yes	one . . . integer 0-32767, or the keyword ON or OFF	REQUEST 13 REQUEST?	Sets ready & SRQ masks. Returns ready & SRQ masks.
RESET	yes	no	none	RESET	Resets the instrument.
REVISION	no	yes	none	REVISION?	Returns an integer corresponding to the firmware revision number . . . e.g., 2433.
RUN	yes	no	none	RUN	Causes the acquisition process to begin based on the timebase mode.
SAVE	yes	no	one . . . integer 0 . . 9	SAVE 1	Saves instrument setup in memory 1.
SERIAL	no	yes	none	SERIAL?	Returns instrument serial number as a quoted string from battery backed-up memory, e.g., 2436A01045.
SETUP	yes	yes	one . . . binary block	SETUP SETUP?	learn string Sends learn string to instrument. Returns learn string from instrument.
SPOLL	no	yes	none	SPOLL?	Similar to an HP-IB serial poll.
STATUS	no	yes	none	STATUS?	Returns the status word as a 16 bit integer.
STOP	yes	no	none	STOP	Stops the display acquisition process.
TEST	yes	no	none	TEST	Starts a self-test.
TRANSFER	yes	no	two . . . first is MEMORYn where n = 1,2 and second is PLANEd where d = 0 to 3	TRANSFER MEMORY1, PLANE1	Transfers the contents of waveform memory 1 to waveform storage memory 1.
TRG GET	yes	no	none	TRG	Same as HP-IB < GET > command.

SYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
VIEW	yes	no	one of the form CHANNELn or PLANEn where n = 1,2	VIEW CHANNEL1	Turns on the channel 1 display.

SUBSYSTEM SELECTORS

ACQUIRE	yes	yes	none	ACQUIRE ACQUIRE?	Selects the acquisition subsystem. Returns the acquisition settings.
CHANNELn	yes	yes	none	CHANNEL1 CHANNEL1?	Selects the Channel subsystem, channel 1. Returns the settings for chan 1.
DISPLAY	yes	yes	none	DISPLAY DISPLAY?	Selects the display subsystem. Returns the display settings.
GRAPHn	yes	yes	none	GRAPH1 GRAPH1?	Selects the graph subsystem, graph 1. Returns the parameters for graph 1
HARDCOPY	yes	yes	none	HARDCOPY HARDCOPY?	Selects the hardcopy subsystem. Returns the hardcopy settings.
MEASURE	yes	no	none	MEASURE	Selects the measurement subsystem.
TIMEBASE	yes	yes	none	TIMEBASE TIMEBASE?	Selects the timebase subsystem. Returns the timebase settings.
TRIGGER	yes	yes	none	TRIGGER TRIGGER?	Selects the trigger subsystem. Returns the trigger settings.
WAVEFORM	yes	yes	none	WAVEFORM WAVEFORM?	Selects the waveform subsystem Returns the waveform settings & last specified waveform.

ACQUIRE SUBSYSTEM COMMANDS

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
COMPLETE	yes	yes	one . . . integer from 50 to 100	COMPLETE 90 COMPLETE?	Specifies acquisition until at least 90% of the time buckets have data. Returns the completion criteria.
COUNT	yes	yes	one . . . integer from 1 to 2048	COUNT 128 COUNT?	Sets # of averages to 128. Returns count value.
POINTS	yes	yes	one . . . integer (128, 256, 512, or 1024)	POINTS 1024 POINTS?	Specifies that an acquisition record consists of 1024 points. Returns number of points acquired for each record of data.
TYPE	yes	yes	one . . 1/2/3/4 or NORMAL/ AVERAGE/ENVELOPE/RANDOM	TYPE AVERAGE TYPE?	Selects the average mode. Returns acquisition mode.

CHANNEL SUBSYSTEM COMMANDS

ECL	yes	no	none	ECL	Presets the vertical and trigger parameters for the selected channel for optimum viewing of ECL signals
OFFSET	yes	yes	one . . . real (±1 5 times the range)	OFFSET 1.5 OFFSET?	Sets voltage at center screen to 1.5 volts. Returns voltage at center screen.
PROBE	yes	yes	one . . . real from 1.0 to 1000 0	PROBE 10.0 PROBE?	Sets probe attenuation to 10:1. Returns probe attenuation factor.
RANGE	yes	yes	one . . . real (4 * sensitivity in DISPLAY FORMAT DUAL, 8 * sensitivity in DISPLAY FORMAT SINGLE)	RANGE 8.0 RANGE?	Sets channel to 8V full screen. Returns the vertical screen height in volts.

CHANNEL SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
SENSITIVITY	yes	yes	one . . . real (.01, .02, .05, .1, .2, .5, or 1 with 1:1 probe when in DISPLAY FORMAT SINGLE double these values in DISPLAY FORMAT DUAL)	SENSITIVITY 1.0 SENSITIVITY?	Sets channel to 1 V/div. Returns channel volts per division.
TTL	yes	no	none	TTL	Presets the vertical and trigger parameters for the selected channel for optimum viewing of TTL signals.

DISPLAY SUBSYSTEM COMMANDS

ATTRIBUTE	yes	yes	one . . . 0/1 or DISABLE/ENABLE	ATTRIBUTE ENABLE	Specifies that any embedded attribute is to override the previous attribute definitions.
				ATTRIBUTE?	Returns the present state of the embedded attribute function.
BLINK	yes	yes	one . . . 0/1 or OFF/ON	BLINK ON	Specifies that subsequent characters will blink.
				BLINK?	Returns the current state of the blink attribute.
BRIGHTNESS	yes	yes	one . . 0/1 or LOW/HIGH	BRIGHTNESS LOW	Specifies that subsequent characters will be written in half bright intensity.
				BRIGHTNESS?	Returns the current state of the brightness attribute
COLUMN	yes	yes	one...integer from 0 to 62	COLUMN 50	Moves the LINE or STRING starting point to column 50
				COLUMN?	Returns the present column #.

DISPLAY SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
DATA	yes	yes	one . . . binary block	DATA <pixel data>	Sends waveform pixel data to the previously specified display source.
				DATA?	Returns waveform pixel data from the previously specified display source
FORMAT	yes	yes	one . . . 1/2 or SINGLE/DUAL	FORMAT SINGLE	Specifies display all traces full screen.
				FORMAT?	Returns the number of display areas on screen,
GRATICULE	yes	yes	one . . . 0/1/2/3 or OFF/GRID/AXES/FRAME	GRATICULE FRAME	Selects the frame graticule.
				GRATICULE?	Returns the graticule type.
INVERSE	yes	yes	one . . . 0/1 or OFF/ON	INVERSE ON	Specifies that subsequent characters are to be written in inverse video.
				INVERSE?	Returns the current state of the inverse attribute.
LINE	yes	yes	one . . . string	LINE <string>	Writes string starting at defined row and column . . . line is blanked from end of string to EOL and row is set to next line, same column.
				LINE?	Queries the instrument for a line of text from the row and column location to the EOL and moves row to next line.
PERSISTENCE	yes	yes	one . . . a real number from .2 to 10.0 or the keyword INFINITE	PERSISTENCE 1.0	Sets the persistence in the normal display mode to 1 second.
				PERSISTENCE?	Returns the current persistence value.

DISPLAY SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
ROW	yes	yes	one . . . integer from 0 to 22	ROW 4	Moves the LINE and STRING starting point to row 4.
				ROW?	Returns the present row #.
SOURCE	yes	yes	one of the form PLANEd where d = 0 . . 2	SOURCE PLANE1	Specifies that pixel memory 1 is the source for the following pixel data commands.
				SOURCE?	Returns the last selected source.
STRING	yes	no	one . . . string	STRING <string>	Writes string starting at defined row and column.
TEXT	yes	no	one . . . 2 or BLANK	TEXT BLANK	Erases the user text display.
TMARKER	yes	yes	one . . . 0/1 or OFF/ON	TMARKER ON	Turns the time markers on.
				TMARKER?	Returns the time marker state.
UNDERLINE	yes	yes	one . . . 0/1 or OFF/ON	UNDERLINE ON	Specifies that subsequent characters are to be written underlined.
				UNDERLINE?	Returns the current state of the underline attribute.
VMARKER	yes	yes	one . . . 0/1 or OFF/ON	VMARKER ON	Turns the voltage markers on.
				VMARKER?	Returns the voltage marker state.

GRAPH SUBSYSTEM COMMANDS

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
MAGNIFY	yes	no	one...0/1/2 or OFF/ON/WINDOW	MAGNIFY OFF	Specifies that the graph is to be displayed in unmagnified form.
YOFFSET	yes	yes	one . . . real within the vertical range	YOFFSET 1.0	Specifies the voltage at the center of the magnification window to be 1 volt.
				YOFFSET?	Returns the voltage at the center of the magnification window.
YRANGE	yes	yes	one . . . real between 1/16 * vertical range and vertical range	YRANGE 4.0	Specifies the magnification window size to be 4 volts.
				YRANGE?	Returns the magnification window size.

HARDCOPY SUBSYSTEM COMMANDS

PAGE	yes	yes	one . . . 0/1 or MANUAL/AUTO	PAGE AUTO	Causes a form feed to be done at the end of a printer dump.
				PAGE?	Returns the current page parameter.
PEN	yes	yes	one . . . 0/1 or MANUAL/AUTO	PEN AUTO	Enables automatic pen selection for the plotter.
				PEN?	Returns the current pen parameter.
SOURCE	yes	no	one or more of the form 0/1/2/4 or PLANE0/PLANE1/PLANE2/ FACTORS using commas as separators	SOURCE PLANE1,FACTORS	Selects pixel memory 1 and the scale factors as the sources for hardcopy output.
SPEED	yes	yes	one . . . 0/1 or SLOW/FAST	SPEED SLOW	Specifies plotting at a lower speed suitable for transparencies.
				SPEED?	Returns the currently selected pen speed.

MEASURE SUBSYSTEM COMMANDS

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
CURSOR	no	yes	one . . . 0/1/2 or DELTA/START/STOP	CURSOR 1?	Returns the time/voltage values for the start cursor.
DUTYCYCLE	no	yes	none	DUTYCYCLE?	Measures and returns the duty cycle of the selected source (+ pulse).
ESTART	yes	no	one . . . integer between 1 and 100 in magnitude with a mandatory sign	ESTART +3	Positions the start cursor on the third rising edge from the left of the screen using the start cursor voltage.
ESTOP	yes	no	one . . integer between 1 and 100 in magnitude with a mandatory sign	ESTOP –2 Positions the stop cursor on the	second falling edge from the left of the screen using the stop cursor voltage.
FALL	no	yes	none	FALL?	Measures and returns the fall time of the selected source.
FREQUENCY	no	yes	none	FREQUENCY?	Measures and returns the frequency of the selected source.
NWIDTH	no	yes	none	NWIDTH?	Measures and returns the negative pulse width of the selected source.
OVERSHOOT	no	yes	none	OVERSHOOT?	Measures and returns the overshoot of the selected source.
PERIOD	no	yes	none	PERIOD?	Measures and returns the period of the selected source.
PRECISION	yes	yes	one . . 0/1 or LOW/HIGH	PRECISION HIGH	Specifies that all measurements that involve finding edges will expand. the waveform as necessary for optimal resolurion.
				PRECISION?	Returns the currently selected measurement precision

MEASURE SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
PRESHOOT	no	yes	none	PRESHOOT?	Measures and returns the preshoot of the selected source.
PWIDTH	no	yes	none	PWIDTH?	Measures and returns the positive pulse width of the selected source.
RISE	no	yes	none	RISE?	Measures and returns the rise time of the selected source.
SOURCE	yes	yes	0/1/2 or DUAL/CHANNEL1/CHANNEL2 one of the form CHANNELn, n = 1 or 2, or the keyword DUAL	SOURCE CHANNEL1	Specifies measurements to be done on channel 1.
TOPBASE	no	yes	none	TOPBASE?	Measures and returns the top-base voltage of the selected source.
TDELTA	no	yes	none	TDELTA?	Returns the time difference between start and stop markers.
TSTART	yes	yes	one . . . real	TSTART 1.0E-6 TSTART?	Sets the start marker time to 1μs. Returns the start marker time.
TSTOP	yes	yes	one . . real	TSTOP 2.0E-6 TSTOP?	Sets the stop marker time to 2μs. Returns the stop marker time.
TVOLT	no	yes	two . . . real within the vertical range and an integer between 1 and 100 in magnitude with a mandatory sign	TVOLT 1 0,+3?	Returns the time of the third positive transition through 1.0V.
VBASE	no	yes	none	VBASE?	Measures and returns the base voltage of the selected source.
VDELTA	no	yes	none	VDELTA?	Returns the voltage difference between the start and stop markers.

MEASURE SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
VMAX	no	yes	none	VMAX?	Measures and returns the absolute max voltage of the selected source.
VMIN	no	yes	none	VMIN?	Measures and returns the absolute min voltage of the selected source.
VPP	no	yes	none	VPP?	Measures and returns the peak-to-peak voltage of the selected source.
VRELATIVE	yes	yes	one . . . 10/20/50/100	VRELATIVE 10	Changes the voltage of the start and stop markers to 10% and 90% of the difference between the original values.
				VRELATIVE?	Returns the last selected value.
VRMS	no	yes	none	VRMS?	Measures and returns the rms voltage of the selected source.
VSTART	yes	yes	one . . . real	VSTART 1.0	Sets the start marker (marker 1) voltage to 1.0V.
				VSTART?	Returns the start marker voltage.
VSTOP	yes	yes	one . . . real	VSTOP 2.0	Sets the stop marker (marker 2) voltage to 2.0V.
				VSTOP?	Returns the stop marker voltage.
VTIME	no	yes	one . . . real within the screen window	VTIME 1.0E-6?	Returns voltage of last data taken at 1 0 μs.
VTOP	no	yes	none	VTOP?	Measures and returns the top voltage of the selected source.

TIMEBASE SUBSYSTEM COMMANDS

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
DELAY	yes	yes	one . . . real (depends on sweep speed)	DELAY -1.0E-3 DELAY?	Sets delay to -1ms. Returns delay value.
MODE	yes	yes	one . . 0/1/2 or AUTO/TRIGGERED/SINGLE	MODE AUTO MODE?	Selects the auto-triggered mode. Returns the sweep mode.
OFFSET	yes	yes	one . . . real (depends on sweep speed)	OFFSET 1.0E-6 OFFSET?	Same as delay.
RANGE	yes	yes	one . . . real between 1 ns/div and 10 s/div	RANGE 1.0E-6 RANGE?	Sets sweep to 1us full screen. Returns width full screen in seconds.
REFERENCE	yes	yes	one . . . 0/1/2 or LEFT/CENTER/RIGHT	REFERENCE LEFT REFERENCE?	Sets delay reference to left side of screen. Returns delay reference.
SENSITIVITY	yes	yes	one . . . real between 100 ps/div and 1 s/div	SENSITIVITY 1.0E-7 SENSITIVITY?	Sets time per division to 100ns. Returns current time per division.

TRIGGER SUBSYSTEM COMMANDS

CONDITION	yes	yes	one . . 0/1 or ENTER/EXIT	CONDITION ENTER	Specifies triggering on entering the selected condition.
				CONDITION?	Returns the current condition specification. (pattern or state modes)
DELAY	yes	yes	one . . . real or integer	DELAY 2.0E-7	Specifies the delay in the time delay mode to 200ns.
				DELAY 200	Specifies the delay in the events delay mode to 200 events.
				DELAY?	Returns the delay for the current trigger mode. (events and time delay modes)

TRIGGER SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
DURATION	yes	yes	two . . . first is < / > or LT/GT or 1/2, second is a real number	DURATION >,1.0E-6	Specifies that the pattern must be present for at least 1μs before being considered.
				DURATION?	Returns the current duration parameters. (54100D only, pattern mode)
ENABLE	yes	yes	one . . . 1/2/3/4 or CHANNEL 1/CHANNEL2/ EXTERNAL1/EXTERNAL2	ENABLE CHANNEL1	Specifies the trigger enable source to be channel 1.
				ENABLE?	Returns the trigger enable source. (time & event delay modes)
HOLDOFF	yes	yes	two . . . keyword TIME followed by a real number (70 ns to 670 ms) or keyword EVENT followed by an integer (2 to 67000000)	HOLDOFF TIME,1.5E-7	The 54100D sets holdoff to holdoff by a time to 150 ns.
				HOLDOFF?	Returns the holdoff mode and value (time holdoff in edge, pattern and state modes; event holdoff in edge.
LEVEL	yes	yes	one . . . real (±2 * vertical range)	LEVEL 1.65	Sets trigger level of selected source or path to 1.65 V.
				LEVEL?	Returns trigger level of selected source or path (all modes).
LOGIC	yes	yes	one . . . 0/1/2 or LOW/HIGH/DONTCARE	LOGIC HIGH	Specifies the logic level for the last selected path or source to be high.
				LOGIC?	Returns the logic level for the last selected path or source. (state or pattern modes)
MODE	yes	yes	one . . . 0/1/2/3/4 or EDGE/PATTERN/STATE/TDLY/ EDLY	MODE EDGE	Selects the edge mode.
				MODE?	Returns the trigger mode. (54100A has edge and pattern modes only, 54100D has all modes)

TRIGGER SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
PATH	yes	yes	one . 1/2/3/4 or CHANNEL 1/CHANNEL2/ EXTERNAL1/EXTERNAL2	PATH CHANNEL2	Specifies the trigger pattern bit to be channel 2. (pattern and state modes)
				PATH?	Returns the current trigger pattern path selection. (pattern and state modes)
PROBE	yes	yes	one . . . real between 1.0 and 1000.0	PROBE 5.0	Specifies the probe attenuation for the selected source.
				PROBE?	Returns probe attenuation of selected source.
SLOPE	yes	yes	one . . . 0/1 or NEGATIVE/POSITIVE	SLOPE POSITIVE	Specifies positive slope for the selected source.
				SLOPE?	Returns slope of selected source. (edge, state, event & time delay modes)
SOURCE	yes	yes	one . . 1/2/3/4 or CHANNEL 1/CHANNEL2/ EXTERNAL1/EXTERNAL2	SOURCE CHANNEL1	Selects chan 1 as trigger source. (in edge, state, time delay and edge delay modes)
				SOURCE?	Returns the selected source. (edge, state, time delay and edge delay modes)

WAVEFORM SUBSYSTEM COMMANDS

COMPLETE	yes	yes	one integer between 50 and 100	COMPLETE 50 Specifies	50% completion criteria in the preamble.
				COMPLETE?	Returns the preamble completion criteria.

WAVEFORM SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
COUNT	yes	yes	one . . . integer between 1 and 2048	COUNT 128	Specifies 128 averages (or 128 hits per bucket in enveloped mode) in the preamble.
				COUNT?	Returns the preamble count parameter.
DATA	yes	yes	one . . . either binary block or ASCII string	DATA <parameter>	Sends a data record to waveform memory.
				DATA?	Returns a waveform record.
FORMAT	yes	yes	one . . . 0/1/2 or ASCII/BYTE/ WORD	FORMAT WORD	Specifies the waveform transfer format.
				FORMAT?	Returns the transfer format.
POINTS	yes	yes	one . . . integer (128, 256, 512, or 1024)	POINTS 1024	Specifies 1024 points in the preamble of the waveform record.
				POINTS?	Returns the number of points from the preamble.
PREAMBLE	yes	yes	one . . . string	PREAMBLE <string>	Sends preamble to waveform memory.
				PREAMBLE?	Returns preamble from waveform memory.
SOURCE	yes	yes	one of the form MEMORYn n = 1 or 2	SOURCE MEMORY1	Selects memory 1 as the source for the subsequent waveform commands.
				SOURCE?	Returns the selected source number.
TYPE	yes	yes	one . . . 1/2/3/4 or NORMAL/ AVERAGE/ENVELOPE/RANDOM	TYPE AVERAGE	Sets waveform type to average in the preamble.
				TYPE?	Returns the preamble type parameter.
VALID	no	yes	none	VALID?	Returns the status of the waveform stored in the selected memory . . . > 0 means good data, = 0 indicates problems.

WAVEFORM SUBSYSTEM COMMANDS (CONT'D)

KEYWORD	COMMAND?	QUERY?	PARAMETERS	EXAMPLE SYNTAX	FUNCTION
XINCREMENT	yes	yes	one . . . real (depends on sweep speed)	XINCREMENT 1.0E-7	Sets preamble value for time between points to be 100 ns.
				XINCREMENT?	Returns the preamble x-increment value.
XORIGIN	yes	yes	one . . . real (depends on delay)	XORIGIN 1.0E-6	Sets time between trigger & x ref in the preamble to be 1 μs.
				XORIGIN?	Returns the preamble x-increment value.
XREFERENCE	yes	yes	one . . integer (should be 0)	XREFERENCE 0	Specifies preample value for the x-origin is point # 0.
				XREFERENCE?	Returns the preamble x-reference value.
YINCREMENT	yes	yes	one . . . real (depends on vertical range and probe attenuation)	YINCREMENT 1.0E-3	Sets preamble value of voltage between quantization levels to be 1 mV
				YINCREMENT?	Returns the preamble y-increment value.
YORIGIN	yes	yes	one . . . real (depends on vertical range and probe attenuation)	YORIGIN 1.0E-3	Sets preamble value of voltage at y-reference value to be 1 mV.
				YORIGIN?	Returns the preamble y-origin value.
YREFERENCE	yes	yes	one . . integer (should be 64 for byte format and 16384 for word or ASCII format)	YREFERENCE 64	Specifies preamble value for center of waveform to be point # 64.
				YREFERENCE?	Returns the preamble y-reference value.

Appendix A
Example/Demo Programs

INTRODUCTION

This section contains example programs using the command set for the 54100A/D. In general, they use the longform of the command with alpha, (as apposed to numeric), arguments with each command using a separate output statement for clarity. To optimize the speed, switch to concatenated shortform numberics.

Throughout these examples the 54100A/D is assumed to be at address 7, the hardcopy devices are assumed to be at address 1, and the system bus is at 700. The input signal used is the calibration signal available from the rear panel of the instrument connected to channel 1.

All programs were developed on an HP 200 series scientific computer using HP Basic 2.0. Several examples use the BASIC command "ENTER 2". This pauses program execution until the "ENTER" key is depressed on the controller. This is used to separate different blocks in the example for feature dramatizations, for user interaction, or to wait the 54100A/D to finish something such as a hardcopy dump or an acquisition.

```
10    ! This sample program demonstrates some of the commands
20    ! used to set a vertical channel, in this case channel 1.
30    ! This program works well using the cal signal from the
40    ! rear panel of the 54100A/D.
50    !
60    !
70    !
80    OUTPUT 707;"AUTOSCALE"            ! Autoscales the unit.
90    OUTPUT 707;"CHANNEL1"             ! Enter Channel 1 subsystem.
100   OUTPUT 707;"OFFSET 0.0"           ! Set offset to 0 volts.
110   REAL Offset,Range
120   INTEGER J
130   Offset=0.                         ! Set offset to 0.
140   FOR J=1 TO 11
150      OUTPUT 707;"OFFSET";Offset     ! Set next offset.
160      Offset=Offset-.04
```

```
170      WAIT .3
180      NEXT J
190   !
200   !
210   !
220   OUTPUT 707;"AUTOSCALE"           ! Does as it says.
230   OUTPUT 707;"RANGE .080"          ! Set vertical range to 80 mV (min)
240   !                                   Can also use "SENSITIVITY" for
250   !                                   volts/div.
260    Range=.08                       ! Set range variable to minimum range
270   !                                   or maximum sensitivity.
280    FOR J=1 TO 12
290       OUTPUT 707;"RANGE";Range     ! Set new range.
300       Range=Range*2
310       WAIT .3
320       NEXT J
330   !
340   !
350    OUTPUT 707;"GRAPH"               ! Enter GRAPH subsystem.
360    OUTPUT 707;"YOFFSET -.2"         ! Set magnified offset.
370    OUTPUT 707;"YRANGE 8.0"          ! Set magnified range.
380    OUTPUT 707;"MAGNIFY MARKER"      ! Turns on magnify Markers.
390    Range=8.0
400    FOR J=1 TO 12
410       OUTPUT 707;"YRANGE";Range    ! Set new magnified range.
420       Range=Range/1.5              !  automatically moves markers
430       WAIT .3                      !  to reflect new range.
440       NEXT J
450    !
460    OUTPUT 707;"MAGNIFY ON"          ! Puts unit into the magnify mode.
470    LOCAL 707
480    END
```

```
10    ! This is a sample program demonstrating the TIMEBASE
20    ! subsystem.  The rear panel calibrator signal works well
30    ! with this sample program.
40    !
50    !
60    !
70    OUTPUT 707;"AUTOSCALE"                ! Does as it says.
80    REAL Sens,Delay
90    INTEGER J
100   OUTPUT 707;"TIMEBASE"                 ! Enter TIMEBASE subsystem.
110   OUTPUT 707;"SENSITIVITY 200E-9"       ! Set timebase to 200 ns/div.
120   !                                        Can also use "RANGE" for
130   !                                        seconds/full screen.
140   !
150   OUTPUT 707;"DELAY 0.0 "               ! Set delay to 0.
```

```
160   OUTPUT 707;"REFERENCE LEFT"          ! Puts delay reference at left
170   !                                       of graticule.
180   !
190   Delay=0.                             ! Sets delay to 0.
200   FOR J=1 TO 25
210      OUTPUT 707;"OFFSET ";Delay        ! "OFFSET" = "DELAY" - next delay.
220      WAIT .23
230      Delay=Delay-1.00E-7
240      NEXT J
250   !
260   !
270   !
280   OUTPUT 707;"AUTOSCALE"               ! Does as it says.
290   Range=.080                           ! Sets full scale to 80 ms
300   !                                       i.e., 8 ms/div.
310   FOR J=1 TO 25
320       OUTPUT 707;"RANGE";Range         ! Next fullscale range.
330       Range=Range/2
340       WAIT .4
350       NEXT J
360   !
370   WAIT 1
380   !
390   !
400   ! WATCH AND SEE HOW DATA IS ACQUIRED.
410   ! NOTE THAT DATA POINTS ARE 25 ns APART
420   ! FOR EVERY ACQUISITION
430   !
440   OUTPUT 707;"HEADERS OFF"             ! Turns off headers in query reply.
450   OUTPUT 707;"AUTOSCALE"               ! Does as it says.
460   OUTPUT 707;"SENSITIVITY?"            ! Ask for time/div.
470   ENTER 707;Sens                       ! Reads time/div.
480   Sens=Sens/8
490   OUTPUT 707;"SENSITIVITY";Sens        ! Set faster sweep speed.
500   OUTPUT 707;"STOP"                    ! Halt acquisition (system command)
510   OUTPUT 707;"ERASE PLANE0"            ! Clears the active display plane.
520   !                                       This is a system command.
530   OUTPUT 707;"MODE SINGLE"             ! Sets single shot operation.
540   FOR J=1 TO 20
550         OUTPUT 707;"RUN"               ! One acquisition.
560   !
570         WAIT 1
580         NEXT J
590   !
600   !
610   OUTPUT 707;"MODE TRIGGERED"          ! Puts unit in the triggered mode.
620         OUTPUT 707;"RUN"               ! Starts acquisition.
630   END

10    !
```

```
20    ! This program demonstrates some of the learn string capabilities.
30    !
40    !
50    !
60    DIM Setting$[242]              !  232 = # of bytes in learn string
70    !                                 plus 10 = "SET   #A**"
80    !                                 Where SET   =  header
90    !                                       #A    =  indicates binary block
100   !                                       **    =  2 byte integer = length
110   !
120   OUTPUT 707;"HEADER ON"         ! Tells 54100A/D to precede the learn
130   !                                 string with header.
140   OUTPUT 707;"EOI ON "           ! Tells scope to output an EOI
150   !                                 with last byte.
160   OUTPUT 707;"SET?"              ! This asks the scope for the learn string.
170   ENTER 707 USING "-K";Setting$  ! Reads in header and string  (-K tells
180   !                                 computer to treat CR & LF as data).
190   LOCAL 707
200   !
210   !
220   !
230   ENTER 2                         ! This allows you to change the
240   !                                  scope's set up.
250   !                                  Hit 'ENTER' to continue.
260   !
270   !
280   OUTPUT 707;Setting$             ! Outputs the learn string and header.
290   !                                  Scope is reset to previous
300   !                                  setup.
310   LOCAL 707
320   !
330   END
340   !
```

```
10    ! This sample program demonstrates some of the commands in
20    ! the Hardcopy subsystem.  Use a graphics printer for this sample.
30    ! It assumes that the scope is at address 7, the printer is at
40    ! address 1,and that the system bus is 700.
50    !
60    OUTPUT 707;"HARDCOPY"               ! This puts the scope in the
70    !                                      HARDCOPY subsystem.
80    OUTPUT 707;"PAGE AUTO"              ! Sets the scope to automatically
90    !                                      output a formfeed.
100   OUTPUT 707;"SOURCE PLANE0,FACTORS"  ! Selects the active display (plane0)
110   !                                      and the scale factors for output.
120   !                                      Other sources are not output.
130   !
140   !
```

```
150   OUTPUT 707;"PRINT"                ! Starts print buffering.
160   SEND 7;UNT UNL                    ! Clears bus.
170   SEND 7;LISTEN 1                   ! Address printer to  listen
180   SEND 7;TALK 7                     ! Sets scope to the talk mode.
190   WRITEIO 7,23;11                   ! Lowers the ATN @ controller.
200   WAIT 50                           ! Wait 50 seconds for transfer to
210   !                                    finish.
220   !                                    Note: If programming, use the
230   !                                    SRQ capabilities of the 54100A/D
240   !                                    to determine when the transfer
250   !                                    is complete. Attempting to
260   !                                    program the 54100A/D while making
270   !                                    a hardcopy dump will cause
280   !                                    errors to result.
290   END
```

```
10    !  This sample program demonstrates some of the commands in the
20    !  Hardcopy subsystem and the PLOT command.
30    !  It assumes that the scope is at address 7, the plotter is at
40    !  address 1, and that the system bus is 700.
50    !
60    OUTPUT 707;"HARDCOPY"             ! This puts the scope into the
70    !                                    HARDCOPY subsystem
80    OUTPUT 707;"PEN AUTO"             ! Sets the 54100A/D to the Auto
90    !                                    pen mode.
100   OUTPUT 707;"SOURCE PLANE0,FACTORS"  ! Selects the active display (plane0)
110   !                                      and the scale factors for output.
120   !                                      Other sources are not output.
130   !
140   OUTPUT 707;"PLOT"                 ! Outputs data to the plotter.
150   SEND 7;UNT UNL                    ! Clears bus.
160   SEND 7;LISTEN 1                   ! Address printer to  listen.
170   SEND 7;TALK 7                     ! Sets scope to talk mode.
180   WRITEIO 7,23;11                   ! Lowers ATN line @ controller.
190   WAIT 50                           ! Wait 50 seconds for transfer to
200   !                                    complete.
210   !                                    Note: If programming, use the
220   !                                    SRQ capabilities of the 54100A/D
230   !                                    to determine when the transfer
240   !                                    is complete.  Attempting to
250   !                                    program the 54100A/D while making
260   !                                    a hardcopy dump will cause
270   !                                    errors to result.
280   END
```

```
10    ! This sample program demonstrates some of the commands in the
20    ! MEASURE Subsystem.
30    !
```

```
40   !
50   OUTPUT 707;"AUTOSCALE"              ! Does as it says.
60   OUTPUT 707;"DISPLAY"                ! Selects DISPLAY Subsystem.
70   OUTPUT 707;"TMARKER ON"             ! Turns on Tmarkers.
80   !
90   !
100  OUTPUT 707;"MEASURE"                ! Selects MEASURE Subsystem.
110  OUTPUT 707;"VSTART -.2"             ! Set Voltage Start Marker to -200 mV.
120  !                                      This will be used as a reference
130  !                                      for the edge find function.
140  !
150  INTEGER J
160  FOR J=1 TO 3
170        OUTPUT 707;"ESTART +";J       ! Find Jth positive edge.
180        WAIT .75
190        OUTPUT 707;"ESTART -";J       ! Find Jth negative edge.
200        WAIT .75
210        NEXT J
220  !
230  ENTER 2                            ! This statement causes a pause in the
240  !                                      program, press ENTER on the
250  !                                      controller to continue.
260  !
270  !
280  REAL Delay,Offset
290  Delay=2.4E-6                        ! Sets Delay to 2.4us.
300  Offset=.4                           ! Sets Offset to 400mV.
310  FOR J=1 TO 80
320      OUTPUT 707;"TSTART";Delay       ! Moves Time Start Marker.
330      OUTPUT 707;"TSTOP";-Delay       ! Moves Time Stop Marker.
340      OUTPUT 707;"VSTART";-.19-Offset ! Moves Voltage Start Marker.
350      OUTPUT 707;"VSTOP";-.19+Offset  ! Moves Voltage Stop Marker.
360      Offset=Offset-.01
370      Delay=Delay-6.0E-8
380      NEXT J
390  !
400  ENTER 2                             ! Same as above.
410  !
420  !
440  OUTPUT 707;"PRECISION LOW"          ! Select PRECISION flag low.
450  !                                      Low precision uses previously
460  !                                      acquired data for measurements.
470  !                                      This allows faster completion of
480  !                                      measurements at the expense of some
490  !                                      accuracy and repeatability.
500  OUTPUT 707;"ALL?"                   ! Measures parameters. They will be
510  !                                      displayed on scope, but they are
520  !                                      also available over the bus.
530  !
540  !
```

```
550  ENTER 2                          ! Same as previous "ENTER 2".
560  !
570  !
580  OUTPUT 707;"RISE?"               ! Measures RISE time using low
590  !                                   precision.  You set precision
600  !                                   flag low earlier.
610  ENTER 2                          ! Same as above
620  !
630  !
650  OUTPUT 707;"PRECISION HIGH"      ! Sets PRECISION flag high.
660  OUTPUT 707;"RISE?"               ! Measures precise RISE time.
670  !                                   Watch the display during this
680  !                                   measurement.
690  ENTER 2                          ! Same as above.
700  !
710  !
720  OUTPUT 707;"PRECISION LOW"       ! Sets PRECISION flag to low.
740  LOCAL 707
750  END
```

```
10    ! This sample program demonstrates some techniques of moving
20    ! data over the HP-IB as well as moving data internal to the
30    ! 54100A/D.  This program also demonstrates the ability to
40    ! concatenate commands in a single output statement.
50    !
60    !
70    !
80    OUTPUT 707;"ACQUIRE "                  ! Enters ACQUIRE subsystem.
90    !
100   OUTPUT 707;"TYPE ENVELOPE COUNT 256 POINTS 512 COMPLETE 90"
110   !
120   !                                        Selects parameters for
130   !                                        acquired data.
140   !                                         ENVELOPE = Min-Max data,
150   !                                         256 hits in each time bucket,
160   !                                         512 time buckets and
170   !                                         90% completion criteria.
180   !
190   OUTPUT 707;"DIGITIZE 1"                ! Starts acquisition
200   !                                        on Channel 1.
210   !
220   !                                        Waits for acquisition to
230   ENTER 2                                ! finish.  Status line will go
240   !                                        from "Measuring" to "Running"
250   !
260   !
270   OUTPUT 707;"HEADER OFF"                ! Turns headers off for queries.
280   !
```

```
290   OUTPUT 707;"WAVEFORM SOURCE MEMORY1 FORMAT WORD" ! Enters WAVEFORM sub-
300   !                                                  system
310   !                                  ! Selects data in memory 1.
320   !
330   !                                  ! Outputs memory 1 data as
340   !                                     binary-words block formatted.
350   !
360   OUTPUT 707;"DATA?"                 ! Asks for the data record.
370   ENTER 707 USING "#,2A";Head$       ! Reads & stores "#A".
380   ENTER 707 USING "#,W";Length       ! Reads block length.
390   !                                    # = ignore End of line
400   !                                    sequences.
410   !                                    2A = read 2 ASCII char.
420   !                                    W = read 1 integer word.
430   !
440   Length=Length/2                    ! Accounts for byte data
450   !                                     in word format.
460   ALLOCATE INTEGER Waveform(1:Length)
470   ASSIGN @Scope TO 707;FORMAT OFF    ! Speeds up transfer rate.
480   ENTER @Scope;Waveform(*)           ! Gets data.
490   ASSIGN @Scope TO 707;FORMAT ON
500   !
510   DIM Preamble$[116]                 ! Preamble with header has 116
520   !                                     bytes.
530   OUTPUT 707;"HEADER ON LONGFORM OFF"  ! Short headers on for preamble.
540   OUTPUT 707;"PREAMBLE?"             ! Asks for preamble.
550   ENTER 707;Preamble$                ! Gets preamble.
560   !                                    The preamble contains the info
570   !                                    necessary to decode the wave-
580   !                                    form data when returned to the
590   !                                    54100A/D.
600   !
610   !
620   !   Draw Graticule
630   !
640   GINIT
650   GRAPHICS ON
660   WINDOW 0,512,0,256
670   LINE TYPE 4
680   !
690   !   draw vertical lines
700   !
710   FOR I=0 TO 10
720      MOVE I*512/10,0
730      DRAW I*512/10,256
740      NEXT I
750   !
760   !   draw horizontal lines
770   !
780   FOR I=0 TO 8
```

```
790     MOVE 0,I*256/8
800     DRAW 512,I*256/8
810     NEXT I
820   LINE TYPE 1
830   !
840   !   Draw Waveform
850   !                                The waveform is transmitted in two blocks
860   !                                with the significant data in the upper
870   !                                byte of the word. The first is the minimum.
880   !
890   FOR I=1 TO 512
900     MOVE (I),Waveform(I)/128       ! Draw min. The '/128' = shift right 7.
910     DRAW (I),Waveform(I)/128
920     MOVE (I),Waveform(I+512)/128   ! Draw max.
930     DRAW (I),Waveform(I+512)/128
940     NEXT I
950   !
960   !
970   !
980   ENTER 2                          ! For user interaction.
990   !
1000  !
1010  ! This section transfers the input waveform data back to the 54100A/D
1020  ! and then transfers it to one of the memory planes. It also transfers the
1030  ! data that remained internal to the other memory plane for comparison.
1040  !
1050  !
1060  OUTPUT 707;"SRC MEM2"              ! Selects destination in 54100A/D.
1070  OUTPUT 707;Preamble$               ! Sends preamble info.
1080  Length=Length*2                    ! Reconstruct length.
1090  Head$="DATA #A"                    ! Sets proper header string.
1100  OUTPUT 707 USING "#,7A,W";Head$;Length  ! Sends header & length.
1110  OUTPUT 707 USING "W";Waveform(*)   ! Sends data.
1120  OUTPUT 707;"TRANSFER MEMORY2,PLANE2" ! Transfers data from destination
1130  !                                    to memory plane 2.
1140  OUTPUT 707;"TRANSFER MEMORY1,PLANE1" ! Transfer internal data to
1150  !                                    memory plane 1.
1160  LOCAL 707
1170  END



10    !
20    ! This sample program demonstrates some of the uses of
30    ! Service Requests (SRQ's).  This set of instructions uses
40    ! the Acquisition, Done, Local, Front Panel Service,
50    ! Ready & Ready Masks.  An Acquisition that will produce
60    ! buffered results will be started.  When a SRQ is sent the
70    ! results will be read and displayed.
80    ! The scope will then monitor the front panel using SRQ's and
```

```
90    ! echo any activity. Any Advisories or Acquisitions initiated
100   ! by the front panel will be disclosed.
110   !
120   !
130   !
140   PRINTER IS 1                          ! Display is PRINT destination.
150   DIM B$(1:16)[30],K$[80],A$[80]
160   !
170   ON INTR 7 GOSUB Srq_svc               ! Goto 'Srq_svc' on Service Request.
180   ENABLE INTR 7;2                       ! Enables SRQ on bus #7.
190   DISABLE INTR 7                        ! Disable all interrupts on bus #7.
200   !
210   PRINT
230   OUTPUT 707;"AUTOSCALE"                ! Does as it says
240   INTEGER Rqsmask
250   Rqsmask=1024+16+4                     ! request mask
260   !                                       1024 = Acquisition done - bit 10
270   !                                         16 = Ready - bit 4
280   !                                          4 = Front Panel Service - bit 2
290   !
300   OUTPUT 707;"REQUEST";Rqsmask          ! Sends Request Mask.
310   OUTPUT 707;"REQUEST ON"               ! Sets RQS - bit 6 in Request mask.
320   OUTPUT 707;"LONGFORM ON"              ! Turns on longform for headers.
330   OUTPUT 707;"HEADER ON"                ! Turns headers on for queries.
340   Stat=SPOLL(707)                       ! Serial Poll scope, should be 0.
350   PRINT "Result of Serial Poll is ";Stat
360   !
370   Meas_flag=0
380   OUTPUT 707;"MEASURE "                 ! Enters MEASURE subsystem.
390   OUTPUT 707;"PRECISION HIGH; ALL?"     ! Sets PRECISION flag high.
400   !                                       Measures all.
410   ENABLE INTR 7                         ! Enable interrupts on bus #7
420   !
430   PRINT " Waiting for measurement to complete."
440   PRINT " Time available for other tasks."
450   PRINT " Bus is available."
460   !
470   GOTO 470
480   !
490   !
500   !
510   ! Service Request Interrupt Routine
520   !
530 Srq_svc:
540   Stat=SPOLL(707)                       ! Serial Poll for scope.
550   !                                       Clears SRQ.
560   INTEGER J
570   PRINT
580   PRINT "Service Request Status= ";Stat
590   !
```

```
600   !
610   IF BIT(Stat,0) THEN                        ! Request Control - 54100A/D is
620      PRINT "RQC should not set - PROBLEM"    !  not a controller and cannot
630   END IF                                     !  send a RQC.
640   !
650   !
660   IF BIT(Stat,1) THEN                        ! RAM power failure.
670      PRINT "PWR status has been set WHY?"
680   END IF
690   !
700   !
710   IF BIT(Stat,2) THEN                        ! Front Panel Service.
720     PRINT "FPS status has been set"
730     OUTPUT 707;"key?"                        ! Asks for key code.
740     ENTER 707;K$                             ! Reads key code.
750     OUTPUT 707;K$                            ! Outputs key code.
760     PRINT "     "&K$
770   END IF
780   !
790   !
800   IF BIT(Stat,3) THEN                        ! Local operation occurred.
810      PRINT "LCL operation has occurred"
820   END IF
830   !
840   !
850   IF BIT(Stat,4) THEN                        ! Ready - only bits active
860      PRINT "Acquisition done !!!!"           !  are the Acquisition done bit
870      IF Meas_flag=0 THEN                     !  and the Front Panel Service
880           FOR J=1 TO 16                      !  bit.
890           ENTER 707;B$(J)                    ! Read measurement results
900              PRINT B$(J)                     !  and print them.
910              NEXT J                          !
920           Meas_flag=1
930           PRINT
940           PRINT "Now try pressing keys, they will echo from controller"
950      END IF
960   END IF
970   !
980   !
990   IF BIT(Stat,5) THEN                        ! Go read the errors.
1000    REPEAT
1010      OUTPUT 707;"ERR?"                      ! Ask for next error in queue.
1020      ENTER 707;A$                           ! Read error.
1030      PRINT "Error was : ";A$                ! Print error.
1040    UNTIL VAL(A$[9,12])=0                    ! Until error queue is empty.
1050  END IF
1060  !
1070  !
1080  IF BIT(Stat,6) THEN                        ! A SRQ has been generated.
1090    OUTPUT 707;"REQUEST?"                    ! Ask for mask value.
```

```
1100    ENTER 707;A$                        ! Read mask.
1110    PRINT A$&" is the mask value"       ! Print mask value.
1120  END IF
1130  !
1140  !
1150  IF BIT(Stat,7) THEN                   ! Advisory has been initiated.
1160    OUTPUT 707;"DSP?"                   ! Ask for Advisory.
1170    ENTER 707;A$                        ! Read Advisory.
1180    PRINT A$&" is the Advisory"         ! Print advisory.
1190  END IF
1200  !
1210  !
1220  ENABLE INTR 7                         ! SRQ disables Interrupts.
1230  RETURN                                ! This re-enables them.
1240  !
1250  END


10    !
20    ! This sample program demonstrates more uses of the Service
30    ! Requests (SRQ's).  This set of instructions use Hardcopy
40    ! done, Local, Front Panel Service, Ready bit and Ready Masks.
80    ! The scope  will monitor the front panel from SRQ's and
90    ! echo any activity. Any Advisories or Acquisitions initiated
100   ! by the front panel will be disclosed. These examples assume
101   ! the scope to at address 7 and the plotter to be at
110   ! address 1 on bus 7.
120   !
130   !
140   PRINTER IS 1                          ! Display is PRINT destination.
150   DIM K$[80],A$[80]
160   !
170   ON INTR 7 GOSUB Srq_svc               ! Goto 'Srq_svc' on Service Request.
180   ENABLE INTR 7;2                       ! Enable SRQ on bus #7.
190   DISABLE INTR 7                        ! Disable all interrupts on bus #7.
200   !
210   PRINT
220   OUTPUT 707;"RESET"                    ! Resets 54100A/D.
230   OUTPUT 707;"AUTOSCALE"                ! Does as it says.
231   OUTPUT 707;"ACQUIRE MODE AVERAGE"     ! Puts scope into averaged mode.
233   WAIT 4                                ! Wait for data accumulation.
240   INTEGER Rqsmask
250   Rqsmask=4096+16+4                     ! request mask.
260   !                                       4096 = Hardcopy done - bit 12.
270   !                                         16 = Ready - bit 4.
280   !                                          4 = Front Panel Service - bit 2.
290   !
300   OUTPUT 707;"REQUEST";Rqsmask          ! Send Request Mask.
310   OUTPUT 707;"REQUEST ON"               ! Sets RQS - bit 6 in Request Mask.
```

```
320   OUTPUT 707;"LONGFORM ON"           ! Sets longform for headers.
330   OUTPUT 707;"HEADER ON"             ! Sets headers on for queries.
340   Stat=SPOLL(707)                    ! Serial Poll scope, should be 0.
350   PRINT "Result of Serial Poll is ";Stat
360   !
370   Dump_flag=0
380   OUTPUT 707;"HARDCOPY SOURCE PLANE0,FACTORS" ! Sets Hardcopy subsystem,
381   !                          selects active display and scale factors.
390   OUTPUT 707;"PEN AUTO"                        ! Sets auto pen on.
393   OUTPUT 707;"PLOT"                            ! Start PLOT
394   SEND 7;UNT UNL                               ! Turns off entire bus.
395   SEND 7;LISTEN 1                              ! Puts plotter to listen.
396   SEND 7;TALK 7                                ! Puts scope to talk.
397   WRITEIO 7,23;11                              ! Lower ATN line
400   !                                               @ controller.
410   ENABLE INTR 7                                ! Enable interrupts
420   !                                               on bus #7.
421   IF Dump_flag=0 THEN
422      PRINT
430      PRINT " Waiting for Hardcopy transfer to complete."
440      PRINT " Time available for other tasks."
450      PRINT " !!!!!    Bus is  NOT  available      !!!!!!"
451      WAIT 2
453      GOTO 421
454   END IF
470   GOTO 470
480   !
490   !
500   !
510   ! Service Request Interrupt Routine.
520   !
530 Srq_svc:
540   Stat=SPOLL(707)                        ! Serial Poll scope
550   !                                         clears SRQ.
560   INTEGER J
570   PRINT
580   PRINT "Service Request Status= ";Stat
590   !
600   !
610   IF BIT(Stat,0) THEN                    ! Request Control - 54100A/D
620      PRINT "RQC should not set - PROBLEM" !  is not a controller - RQC
630   END IF                                 !  cannot be set by 54100A/D.
640   !
650   !
660   IF BIT(Stat,1) THEN                    ! RAM power failure.
670      PRINT "PWR status has been set WHY?"
680   END IF
690   !
700   !
710   IF BIT(Stat,2) THEN                    ! Front Panel Service.
```

```
720     PRINT "FPS status has been set"
730     OUTPUT 707;"key?"                   ! Asks for key code.
740     ENTER 707;K$                        ! Reads key code.
750     OUTPUT 707;K$                       ! Outputs key code.
760     PRINT "     "&K$
770   END IF
780   !
790   !
800   IF BIT(Stat,3) THEN                   ! Local operation occurred.
810     PRINT "LCL operation has occurred"
820   END IF
830   !
840   !
850   IF BIT(Stat,4) THEN                   ! Ready - only bits active
860     PRINT "Hardcopy Complete  !!!!"     !  are the Hardcopy done bit
861     IF Dump_flag=0 THEN                 !  and the Front Panel Service
863       SEND 7;UNT UNL                    !  bit.
871       Dump_flag=1
881     END IF
940     PRINT "Now try pressing keys, they will echo from controller"
960   END IF
970   !
980   !
990   IF BIT(Stat,5) THEN                   ! GO read the errors.
1000    REPEAT
1010      OUTPUT 707;"ERR?"                 ! Ask for next error in queue.
1020      ENTER 707;A$                      ! Read next error.
1030      PRINT "Error was : ";A$           ! Print next error.
1040    UNTIL VAL(A$[9,12])=0               ! Until queue is empty.
1050  END IF
1060  !
1070  !
1080  IF BIT(Stat,6) THEN                   ! A SRQ was generated by someone.
1090    OUTPUT 707;"REQUEST?"               ! Ask for mask value.
1100    ENTER 707;A$                        ! Read mask value.
1110    PRINT A$&" is the mask value"       ! Print mask value.
1120  END IF
1130  !
1140  !
1150  IF BIT(Stat,7) THEN                   ! Advisory has been initiated.
1160    OUTPUT 707;"DSP?"                   ! Ask for Advisory.
1170    ENTER 707;A$                        ! Read Advisory.
1180    PRINT A$&" is the Advisory"         ! Print Advisory.
1190  END IF
1200  !
1210  !
1220  ENABLE INTR 7                         ! SRQ disables interrupts, this
1230  RETURN                                !  command re-enables interrupts.
1240  !
1250  END
```

Appendix B

SOFTWARE DELAY CALIBRATION AND TRIGGER DELAY OPTIMIZATION

The trigger delay and channel to channel skew calibrations in the Cal menu on the 54100A/D are provided to null delay differences in the trigger and data acquisition paths of the trigger and the data. This would include acquisition time differences both internal and external to the instrument.

Channel to channel skew adjustment is used to change the placement of the channel 2 data relative to channel 1 so delay differences in the data acquisition paths do not introduce offsets in channel-to-channel time interval measurements.

Differences in internal delays as well as differences in external delays caused by dissimilar probes, cable lengths etc. can be nulled. This is done by injecting the cal signal at the probe tips or other desired points when performing the calibrations.

The trigger delay calibrations are used to position waveforms horizontally so that the zero reference corresponds with the trigger event. When both the internal and external delays have been compensated for, the instrument provides a timebase delay that is calibrated in an absolute sense to the trigger point. The timebase delay tells you where the display window is located relative to the trigger.

Trigger delay calibrations do not affect channel-to-channel measurements as the vertical inputs are always displayed relative to each other depending on the setting of the Ch-to-Ch Skew cal factor. As long as Ch-to-Ch Skew cal factor is set correctly you can make accurate channel-to-channel measurements even if the trigger delay cal factors are not set correctly.

The delay calibration feature, a consequence of the 54100A/D's negative time and digital architecture, is convenient for referencing measurements to the probe tips, or other points, even if different types of probes or a probe multiplexer is used. To calibrate a given probe configuration inject a fast risetime signal at the probe tips, or wherever you want your measurement to be referenced and follow the instructions in the Cal menu. Refer to Section 6 for a discussion of the cal menu.

Once the cal procedure is completed the trigger edge will be displayed at the time-zero reference, and if you use an external trigger the time-zero reference will correspond to the time of the trigger event at the Trig 3 or 4 probe tip, or other point of interest.

The cal factors are stored in the nonvolatile SAVE/RECALL registers. This allows the instrument to retain calibrations for up to 10 different probe or measurement configurations. By using the time interval measurements built into the 54100A/D, the display skew and trigger delay cal factors can be determined and programmed via the HP-IB.

The trigger delay calibrations compensate for delays to a first order approximation. Actual trigger delays, in addition to probe length, are a function of signal characteristics such as risetime, amplitude, and rep. rate. If these signal characteristics are not the same when making measurements as they were during calibration, the trigger edges will be displaced from time-zero. The error, however, will be small and will rarely result in any confusion as to which edge is the trigger. For fast risetime signals (<3 ns) this displacement will be less than ±400 ps. Because of these second order affects it should not be assumed that the trigger edge is at precisely time-zero when making time interval measurements unless the edges are fast and 400 ps error can be tolerated. These effects apply only to trigger delays as channel-to-channel skew has no dependency on signal characteristics.

For signals with slower edge speeds, trigger hysteresis can cause a displacement from time-zero, however, compared to the sweep speed at which the signal would be viewed the displacement usually would be small. Trigger hysteresis on the 54100A/D is 1 minor division on channels 1&2 and 10 mv (with 50 ohm pods) on Trig 3&4. The trigger level is at the center of the hysteresis band and the trigger comparator actually begins to switch when the input voltage is 1/2 a minor division from the programmed threshold. This causes the actual threshold crossing to be displaced from time-zero by the amount of time it takes the signal to traverse 1/2 a minor division vertically. The direction of the displacement depends on the trigger slope. At sweep speeds where the signal appears as anything but a near-horizontal line, this displacement is not significant for viewing but can affect time interval measurements if ignored.

With trigger delay calibration captured signals can be correctly plotted relative to the time-zero reference with a small error caused by the second order effects. This applies for the Edge triggering mode on the 54100A and for the Edge, State, Time-Delayed, and Event-Delayed modes on the 54100D. In the Pattern mode, however, the instrument does not know which input will provide the trigger and does not know which cal factor to use. In this case the average of Channel 1 and Channel 2 trigger delay cal factors is used as a compromise. This will result in a minimal displacement when the trigger edge comes from one of the vertical channels but a larger displacement can result if the trigger comes from Trig 3 or 4.

Large delay differences in the signal paths for channel 1 and channel 2 will result in a large displacement, so it is desirable to match these paths as close to one another as possible if an accurate time-zero reference is needed in the pattern mode. Also of concern, when you are in the pattern mode is the relative skew between the inputs. This skew results from delay differences in the acquisition paths internal and external to the instrument. For example, when using the time qualified pattern trigger on the 54100D, skew can cause the pattern true-time seen by the filter timer to be different than the actual time at the probe tips.

Just how much skew, or differential delay, exists between paths is reflected in the trigger delay cal factors (assuming the instrument is calibrated) because the cal factor for each input is referenced to the same channel (channel 1). The difference in the cal factors is equal to the amount of skew in the trigger paths. A more negative cal factor means that the trigger path delay for that channel is longer.

The differential delay between channel 1 & 2 and between Trig 3 & 4 is usually less than 400 ps. This assumes the use of 54002A 50 ohm pods and is referenced to the BNC connectors.

The delay through Channel 1 & 2 is nominally 1.6 ns longer than the delay through Trig 3 & 4. This can cause erroneous pattern triggering unless the extra delay is compensated for by inserting extra delay by using longer cables on Trig 3 and Trig 4. Inserting delay(s) to reduce skew for pattern triggering will also reduce time-zero offset in the Pattern mode.

While skew is not of concern with respect to the time-zero reference in other than Pattern mode, it can affect the operation of the other modes. For Example, the setup and hold times in the State mode (54100D) can be different at the probe tips than they are at the instrument's inputs because of dissimilar probes or cable lengths. This is caused by the fact that the trigger circuitry operates on signals in real-time, thus ruling out software calibration.

Appendix C

DETAILED OPERATION OF THE AUTOMATIC MEASUREMENTS

The automatic waveform parameters and edge find features resident in the 54100A/D are designed to allow you to optimize measurement speed and accuracy for your application. Depending of the sweep speed, display mode, number of averages, and the state of the PRECISION command (HP-IB), the instrument will use different criteria for establishing how much data needs to be acquired to make a measurement. The required amount of data for a measurement may also be defined by the user.

When automated measurements are used the effective display resolution is 256 x 501, the horizontal axis having the greater resolution. Internally, the instrument maintains a waveform record which is constrained to have not more than 1 value for each horizontal address (time bucket). The waveform record used for the automated measurements is the same as the Averaged mode display memory but differs from the Normal mode display memory in that the Normal mode display memory can have multiple values for each time bucket.

DISPLAY MODE CONSIDERATIONS

The waveform record used for the automatic measurements in Normal mode contains the last acquired data point for each time bucket. The waveform record used for the Averaged mode is the same as displayed on the screen, but with additional resolution.

When precise measurements are made the 54100A/D will rescale the time timebase to zoom in (increase the resolution) on the signal edge of interest. In this case the Normal mode waveform record consists of the first acquired data in each time bucket instead of the last. In the Averaged mode the waveform record consists of the average of the first N hits in each time bucket where N is the specified number of averages.

When the timebase is rescaled for precise measurements the instrument requires that 90% of the time buckets receive N data points before it stops acquiring data and calculates the edge crossing. In the Normal display mode N=1.

The larger the number of averages the more time that will be required to make a given measurement, however, the greater the number of averages the better the accuracy and repeatability. Increasing the number of averages past 128 on relatively clean signals does not significantly improve accuracy.

Inasmuch as the time resolution on the 54100A/D is limited to 10 ps, sweep speeds faster than 500 ps/div will result in a waveform record with less than 501 time buckets, e.g., at 100 ps/div the waveform record will have (10 x 100 ps/10 ps+1)=101 time buckets.

AUTO TOP-BASE

The Auto Top-Base function automatically calculates the reference voltage levels which are used for time interval measurements. When this function is invoked a voltage histogram of the waveform is generated from the waveform record. This function returns the top and base values of the waveform, assuming they are statistically recognizable. If not, the max and min levels of the waveform will be returned as default values. The Auto-Top Base function will return the steady state levels of a square wave, even if there is preshoot and overshoot present, as long as there is enough data available in the waveform record to make the histogram valid.

If there are more than 5 data points in a waveform record the instrument will attempt to find the histogram peaks using the currently available data. If there are less than 5 data points in a waveform record the instrument will acquire new data until the 90% completion requirement is met.

If a majority of the timebase buckets are empty when the Top-Base function is invoked, a valid top and base will not be identified and the max and min values of the waveform record will be returned.

Even with all time buckets filled some waveforms will not show well defined peaks in their voltage histograms and will cause the 54100A/D to return max and min values, e.g., a sine wave.

COARSE MEASUREMENTS

The 54100D performs two types of automatic time interval measurements; Coarse and Precise. Coarse measurements use the data in the waveform record (on screen) unless there are less than 5 data points in the record, in that case the instrument will acquire new data until the 90% completion criteria is met and then the edge crossing(s) will be calculated. The Start On Edge and Stop On Edge functions are coarse measurements. A coarse measurement is performed as the first step for the Precise Edge Find function or when the automatic waveform parameters are invoked. The automatic waveform parameter measurements which are precise measurements when used from the front panel can be changed to coarse measurements when the instrument is in remote operation by setting the PRECISION flag to LOW via HP-IB.

Coarse measurements are faster but their accuracy, unlike precise measurements, depends on the sweep speed setting. They do, however, allow you to determine the amount of data that is acquired for a given measurement. This is important when measurement speed is of concern on a low rep rate signal viewed at a fast sweep speed. Both coarse and precise time interval measurements perform linear interpolation between data points so at least, rough results can be obtained from limited data.

PRECISE MEASUREMENTS

Precise measurements in general, but not always, automatically rescale the timebase to expand signal edges for maximum resolution. This technique provides maximum accuracy and results that are independent of the initial sweep speed setting. Precise measurements include the Precise Edge Find and the automatic waveform parameters. These functions all calculate edge crossing times in the same manner. The difference between them is that the automatic parameters have fixed definitions for the voltage levels and edges which determine the time interval while Precise Edge Find allows you to specify these parameters.

When a precise time interval measurement is made the instrument will perform a coarse calculation to locate the edge(s) of interest. Next, for each edge, the display window will be positioned so that the edge of interest is center screen and the sweep speed is increased causing the signal to be expanded on the horizontal axis. The instrument will continue to do this until one of three conditions is met: (1) The slope of the signal is less than 45 degrees to horizontal. (2) The sweep speed equals 500ps/div (maximum resolution). (3) Signal jitter at the current sweep speed makes it fruitless to increase the sweep speed further. At each faster sweep speed setting a calculation is made to determine if any of these three conditions are met. If so, expansion is stopped and the edge crossing time is determined. At each successively faster sweep speed data is acquired until the 90% completion criterion is met. This requires a repetitive signal at the 54100A/D input; therefore, measurements that use the precise time interval measurement cannot be made on single shot data. If such a measurement is attempted on single shot data, the data may be lost.

If the sweep speed is set to 500 ps/div or faster or if the measurement requires only a single edge that already has less than 45 degrees slope as displayed, a precise function, when invoked, will revert to a coarse measurement. This feature is useful for obtaining quick results when data acquisition is slow due to low rep rate signals or fast sweep speeds when large delays are used. Accuracy is not sacrificed unless the available data is less than what the 90% completion criterion would have acquired.

When programming the instrument over the HP-IB, all Precise measurements can be forced to coarse with the PRECISION flag. When coarse measurements are selected, accuracy and resolution will depend on the scaling of the timebase and how much data is displayed on screen.

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